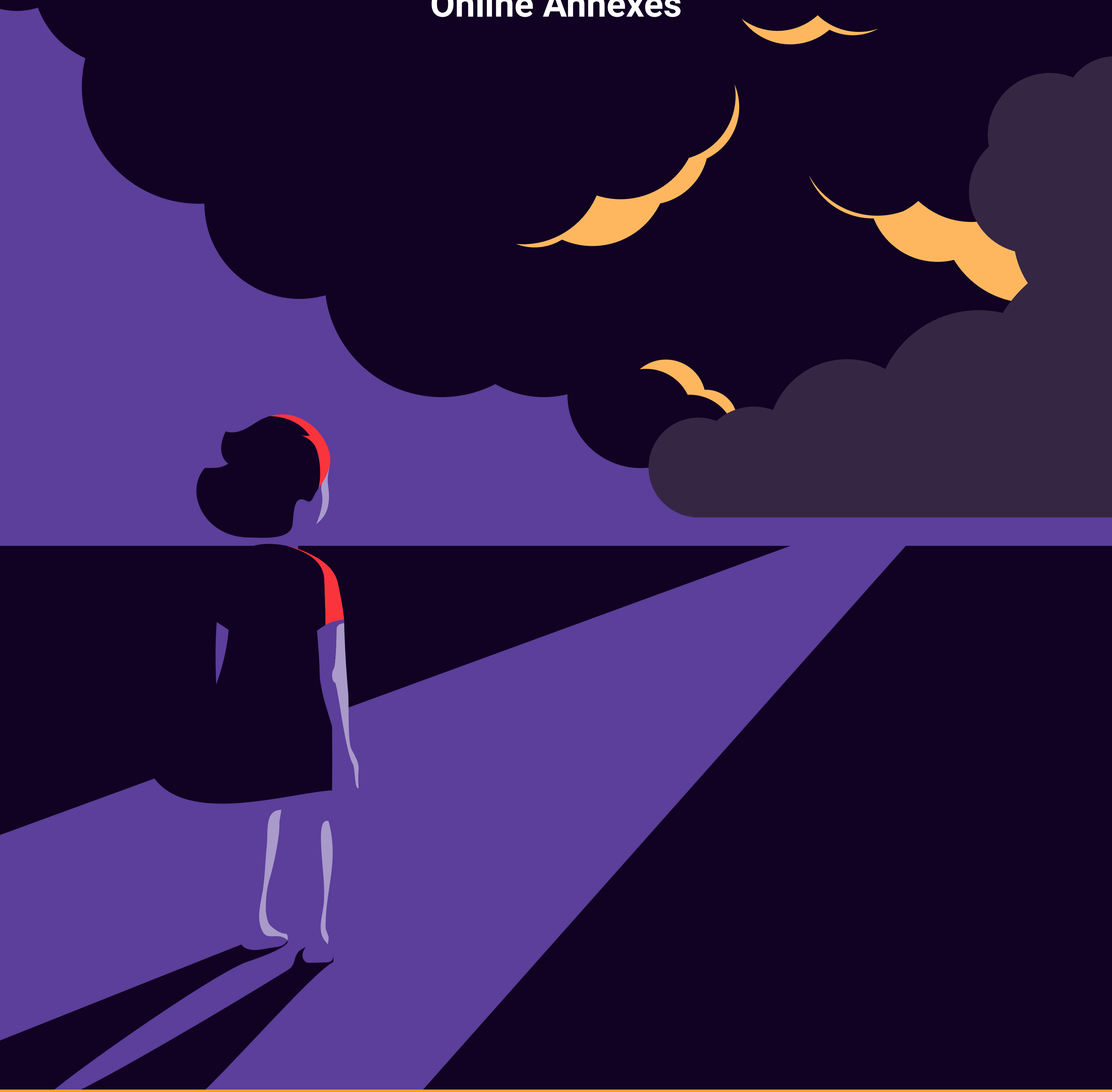
The Gathering Storm

Adapting to climate change in a post-pandemic world

Online Annexes



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Adaptation Gap Report 2021

Annex 4.A:
New estimates of the costs of adaptation

Estimating the costs of adaptation

The economic impacts of climate change – and thus adaptation costs – will vary by region: relative economic costs of climate change and adaptation costs as a percentage of Gross Domestic Product (GDP) will be higher in many of the world's poorest countries, despite the fact that the size of their economies means they make a lower contribution to emissions and global damage or adaptation costs in absolute terms. Estimating the economic costs of climate change and the costs of adaptation is highly challenging, primarily due to the complexity of trying to assess the impacts of climate change for multiple hazards, for all sectors (market and non-market) and for all countries globally and over long lifetimes. The difficulties are compounded by high uncertainty when it comes to scenarios and impacts. Similarly, there are also very high levels of uncertainty regarding future emissions scenarios and climate model projections, as well as in terms of coverage and modelling of impacts. This leads to a large range of possible climate impacts, and in turn, adaptation costs and benefits. Not surprisingly, there are also still major gaps across sectors and impacts, most notably the lack of evidence on the costs of adaptation for ecosystems. Furthermore, the focus to date has been on the estimated costs of planned, proactive adaptation, primarily undertaken by the public sector. For many sectors, there has been less consideration of household and private adaptation (sometimes called autonomous adaptation). These additional categories will increase the estimated costs of adaptation, potentially significantly. Most current adaptation cost estimates are based on technical (engineering) costs for long-term and defined scenarios. They often fail to take into account opportunity costs, transaction costs and implementation costs, which means adaptation costs could be much higher in practice. On the other hand, non-technical options, learning and innovation all have the potential to reduce future adaptation costs. Further information is provided in previous editions of the Adaptation Gap Report (AGR) (United Nations Environment Programme [UNEP] 2014; UNEP 2016a; UNEP 2016b; UNEP 2018; UNEP 2021).

