ICAT Initiative for Climate Action Transparency


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Assessing climate change-driven losses and damages

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Executive summary

Loss and damage has become a most prominent issue in intergovernmental climate change negotiations, against a background of national governments facing increased difficulties to manage the impacts of climate change that occur despite or in the absence of adaptation action. Assessing those impacts, both retrospectively and prospectively, is a precondition for efficiently and effectively managing losses and damages. This document provides guidance on how to do so.

Losses and damages can be reparable or irreparable. These types of losses and damages are termed, respectively, 'economic loss and damage' (primarily damages), and 'non-economic loss and damage' (primarily losses). The document provides separate guidance for each type of loss and damage. In both cases, a sectoral approach is recommended, as opposed to attempting to conduct an all-encompassing assessment.

Regarding damages, the assessment can be structured around three sets of activities. First, distinguishing between damages driven by climate change versus damages driven by other factors, such as natural hazards; and distinguishing between direct versus indirect damages, because the latter can be more important than the former. Second, calculating counterfactuals, to obtain a reference against which the magnitude of the damages assessed can be interpreted. Third, identifying the level of detail that can be afforded, considering available resources, and identifying and calculating indicators that suit the level of detail chosen. For the sake of efficiency, all three sets of activities ought to be integrated in related efforts, notably those associated with assessing disaster-related risks beyond those caused by climate change.

BOX 2.1

"Damage" categories

Infrastructure

- water and sanitation
- power generation
- transport
- telecommunications
- education
- health
- housing

Economic sectors

- agriculture and forestry
- manufacturing
- services
- tourism

Regarding losses, the assessment must start by clarifying framing issues related to what loss entails, what the objectives of the assessment are, and what the drivers of loss are. The actual assessment can be structured around four sets of activities. First, drawing on desk studies and expert interviews, national- or even subnational-level indicators are developed. Second, supplementing the desk studies and expert interviews referred to above, semi-structured interviews and focus group discussions, among other social-science data-collection tool, are used to gather the evidence needed to fine tune the indicators. Third, locations where in-depth assessments can be conducted are identified. Potentially relevant locations can be identified using the data available from disaster monitoring programmes and meteorological records for retrospective assessments, and downscaled projections and impact model outputs for prospective assessments. Desk studies, expert interviews and, if warranted, semi-structured interviews can help confirm the selection of locations. Fourth, the sample from which in-depth data will be collected is determined, and qualitative and semi-quantitative data are collected. It is advisable to use two data collection approaches, relative to the sample considered: all members of one or two small communities (the "deep and narrow" approach), and a representative selection of members from a large number of communities (the "broad and shallow" approach).

BOX 3.1

A categorisation of values

Values have been inventoried and grouped into twenty categories (Tschakert et al, 2019). Drawing on this work, a five-item categorisation has been proposed, which is arguably more usable in a public policy context (McNamara, Westoby and Chandra, 2021):

- Human mobility and territory
- Cultural heritage and indigenous knowledge
- Life and health
- Biodiversity and ecosystem services
- Sense of place and social cohesion

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Part I

Assessing loss and damage

Climate change impacts affect both natural and human systems as defined in Box 1.1. In the context of human systems, the Intergovernmental Panel on Climate Change defines adaptation as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC, 2022).

Climate change impacts avoided through adaptation are referred to as avoided impacts, whereas impacts that occur despite adaptation are known as residual impacts. In this document, loss and damage is equated to residual climate change impacts. In other words, this guidance document deals with the impacts adaptation has not sufficiently abated or cannot avoid.

BOX 1

Climate change impacts

> Climate change impacts are "the consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards [...], exposure, and vulnerability" (IPCC, 2022). "Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services [...], and infrastructure" (ibid).

It is worth noting that, in intergovernmental negotiations, loss and damage encompasses a broader set of issues. Indeed, by considering approaches to "avert, minimize and address loss and damage" (UNFCCC, 2016), intergovernmental negotiations effectively bring together avoided impacts ("avert" is a mitigation goal), abated impacts ("minimize" is an adaption goal), and residual impacts ("address" refers to managing loss and damage).

Residual impacts may arise because adaptation measures are insufficient or ineffective. In such situations, residual impacts lead to negative shocks that are reversible or irreversible, but reparable in all cases (Puig, 2022). In this document, this type of residual impacts is equated to "damage". Examples of damages include reduced or lost harvests, and damaged infrastructure, among others.[1]

Alternatively, residual impacts may arise because adaptation limits are exceeded. In such situations, residual impacts lead to negative shocks that are both irreversible and irreparable (Puig, 2022). In this document, this type of residual impacts is equated to "loss". Examples of losses include species extinction, loss of life, impaired human health, or loss of cultural heritage, among others.