There are also important issues regarding how costs are reported. In the AGR, future cost figures are presented in current prices without discounting to allow a direct comparison over time. However, when undertaking economic analysis, cost values may be presented on an annual or cumulative basis, and they will often be expressed in present value terms (where future costs are discounted). This means care is needed when interpreting adaptation cost estimates, especially when comparing or aggregating estimates.

Updated estimates of adaptation costs

The previous literature was summarized in the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC AR5) in 2014 and in other synthesis studies (Arent *et al.* 2014; Nordhaus and Moffat 2017; Tol 2018). In recent years, aggregate estimates of damages (as a per cent of GDP) and estimates of the social cost of carbon (SCC), which is defined as the marginal cost of a ton of additional carbon emitted, have generally risen. There are two main reasons for this increase.

The first is that updates to existing integrated assessment models show rising costs. For example, updates to the DICE model have led to increased SCC values (Nordhaus and Moffat 2017). Recent studies using the PAGE model generate higher net present values of damage (Chen, Liu, and Cheng 2020). Similarly, recent analysis using the CLIMRISK model (Estrada and Botzen 2021) report that the consequences of unabated climate change could be substantially higher than previously estimated. The consideration of uncertainty in integrated assessment models also influences results, increasing mean impacts (Lemoine 2021) and adaptation costs (de Bruin and Krishnamurthy 2021).

The second factor is that additional methods have emerged for assessing the economic costs of climate change. There are now more studies that use computable general equilibrium models, which indicate higher estimates than integrated assessment models studies (Kompas, Pham and Che 2018, Bosello *et al.* 2021), as well as econometric-based studies (notably Burke, Hsiang and Miguel 2015; Burke, Davis and Diffenbaugh 2018), which present much higher values, partly due to consideration of climate change impacts on growth rates, as well as output.

The costs of adaptation in many global, national and sectoral studies are also increasing, relative to earlier studies. For example, a recent estimate of the global costs of adaptation for developing countries, using a similar approach to the AGR 2016, indicates costs in a similar range but with higher adaptation costs in high-emissions scenarios after 2030 (Chapagain *et al.* 2020). Similarly, studies using global integrated assessment models have estimated higher adaptation costs (in line with the higher damage from the AGR). For example, Markandya and González-Eguino (2019) provide new integrated assessment model estimates of US$ 411 billion in 2030, rising to US$ 1,088 billion by 2050 (for high damages, low discount rates).

The same trend is arising in sectoral studies. There have been several studies on the costs of coastal adaptation.

Nicholls *et al.* (2019) provide an update to previous coastal modelling studies, taking into account the investment costs of a coastal adaptation strategy applied globally throughout the twenty-first century. Estimated total defence costs were significantly higher than previous estimates, with rising costs from maintenance and new capital investment (however, it should also be noted that rising costs can be due to socioeconomic factors, as well as climate change). Similar findings emerge from other global coastal adaptation studies such as Schinko *et al.* (2020), Tiggeloven *et al.* (2020), Brown *et al.* (2021) and Tamura *et al.* (2019). In terms of river flood adaptation, Ward *et al.* (2017) show that global estimates of costs vary significantly, depending on whether the objective for adaptation is based on economic optimization, maintaining constant relative risk or maintaining constant absolute risk. Their research finds that adaptation costs increase significantly (several fold) across these three alternatives. Adaptation in the water sector could cost US$ 79 billion per year throughout the century, even in the most optimistic scenario, and US$ 115 billion under an extreme scenario (Straatsma *et al.* 2020). In the agricultural sector, adaptation to maintain the same yields of four key crops has been estimated at between US$ 53 billion and US$ 78 billion per year, depending on the warming scenario (Iizumi *et al.* 2020), while Baldos, Fuglie and Hertel (2020) estimate that around US$ 10 billion to US$ 70 billion of additional annual investment is required between 2020 and 2040 in agricultural research and development to offset the projected losses in crop yields.

The studies and the costs they report are influenced by the decision approach used (for example, whether adaptation is designed to maintain current protection levels or be economically optimal). This affects the level of residual damage after adaptation, as well as the costs and benefits (Nicholls *et al.* 2019; Ward *et al.* 2017; Tiggeloven *et al.* 2020).

Annex 4.B: Challenges 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.

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 the measurement of 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 funders 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 2011). 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 official development assistance. 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.

Coverage of sectors and sources: While good coverage exists around international concessional public finance flows (predominantly ODA from OECD countries), much less 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 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.

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

Annex 4.C: Methodology for calculating finance flows from 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 period between 2011 and 2019. 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.

Table 4.C.1 Bilateral and multilateral funders in the analysis

Bilateral funders	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, the United States of America
	Non-Annex II countries	The Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, South Korea, the United Arab Emirates
Multilateral funders	Multilateral Development Banks	African Development Bank, African Development Fund, Asian Development Bank, Asian Infrastructure Investment Bank, Caribbean Development Bank, Development Bank of Latin America, European Investment Bank, European Bank for Reconstruction and Development, IDB Invest, Inter-American Development Bank, International Bank for Reconstruction and Development, International Development Association, International Finance Corporation, Islamic Development Bank
	Multilateral climate funds	Adaptation Fund, Climate Investment Funds – Strategic Climate Fund, Global Environment Facility Least Developed Countries Trust Fund (LDCF), Global Environment Facility Special Climate Change Trust Fund (SCCF), Global Environment Facility General Trust Fund, Green Climate Fund (GCF)

Methodologies for reporting climate-related finance

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 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 4.D). The methodology is also increasingly being used as a basis for reporting on climate finance by Annex II Parties (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).

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 only reports the portion of the transaction that specifically targeted climate change, instead of the full value of each transaction. In the analysis, figures reported using the two different methodologies were taken at face value, as reported to the OECD DAC.