This guidance document aims to support policymakers in their attempt to better understand the nature and magnitude of past residual climate impacts, as well as present and future residual climate risks in order to improve the management of losses and damages in subnational to national contexts. The document provides an easily understandable introduction to the underlying framings, concepts, and approaches, but not a step-by-step methodology. This document should therefore be used and understood as the entry point to developing national or subnational loss and damage assessments.

1.1 The rationale for assessing losses and damages

As is the case for most other public policy issues, increasing one's ability to manage both losses and damages is the main reason for conducting loss and damage assessments. In this context, both retrospective and prospective assessments are of relevance: whereas the former makes it possible to understand the challenges posed by residual climate change impacts, the latter are instrumental for designing responses to these challenges.

Most often, national governments lead the design

[1] Note that, despite its phrasing, which includes the notion of 'loss', "lost harvests" are not considered losses: they are considered damages. Indeed, harvests are not goals in themselves and, as a result, a lost harvest admits substitution – for example, in the form of a compensatory payment. Substitution represents the 'reparation' referred to in the definition of damages provided in the main text.

of climate change policies.[2] As a result, assessments aimed at supporting policy design, including assessments of loss and damage, take a national scope (Puig et al, 2019). Nonetheless, cities are increasingly active in assessing losses and damages, even if approaches remain rudimentary, not least because of limited resources (IIED, 2021). To some degree, and compared to their national-level counterparts, city-level assessments are more often driven by the wish to avoid or at least reduce the financial liability that is intrinsic to likely-future residual impacts.

From the point of view of international climate change negotiations, assessments are necessary to inform two types of debates – related to, respectively, loss and damage finance, and non-economic losses. Although negotiations about finance are likely to remain contentious, improved information about the costs of damages, obtained through loss and damage assessments, can only ease these negotiations. Similarly, current efforts to understand how to manage non-economic losses would benefit from more evidence on what those losses entail, which loss and damage assessments can provide.

1.2 Guidance provided in this document

The scientific and grey literatures include guidance on how to assess damages, with some documents providing a great deal of methodological and sectoral detail. To avoid overlapping with this literature, the guidance included in Section 2 of this document focuses on key framing issues (namely, definitions and drivers of damages, direct versus indirect damages, and assessment levels). Nonetheless, Section 2 also includes specific methodological and sectoral suggestions, drawn from the literature referred to above. Simply stated, Section 2 guides the reader on the key design elements of an assessment of damages, and points them to the specialised literature for additional details.

Conversely, there is little guidance available regarding how to assess losses. As such, Section 3 in this document appears to be the first guide on the topic that attempts to cover all aspects associated with the assessment of loss. For this reason, the information included in Section 3 prioritises methodological questions, as opposed to sectoral or thematic applications. As evidence about these applications become available, not least regarding slow-onset events, the guidance provided in Section 3 can be used as a starting point to develop tools that go more in-depth for each individual sector or theme.

[2] Highly decentralized states, where sub-national entities have a great deal of autonomy, constitute exceptions to this statement. With its role of setting common principles applicable to all its member states, the European Union represents a further singularity.

South Africa's loss and damage framework

South Africa represents one of many countries where disasters are reported but no national database on loss and damage has yet been established. Data and information related to loss and damage are fragmented across numerous government departments, sector departments and private sector entities in South Africa. Not only are there various organizations collecting data, but the formats, hazard classifications, spatial and temporal resolution of the data differ substantially between data custodians. This complicates the comparison and integration of the various data sources to get a realistic picture of the true costs associated with weather-related disasters and how this impacts livelihoods. It also impairs an accurate, timely and high-quality monitoring process.

A loss and damage framework for South Africa was therefore developed by the Council for Scientific and Industrial Research (CSIR), as part of the Initiative for Climate Action Transparency (ICAT) Adaptation project, in partnership with the Department of Forestry, Fisheries, and the Environment (DFFE). The purpose of the framework is to guide the country on how it should approach the assessment of impacts from weather and climate-related disasters to ensure an accurate, timely and high-quality monitoring process. The approach followed in developing the loss and damage framework included the review of existing international loss and damage frameworks, defining relevant legislation, sourcing available data on reported damages, losses, and costs of impacts of weather and climate-related disasters as well as consultation with a wide range of data stakeholders and related databases. Key role players in this regard are the South African Weather Services, hosting the Severe Weather Impact Database (SWID), and the National Disaster Management Centre (NDMC). This process allowed for the development of a Loss and Damage framework for South Africa which supports transparency in reporting and developing best practice methodologies that can be utilised as guidance by other countries and for capacity building. The framework is briefly introduced below and in Figure 1.

Loss and damage context: The loss and damage (L&D) framework starts out by setting the context for loss and damage in South Africa, considering questions such as 'what are the main types of hazards that the country needs to deal with', 'where do they occur', 'which hazards are more likely to occur in specific areas', and 'what are the risks of these hazards in future'? The framework also considers loss and damage in context of these hazards, the need to monitor it, existing databases that gather this kind of information in the country, as well as the type of legislation that applies.

Stakeholders involved in loss and damage data collection: The framework aims to pull together all the identified role players involved in reporting on loss and damages, defining their roles and responsibilities, as well as how these stakeholders should collaborate to contribute to a central loss and damage database.

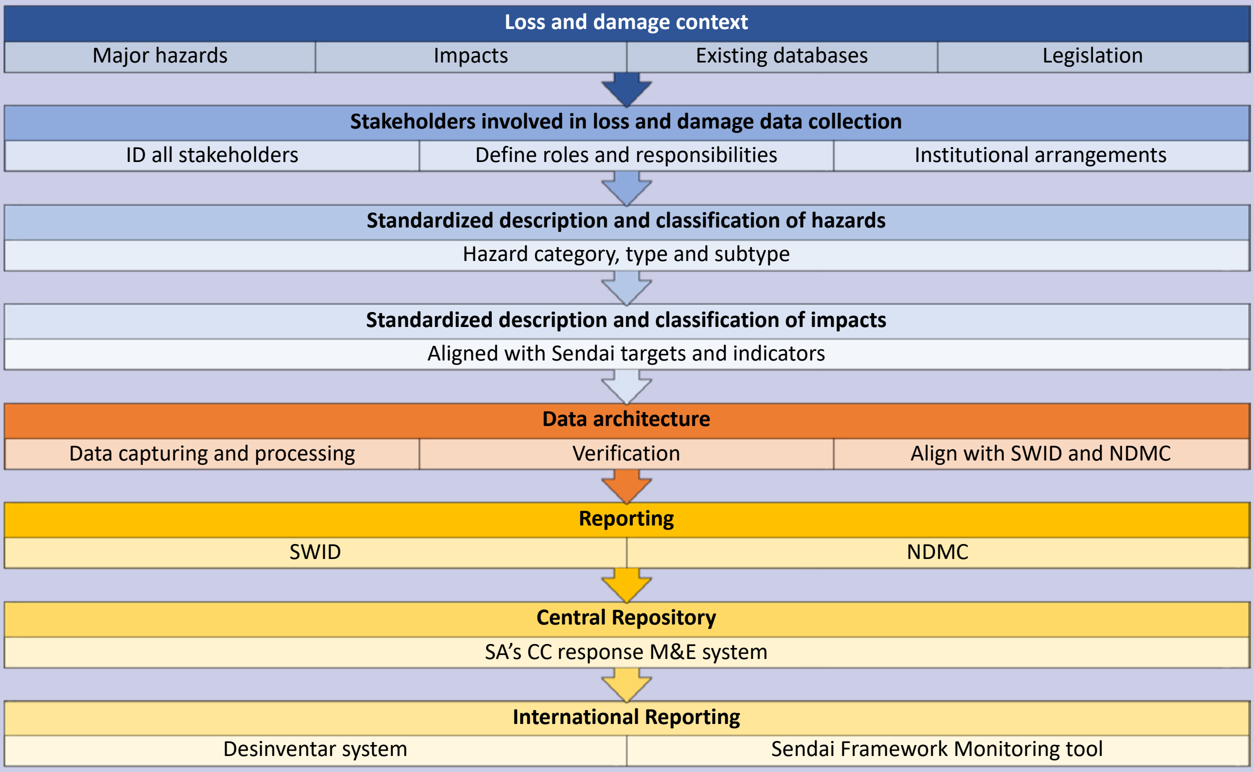
Standardized description and classification of hazards: A very important part of the framework is standardizing the description and classification of hazards. The inconsistent use of various definitions of hazards (e.g. flash flooding versus riverine flooding) makes reporting difficult and leads to discrepancies. The framework suggests a standardized classification of hazards according to the National Disaster Management Centre (NDMC) definitions of types and sub-types.