Alongside MDBs, a number of other development finance institutions are also relevant when it comes to adaptation action. The International Development Finance Club (IDFC), a group of 23 regional and national development finance institutions, programmed US$ 185 billion in climate finance in 2019, of which US$ 19 billion was estimated to flow to adaptation (IDFC 2020). Financing volumes reported by these multilateral institutions cannot be directly compared with the adaptation-related multilateral flows reported by Annex II Parties as these institutions also receive contributions from non-Annex II Parties and do not only fund activities in developing countries.

Annex 4.D: Gender in adaptation finance

The biennial reports submitted by Annex II Parties to the UNFCCC Secretariat do not systematically include data on gender, despite gender-responsive public finance being more effective and efficient (United Nations Development Programme [UNDP] 2018). For adaptation finance, this will mean projects and programmes taking into account the gender dynamics of activities such as food production. The UNFCCC Gender Action Plan, which was approved at COP23, included the use of gender-responsive finance as a core tool for implementation (UNFCCC 2017). While a number of multilateral climate funds are increasingly taking into account gender considerations in their governance and implementation (Schalatek 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).

Annex 4.E: New developments in private-sector financing for adaptation

The physical risks of climate change are increasingly recognized as a financial risk (Task Force on Climate-related Financial Disclosures 2017; Network for Greening the Financial System 2019). This is leading to increased private-sector interest in managing potential climate risks. However, in contrast to mitigation, there are less financial investment-ready (bankable) adaptation projects, even in developed countries (Mortimer, Whelan and Lee 2020). This often reflects a difference between the high societal benefits of adaptation (the economic return, as identified in cost–benefit studies) versus the likely private financial return, as it is harder to generate revenue streams for adaptation (Khosla and Watkiss 2020). Scaling-up has also been hampered by barriers to private-sector adaptation, especially in developing countries, including around information asymmetry, uncertainty and the timing of benefits and revenue flows (UNEP 2016b). However, the last two years have seen considerable innovation in this area.

First, there is the emerging use of private investors and financial markets to raise finance for adaptation. There is high demand for green bonds and, while these have focused on mitigation to date, there is growing interest and early examples for adaptation. For example, the European Bank for Reconstruction and Development (2019) issued a bond dedicated to climate resilience in late 2019, which raised US$ 700 million to finance existing and new climate resilience projects. Another example is the Blue Forest Resilience Bond, which is funding a restoration project worth US$ 4.6 million and which includes the mitigation of wildfire risk in the Tahoe National Forest, California. There are also other potentially relevant bond instruments, including catastrophe bonds and resilience–catastrophe bonds, which encompass the promotion of investment in infrastructure that mitigates risk. However, it is important to highlight that bonds are a debt instrument: the value of the bond is paid by investors to the issuing entity in exchange for guaranteed repayments. This requires avoided costs or increased revenues from bond-financed activities, meaning that appropriate targeting is critical.

Second, there is growing private-sector involvement in financing and delivering adaptation, with a range of new instruments and approaches developed to encourage this. These often seek to use blended finance, which combines public and private-sector finance, normally using the former to address barriers to help unlock investment from the latter. This can help with the development of ideas or attracting private investment at early stages (with challenge funds or seed funding) and help to de-risk investment by offering concessional lending, guarantees or even equity. It is also possible to develop portfolios that can help merge project elements with higher and lower revenues (including mixed mitigation and adaptation projects).