Standardized description and classification of impacts: In term of impacts, there are specific indicators that are used to assess both the economic and social or human dimensions of loss and damages. The Sendai Framework for Disaster Risk Reduction 2015-2030 was used as guideline for specific indicators and targets.

Data architecture and reporting: This element of the framework considers data capturing and reporting, verification, and alignment with existing national disaster and severe weather databases such as the Severe Weather Impact Database (SWID) of the South African Weather Services (SAWS) and NDMC Declared disasters database. It is important that all new data is aligned with and can be integrated across these databases. Collected data should be verified to ensure that it is of good quality, i.e. the data is based on correct inputs, and is valid and makes sense.

Central repository and international reporting: The L&D framework needs to be integrated and aligned with South Africa's existing climate change monitoring and evaluation (M&E) systems thus minimizing duplication and ensuring optimal utilisation by end-users. This will also support the country in fulfilling its international reporting requirements.

Figure 1 Flow diagram of South Africa's Loss and Damage framework. (See text above for descriptions.)

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Part II

Assessing damages

2. Assessing damages

Damages are residual climate change impacts that lead to reparable negative shocks (Section 1). A reparable negative shock is that which allows for substitution. For example, a bridge washed away by a storm can be rebuilt, and a lost harvest can be replaced by insurance payment. Stated differently, because they both have instrumental value and lack intrinsic value, the damaged bridge and the lost harvest represent damages instead of losses.[3]

Over the years, several categorizations of "damages" have been put forward (WB, 2010 ; ECLAC, 2014). With small variations, they all cover two sets of issues: damages to different types of infrastructure, and damages to economic activities (Box 2.1).[4]

BOX 2.1

"Damage" categories

Infrastructure	**Economic sectors**
▪ water and sanitation	▪ agriculture and forestry
▪ power generation	▪ manufacturing
▪ transport	▪ services
▪ telecommunications	▪ tourism
▪ education	
▪ health	
▪ housing	

Next to the two sets of issues listed in Box 2.1, most categorizations of "damages" include a category related to human life and, in some cases, human health. Since human life and human health cannot be substituted, and in contrast to the said categorizations, this document considers that negative impacts on human life and human health constitute losses (Section 3), not damages.

A related point concerns the terminology used to refer to reparable negative shocks. In many instances, damages to infrastructure are referred to as "damages", whereas reductions in economic output are referred to as "losses". Although the latter usage is intuitive and linguistically correct, it is inconsistent with the definition proposed in this document, which reserves the word "loss" to irreparable negative shocks (Section 1).

2.1 Framing the assessment

From the definition of "damages" used in this document (Section 1), it follows that assessing damages entails determining the extent to which climate change impacts bring about the need for reconstruction or rehabilitation. Doing so involves a judgement call, which will be more or less straightforward, depending on two sets of parameters:

- **The severity of the impact.** For example, a small flood may disrupt the activity in a school, but not enough for the affected community to consider that the flood brought about damages to the school. Conversely, a major landslide that blocks a main road for days will no doubt be considered to have damaged the local economy.

- **The tolerance level of the population impacted**. In drought-prone regions, water restrictions are likely to be accepted more readily by the population, which will be better prepared to adjust to them, compared to a region where such shortages are rare and, therefore, the affected communities will equate modest water restrictions to a damage caused by drought. A similar

3 It is worth noting that, in some instances, instrumental and intrinsic values will not be mutually exclusive. Two examples serve to illustrate this point. Centuries' old bridges that remain in use, such as Iran's Dezful bridge, carry both instrumental and intrinsic (heritage-related) value. In some cultures, the same is true for a harvest, which is associated with a man's ability to discharge his duty toward his family, something that cannot be substituted by a financial compensation for the lost harvest.

4 Developed under the auspices of the United Nations' Department of Economic and Social Affairs, the International Standard Industrial Classification of All Economic Activities (or ISIC for short) provides definitions for all items listed in Box 2.1. Although some national governments have adopted their own definitions, most such national definitions are compatible with the ISIC definitions (UN, 2008), thus making cross-country comparisons possible.

argument could be made for coastal communities in regions where coastal flooding is commonplace, compared to coastal communities elsewhere.

- The two sets of parameters described above can be synthesized through one proxy: irrespective of the availability of funding, if expenditures must be incurred, then damages can be said to have occurred. It is worth noting that money is not the only currency through which the size of an expenditure can be measured: in poor areas, a person's work and time may be the most relevant currency, as is the case in communities where damages are repaired using readily available materials and the skill and effort of community members.