There is a growing number of examples in this space. There has been a greater focus on encouraging private-sector investment in adaptation by multilateral funds, such as the initiatives from the Green Climate Fund (2018). There are also a number of innovative mechanisms and approaches, such as the Climate Resilience and Adaptation Finance and Technology Transfer Facility (CRAFT), a commercial investment vehicle that uses blended finance to expand the availability of technologies and solutions for climate adaptation by investing in companies with an accompanying technical assistance facility. It is considered the first private investment vehicle dedicated to investment in adaptation and includes an impact measurement system for assessing impact. Further examples include the Restoration Insurance Service Company (RISCO), which targets mangrove protection using revenue streams from insurance-related payments for flood-risk reduction benefits, as well as blue carbon payments (mitigation co-benefits), and the Global Ecosystem-based Adaptation Fund, which provides targeted seed capital to scale up implementation of ecosystem-based adaptation approaches and encourages partnerships with communities and the private sector. Innovative approaches are also being developed for existing instruments, notably for insurance. One of the most frequently cited examples is the development of a parametric insurance of coral reefs in Quintana Roo, Mexico, which covers actions to identify and address damage to reefs after the impact of hurricanes. There are also a wider set of risk transfer and de-risking mechanisms, including post-disaster recovery contingent financing (for example, the PCRAFI for the Pacific risk pool). Several initiatives are also examining how climate adaptation can be included in public–private partnerships (for example, Frisari *et al.* 2020).

To make the most of these opportunities, public finance sources and actors should be encouraged to move towards a more commercial mindset, as well as to encourage the private sector to recognize risks and opportunities for longer-term adaptation. There is a range of actions to facilitate this process, including links to National Adaptation Plans (for example, Green Climate Fund 2018). However, while there are promising developments as mentioned here, the private sector is not a panacea for adaptation and nor will it be able to bridge the adaptation finance gap on its own, due to the challenges outlined above. Private-sector finance will gravitate to opportunities where revenues are highest and risks are lowest, even with public finance de-risking or blending. It will be more challenging to attract private-sector investment in anticipatory adaptation, especially in non-market sectors, and for the poorest and most vulnerable Least Developed Countries. There is also a risk of private investment being promoted due to the lack of public adaptation funding, even when such action is needed (for example, investment in public goods) and the risk that the most vulnerable end up paying for adaptation. Further analysis is required to identify where public finance is most needed and effective in leveraging private finance, as well as where the private sector is unlikely to fill the gap.

Annex 5.A: Expanded information about the data sources used and assessment methodology applied in chapter 5

Data sources

Chapter 5 draws on three data sources that complement each other (see section 5.2). The data for the three funds that serve the Paris Agreement and the data regarding bilaterally funded principal adaptation projects registered in the Organisation for Economic Co-operation and Development (OECD) Creditor Report System have only minimal overlap since they each contain projects from different funding sources. Adaptation actions reported in journal articles can refer to internationally funded projects that are captured under both of these data sources, but such articles account for only a small proportion of the Global Adaptation Mapping Initiative (GAMI) data set. For developing countries, the three data sources will only capture a certain proportion of adaptation projects being implemented with a value above US$ 500,000.[1] This proportion will vary between countries depending on the extent to which countries are able to fund adaptation projects with domestic funding. To illustrate the variation between what is and is not captured by chapter 5's analysis, Box 5.A.1 uses data from the Transforming Social Inequalities through Inclusive Climate Action (TSITICA) research project to estimate the proportion of large adaptation projects captured by the assessed sources for three countries in sub-Saharan Africa.

Assessment methodology for adaptation supported by the top 10 bilateral donors[2]

In contrast to the publicly available project documents from the three funds that serve the Paris Agreement, information on most bilateral donors' adaptation portfolios could only be obtained through the OECD database (the Development Assistance Committee [DAC] Creditor Reporting System) which includes far less detailed descriptions of the respective entries. This has made it impossible to perform some of the analysis conducted in last year's implementation chapter, in particular determining the addressed hazards, the targeted actors, and the consideration of most vulnerable populations and gender aspects (UNEP 2021).

The type of activities supported by bilateral donors extend beyond projects and include, for instance, support to the budgets of international organizations and non-governmental organizations (NGOs). Beyond the financial values captured in chapter 4, we currently do not have ways to aggregate the implementation of non-project-based adaptation support across donors. The quantification of bilateral adaptation support in section 5.3 is therefore limited to projects, and this type of support typically accounts for less than half of their entries on principal adaptation in the OECD database. Hence, only part of the bilateral adaptation support is quantitatively reported in this chapter.

To enable comparison with last year's chapter, only projects marked as "principal objective adaptation" were considered, for which the OECD defines as adaptation being "fundamental in the design of, or the motivation for, the activity" (OECD 2016). To identify relevant projects and filter out possible over-reporting as pointed out, for instance, by Hattle (2021), Soanes *et al.* (2021) and Weikmans *et al.* (2017), we manually screened the entries marked as "principal objective adaptation" in the OECD database and excluded those that clearly did not target adaptation as their primary objective (e.g. projects that focused on mitigation of greenhouse gas emissions, or where adaptation appeared to be only a minor objective). Furthermore, we focused on the top 10[3] bilateral donors on adaptation, which account for almost 90 per cent of the combined financial value of bilateral adaptation support.

1 This cut-off value was chosen in the Adaptation Gap Report 2020 (AGR2020) since almost all projects funded by the three funds that serve the Paris Agreement exceed it except for readiness funds.

2 The methodology for assessing projects supported by funds that serve the Paris Agreement can be found in the Adaptation Gap Report 2020 (UNEP 2021), while information about the methodology applied by the GAMI can be found in the Supplementary Materials of Berrang-Ford *et al.* (2021).

3 These are Japan, Germany, European Union (EU) institutions, France, Netherlands, United States, United Kingdom, Sweden, Switzerland and Korea (in order of the total financial contributions marked as adaptation in the OECD Creditor Reporting System). "EU institutions" means where the European Union acts like a bilateral donor e.g. through the Global Climate Change Alliance Plus (GCCA+) initiative.

Box 5.A.1 Adaptation projects in developing countries per funding source and compared with the data sources used in chapter 5

The TSITICA research project[a] has identified adaptation projects implemented in Ghana, Kenya and South Africa between 2000 and 2020 (table 5.A.1). In contrast to the data sources used in this year's AGR implementation chapter, the TSITICA project includes projects from all international and domestic funding sources. This enables a comparison between the number of projects identified by TSITICA and by this chapter, to determine the extent to which the latter captures the total number of adaptation projects. The comparison indicates that in countries with very limited domestic resources, such as Kenya and Ghana, the majority of larger adaptation projects are likely to be supported by the three funds that serve the Paris Agreement or by the top 10 bilateral donors (these sources account for 81 per cent and 44 per cent in Kenya and Ghana, respectively). In more advanced economies such as South Africa, however, the data suggest that a significant proportion of larger adaptation projects are supported by domestic sources of finance (e.g. government budgets), and will therefore not be captured by the data sources used by this chapter. That said, South Africa's reported figures might have been influenced by the fact that it has a national database[b] of adaptation actions, which facilitated the identification of domestically funded adaptation projects.

Table 5.A.1 Number of adaptation projects per country and funding source

Country	Adaptation projects identified	Funding source			
		Funds that serve the Paris Agreement or one of the 10 largest bilateral donors	Other international sources of finance[c]	National and subnational budgets[d]	Non-state domestic sources[e]
Ghana	94	44%	56%	0%	0%
Kenya	48	81%	0%	19%	0%
South Africa	168	17%	19%	50%	14%

a Two of the African Research Universities Research Alliance centres of excellence, Climate and Development (ARUA-CD) and African Centre of Excellence for Inequality Research (ACEIR) have a joint ongoing project called Transforming Social Inequalities through Inclusive Climate Action (TSITICA). See www.acdi.uct.ac.za/transforming-social-inequalities-through-inclusive-climate-action-tsitica.

b See https://ccis.environment.gov.za/nccrd/#/.

c Other international sources of finance include multilateral sources of finance (e.g. multilateral development banks and multilateral funds that do not serve the Paris Agreement), international NGOs, and other bilateral donors outside the 10 largest donors.

d Includes finance supplied by state-owned corporations (e.g. parastatals).

e Other domestic sources of finance include the domestic private sector and local NGOs.