- Continuing with the proxy referred to above, it is necessary to consider carefully why expenditures must be incurred, and what for. The importance of these two issues is described in the following paragraphs.

Drivers of damages

In addition to climate change, drivers of damages include natural hazards, conflict and neglect, among others causes (UN, 2015). Although damages are rarely driven by one single cause, most often one cause acts as the primary driver. For this reason, determining the primary driver is generally easy. Doing so is important, because it helps articulate both preventive and reactive responses to damages.

A corollary to the previous statement is that, from the point of view of climate change policy planning and design, an assessment of damages should only include damages that are primarily driven by climate change impacts. Notwithstanding, such an assessment should consider feedback loops between drivers, notably in the context of climate change- and natural hazard-driven damages.

Direct versus indirect damages

Whereas "direct damages" refers to the need for reconstruction or rehabilitation brought about by residual climate change impacts (Section 1), "indirect damages" refers to the negative impacts on communities that arise from disruptions associated with "direct damages". Indirect damages can be clustered in three groups (Box 2.2): gender-driven regressive distributional impacts, adverse macro-economic impacts, and spill-over effects to other sectors.

With regard to the various issues that fall under each of these three groups, methods to assess changes in the status quo are relatively well established (ECLAC, 2014). However, determining the extent to which changes in the status quo arise as a result of direct climate change impacts, as opposed to another cause – that is, determining the extent to which those changes constitute indirect climate change impacts – is far from straightforward. To do so, purpose-developed assessments are required, structured around interviews and semi-quantitative surveys. These assessment tools can also help appraise both the magnitude of the impact and the extent to which it departs from regular conditions.

BOX 2.2

Indirect impacts

Climate change-driven damages aggravate two types of **gendered regressive distributional impacts,** namely lack of economic independence and excess burden of domestic work. Other negative impacts, such as increased fatality rates compared to men, are not considered in this chapter, as they constitute losses, not damages.[5]

Adverse macro-economic impacts manifest themselves through three interlinked developments. First, foregone tax revenue and strained public finances. Second, reduced economic activity and, through inflation, increased consumer prices, which may fuel unemployment and reduce average income levels. Third, unbalanced external accounts, as a result of increased imports (due to temporary domestic shortages), and decreased tourism revenue.

Spill-over effects to other sectors simply refers to the decreased economic activity caused by disruptions in sectors affected by direct impacts, whether they are economic sectors or infrastructure-related sectors (Box 2.1). In most cases, disruptions spread through supply chains.[6]

2.2 Counterfactuals

As is the case with most public policy issues, a counterfactual is an indispensable aid to the process of assessing and managing damages. Simply stated, counterfactuals provide references against which the magnitude of damages can be interpreted.

For present-day damages, historical data constitutes a valid counterfactual. In these cases, long-term (thirty years, if possible) averages for the relevant indicator can be used. Conversely, for likely-future damages projections will be needed (Box 2.3). It is worth noting that, irrespective of the forecasting method chosen, and to a greater or lesser extent, projections will in all cases draw on historical data.

For some types of damages, the data required to calculate a counterfactual is generally available. For example, agricultural surveys, which are routinely updated annually or biannually in most countries, provide the data required to put into perspective losses in agricultural output. However, for many types of damages, data is likely to be lacking. Examples include damages to sectors such as education and health (Box 2.1).

When data is lacking, it is advisable to resort to standardised data from comparable countries. For example, for cities of similar size, data from Bangladesh may be used as a reference in Cambodia, a country with a comparable human development index that is subject to similar climatic stressors. Standardised data – for example, number of hospital admissions during heatwaves as a share of the total population in the relevant age bracket – is far more useful than metrics expressed in absolute numbers. Similarly, compared to single-year data points, multiple-year time series are especially useful.

[5] Increase fatality rates arise because of customs such as traditional dress codes and norms against teaching women to swim. Indeed, compared to men, women (and children) are 14 times more likely to die in a climate change-driven disaster (UNDP, 2016).

[6] Spill-over effects and reduced economic activity are two mutually reinforcing types of indirect impacts. As such, establishing causation is of little interest. Instead, it is more useful to focus on clearly separating the two, to avoid double-counting. A pragmatic approach to separating both issues involves defining “spill-over effects” as the indirect impacts brought about by disruptions in supply chains caused by a (temporary) physical barrier, such as a blocked road. In contrast, economic impacts in one sector arising because of reduced economic output in other sectors can be considered “adverse macro-economic impacts”.