Annex 5.B: Recent developments in assessing adaptation results

Adaptation results can be measured in different ways, for different purposes (Leiter 2017) and at different levels (from community initiatives – e.g. McNamara *et al*. 2020 – to projects – e.g. Leiter 2018 – or at the national level – Brooks *et al.* 2019; UNEP 2017). Therefore, there is no one-size-fits all approach. This annex presents recent developments in the measurement of resilience and climate risk.

Measuring resilience

Recent research highlights that the level of resilience of people and households is highly dynamic and can fluctuate within short periods of time, due to factors such as extreme weather events. Accordingly, the traditional way of assessing resilience once per year or just at the start and end of an intervention, might fail to account for the real impact on people's lives and could even lead to falsely proclaiming improvements in resilience (Jones and d'Errico 2019; Jones and Ballon 2020). Furthermore, resilience indicators may have limited utility as predictors of future outcomes, particularly outcomes associated with hazards outside the range of historical experience.

The use of resilience indicators could be improved by ensuring they are grounded in a sound contextual understanding of the factors that enable people and systems to anticipate, avoid, plan for, cope with, recover from and adapt to climate hazards, and by scrutinizing whether the factors that enhance resilience to familiar intensities and types of hazards are likely to confer resilience to potential future risks.

Assessing risk reduction in the event of climate hazards

A more tangible measure of adaptation success is the extent to which adaptation reduces actual risk and prevents harm to people and systems when they are exposed to climate hazards. This risk reduction might be assessed by measuring adverse outcomes associated with climate hazards and determining whether these are lower than in a "no-adaptation" case (e.g. using control groups or counterfactuals).

Brooks *et al.* (2019) highlight the potential for developing counterfactuals using quantitative approaches based on statistical relationships between climate and well-being variables in certain contexts. Quantitative approaches, which are explored further by Barrett *et al.* (2020), can examine whether losses from a hazard of a particular magnitude are lower than would be expected without adaptation, or whether adaptation has increased thresholds beyond which impacts are usually evident (e.g. temperature thresholds associated with step-changes in mortality in urban environments). Brooks *et al.* (2019) also present a simple typology of adaptation outcomes to aid in the assessment of adaptation effectiveness. This typology identifies simple scenarios in which climate and well-being data can be used to identify where adaptation has improved well-being in the face of intensifying climate hazards, where it has made little or no difference, where it has failed to improve well-being but reduced the level of harm, where it has undermined well-being, and where counterfactuals are required to assess adaptation results.

Improving adaptation programming through inclusive theories of change

While assessment of risk reduction is challenging, more can and must be done to transition adaptation programming towards effective risk reduction. This requires improvements in how adaptation interventions address climate risk contexts and the factors that drive vulnerability, and a move from assessment of outputs to assessment of outcomes and impacts, including after the initial project has finished. For example, the Technical Evaluation Reference Group of the Adaptation Fund (AF-TERG)[1] is currently piloting a method to evaluate sustainability and resilience of projects three to five years after project completion.

The design and interpretation of outcome indicators requires adaptation goals to be clearly articulated. It also requires a sound understanding of climate risk contexts and the pathways via which climate hazards affect target populations and systems, and how differential impacts on different groups or people mediated by evolving vulnerability may evolve in the future. Theories of change are one way of linking adaptation activities with intended risk reduction via the effects of those activities on the factors that influence vulnerability and resilience (Bours, Mcginn and Pringle 2014; Oberlack *et al*., 2019). The accuracy of theories of change can be enhanced through inclusive development involving the intended beneficiaries and other stakeholders. Importantly, the assumptions made in the theory of change (i.e. how adaptation is expected to work) need to be regularly reviewed and updated based on emerging experiences and feedback from implementation.

1 See www.adaptation-fund.org/about/evaluation/.

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