BOX 2.3

Forecasting counterfactuals

As stated above, assessing damages entails determining the extent to which climate change impacts bring about the need for reconstruction or rehabilitation. Therefore, to assess likely-future damages, forecasts are needed of the relevant counterfactual – namely, the status of a given socio-economic condition when that condition is not subject to the impacts of extreme climatic events, and thus neither reconstruction nor rehabilitation are needed. For example, for a given crop and future year, a counterfactual of agricultural output should characterise the level of production of that crop, taking productivity increases and climate change into account but excluding likely-future extreme events.[7] Using this counterfactual as a reference, projections of decreases in production due to likely-future extreme events can be put into perspective.

Over the past few decades, different methods have been developed and used to prepare the forecasts that underpin the counterfactuals referred to above. Five types of methods can be distinguished: econometric methods, statistical methods, analogue methods, cause-and-effect prediction methods, and heuristic methods. Describing these methods is beyond the scope of this document, but they are cited here to underline two points. First, compared to long-term forecasts, regularly updated short-term forecasts are always a preferable option. Ideally, short-term forecasts should be produced using two or more of the types of methods listed above, to explore some of the uncertainties associated with the forecasts. Second, for long-term forecasts heuristic methods (the fifth type of method listed above), which rely on expert judgement, is the preferable option. Expressing the estimates as probability distributions is especially relevant for long-term forecasts.

2.3 Conducting the assessment

Since damages occur at the level of individual assets, a national-level assessment of damages could be built from the bottom up, by adding up assessments of damages occurred at the level of individual assets (Box 2.4). In practice, however, lack of data at the level of individual assets means that, in most cases, assessments will be built from the top down, by comparing aggregated data of actual (or likely-future) damages with aggregated counterfactuals (Section 2.2) that describe past (or likely-future) conditions.

[7] A second counterfactual could be defined as “likely conditions in the absence of anthropogenic climate change impacts”. Such a counterfactual speaks to the benefits of adaptation.

BOX 2.4

Bottom-up assessments

Individual assets can be classified in two groups, as per the following two criteria. First, assets that are associated with a business registration record, such as a farm or an industrial plant. Although these assets will in many instances be located next to similar assets, all of which may be affected in similar ways by climate change impacts, the decision to assess damages will be made by each individual owner. As such, there is no certainty that assessments of climate change-driven damages will be conducted for all similar assets in a location, let alone in a comparable way. Second, assets that are not privately owned, such as schools, hospitals and other types of infrastructure. In these cases, both the decision to assess damages and, the case being, the assessment itself will be centralised by a public entity, such as a local authority. Although resources are likely to be more modest, compared to those of businesses, assessment efforts by public authorities are likely to place greater emphasis on comparability.

Any such bottom-up assessments are likely to be conducted before and even independently from economy-wide top-down assessments, if any. The latter can usefully draw on the former, especially when assessment programmes are in their early days of development. Similarly, the former can facilitate their eventual integration in the latter by adopting the main principles in the Sendai Framework for disaster risk reduction (UN, 2015).[8]

[8] Through its Global Education and Training Institute, the United Nations Office for Disaster Risk Reduction offers training programmes targeting national and sub-national governments. Drawing on this and related resources, national governments can increase awareness about the Sendai Framework among local authorities, the private sector and non-governmental organisations.

2.3.1 Assessment levels

Against this background, it seems sensible to approach economy-wide top-down assessments through a framework based on multiple layers, each encompassing progressively more detailed assessment data (EC-JRC, 2015). The following paragraphs describe the first and second layers from the top in such a framework. One or several additional layers can be added, to expand the level of detail afforded.

First data layer

Intended to provide highly aggregated information, the top data layer consists of a quantitative (or semi-quantitative) assessment, collected separately for each of the items listed in Box 2.1. The assessment is broken down by geographic region and activity:

- **Geographic region**: It is recommended to use the geographic regions included in ISO-3166-2 (ISO, 2020), which are comparable across countries from a governance viewpoint. For example, in Argentina ISO-3166-2 defines 1 city and 23 provinces, whereas in Cameroon it defines 10 regions.

- **Activity**: It is recommended to use the activities listed under "Division" in the ISIC classification (UN, 2008). For example, under "Section F", encompassing "construction", ISIC lists three activities (labelled "Divisions"), namely "construction of buildings", "civil engineering" and "specialized construction activities".

Including both "state" and "economic impact" indicators (Section 2.3.2) is highly encouraged, as is the use of counterfactuals (Section 2.2). Similarly, the use of a pedigree score is greatly recommended (Box 2.5).

Second data layer

Whereas the first data layer includes aggregated information only, the second data layer includes additional information, captured through a much broader range of indicators. Nonetheless, and compared to the first data layer, the second data layer keeps the same geographic and activity breakdowns.[9]

The indicator lists referred to below (Section 2.3.2) include a large number of potential indicators for inclusion in the second data layer. The final choice of indicators will depend on both relevance and feasibility criteria. It is worth noting that, for the same region and activity type, and notwithstanding few exceptions, relevance criteria are likely to vary across hazards: the indicator that will be relevant in the context of, for example, a flood is unlikely to be relevant in the context of, for example, a heatwave. The second data layer also includes indirect impacts (Box 2.2). Ideally, indirect impacts are not only assessed individually, but also with regard to the relative contribution that each direct impact makes on a specific indirect impact. Doing so helps prioritise prevention measures – namely, by placing heightened effort on the activities that result in the larger combination of both direct and indirect impacts.

BOX 2.5

Pedigree scores

The concept of "pedigree" originates in seminal work by Funtowicz and Ravetz (1999), aimed to manage and communicate uncertainty in scientific assessments used to inform policy design. Weidema and Wesnæs (1996) adapted the concept for use in environmental assessments.

Simply stated, a pedigree score is a data quality descriptor, expressed as a discrete number ranging from 1 (high quality) to 5 (sub-optimal quality). Most commonly, pedigree scores are allocated for five data quality aspects, namely reliability, completeness, temporal correlation, geographical correlation, and further technological correlation.

[9] It is recommended that more detailed geographic and activity breakdowns are left for subsequent data layers. Exceptions to this recommendation are city-level assessments, where the level of detail of the geographic breakdown may need to be increased substantially, and sector-specific assessments, notably for economically important sectors, where the level of detail of the activity breakdown may need to be increased substantially.

2.3.2 Indicators

Top-down assessments are best structured around indicators. Separately for each individual category of damages (Box 2.1), extensive lists of indicators have been compiled (WB, 2010 ; ECLAC, 2014).[10]

In a more or less explicit manner, all indicator lists distinguish between “state” and “economic impact” indicators (OECD, 1994). The former reflect the extent of the changes in the status quo, whereas the latter reflect the economic cost associated with reverting back to that status quo.

For both types of indicators, the definitions provided in the indicator lists referred to above are of relevance across world regions. Stated differently, little or no adjustment is likely to be required for these indicator lists to be usable in most countries. Nonetheless, the datasets required to calculate the indicators may not be available everywhere.

For each individual category of damages (Box 2.1), the following paragraphs give examples of indicators suitable for the first data layer referred to above. These are given for illustrative purposes only, and cover direct impacts only. Comprehensive lists of indicators, covering both direct and indirect impacts, can be found elsewhere (WB, 2010 ; ECLAC, 2014).

Water and sanitation

- “State” indicator: Days during which capacity is expected to be reduced by ten percent or more, calculated separately for (i) drinking water, (ii) sewage and (iii) garbage collection infrastructure.
- “Economic impact” indicator: Financial costs, calculated separately for (i) extra costs arising from temporary solutions such as water distribution trucks, and (ii) repair costs.

Power generation

- “State” indicator: Reductions in generation capacity relative to regular levels, calculated separately for (i) generation facilities and (ii) transmission and distribution systems.
- “Economic impact” indicator: Financial costs, calculated separately for (i) foregone revenue and (ii) repair costs.

Transport

- “State” indicator: Reductions in transport volume capacity relative to regular levels, calculated separately for (i) highways and trunk roads, (ii) provincial roads and (iii) bridges and viaducts.
- “Economic impact” indicator: Financial costs, calculated separately for (i) infrastructure repair costs and (ii) additional costs incurred due to alternative freight routes.

Telecommunications

- “State” indicator: Days during which capacity is expected to be reduced by ten percent or more, calculated separately for (i) wired networks and (ii) wireless networks.
- “Economic impact” indicator: Financial costs, calculated separately for (i) temporary solutions such as mobile antennas and (ii) repair costs.

Education

- “State” indicator: Children-days during which schools were closed, by age bracket, and distinguishing between (i) rural and (ii) urban schools.
- “Economic impact” indicator: Financial costs, calculated separately for (i) reconstruction and rehabilitation and (ii) renting of temporary alternative premises.

Health

- “State” indicator: Decrease in healthcare output, defined as the quantity of healthcare, quality-adjusted, relative to regular levels, calculated separately for (i) emergency care, and (ii) outpatient consultations.
- “Economic impact” indicator: Financial costs associated with repair and rehabilitation, calculated separately for (i) rural and (ii) urban healthcare facilities.

[10] Issue-specific lists of indicators also exist, such as one for agriculture, prepared by the Food and Agriculture Organization of the United Nations (FAO, 2020).

Housing

- “State” indicator: Floor area destroyed, distinguishing between (i) insured and (ii) uninsured dwellings.
- “Economic impact” indicator: Financial costs, calculated separately for (i) privately funded reconstruction and rehabilitation, and (ii) publicly funded temporary shelters.

Agriculture and forestry

- “State” indicator: Reduced agricultural output relative to regular levels, calculated separately for (i) crops, (ii) livestock and poultry, (iii) fisheries, and (iv) forests.
- “Economic impact” indicator: Financial costs, calculated separately for (i) insured and (ii) uninsured agricultural output.

Manufacturing

- “State” indicator: Days during which output was reduced by ten percent or more, distinguishing between disruptions that arise from damages in (i) buildings and facilities, (ii) machinery and equipment, (iii) furnishings, and (iv) inventories.
- “Economic impact” indicator: Financial costs, calculated separately for (i) insured and (ii) uninsured plants.

Services

- “State” indicator: Floor area affected, distinguishing between (i) micro enterprises, (ii) small businesses and (iii) franchises.
- “Economic impact” indicator: Financial costs, calculated separately for (i) foregone revenue and (ii) repair costs.

Tourism

- “State” indicator: Days during which output was reduced by ten percent or more, distinguishing between disruptions that arise from damages in (i) tourism facilities, (ii) furnishings, (iii) equipment and (iv) other assets.
- “Economic impact” indicator: Financial losses, calculated separately for (i) hotels and (ii) tour operators.

2.4 Institutional considerations

Under the auspices of the Sendai Framework for Disaster Risk Reduction (UN, 2015), the following guidance has been developed (UNDRR, 2018): minimum standards and metadata for disaster-related data, statistics and analysis; and methodologies for the measurement of indicators and the processing of the associated statistical data. Because the Sendai Framework refers to all types of disasters, whether or not climate change is the main driver, this guidance can be used in the context of climate change-driven damages.

When using the above guidance in a climate change context, it is important to note that the Sendai Framework places substantial emphasis on the hazard element of risk, as opposed to placing it on its vulnerability element (Kelman, 2015). Regarding the indicators referred to in the previous paragraph, this emphasis constitutes an implicit bias, in that the influence that society can exert over vulnerability is comparatively larger.

More generally, it is advisable for national governments to explore how to optimise, from the perspective of climate change-driven damages, the monitoring mechanisms they have set up in the context of the Sendai Framework. Specifically, this might mean undertaking three sets of tasks (OECD, 2020):

- Review indicator lists and data collection mechanisms, with a view to reaping synergies and increasing the overall efficiency of the process.
- Build awareness and capacity within national, sub-national and local governments, possibly through indicator-based planning documents.
- Integrate both disaster-risk reduction and the management of climate change-driven damages into all aspects of legislation.

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Part III

Assessing losses

3. Assessing losses

Losses are residual climate change impacts that lead to irreversible and irreparable negative shocks (Section 1). An irreparable negative shock refers to the loss of what one deems indispensable for one's wellbeing and for which one can find no possible substitute.[11, 12] Thus defined, irreparability and loss are subjective concepts, linked to one's values (Box 3.1).

It follows that an assessment of losses effectively entails determining the extent to which the negative shocks associated with climate change impacts put people's values at risk.[13] Such an assessment is relatively straightforward when it concerns universally shared values, such as the importance of human life. However, the assessment is far more complex regarding values that vary across communities and individuals. Examples of these values are the importance of biodiversity and ecosystem services, or the importance of cultural heritage and indigenous knowledge, among other issues.

BOX 3.1

A categorisation of values

Values have been inventoried and grouped into twenty categories (Tschakert et al, 2019). Drawing on this work, a five-item categorisation has been proposed, which is arguably more usable in a public policy context (McNamara, Westoby and Chandra, 2021):

- Human mobility and territory
- Cultural heritage and indigenous knowledge
- Life and health
- Biodiversity and ecosystem services
- Sense of place and social cohesion

[11] In some contexts, irreparability is referred to as incommensurability. This alternative term helps underscore the idea that "loss" often involves intangible values. For example, the loss of a species to climate change entails both the tangible disappearance of the living organism, and the intangible distress people may experience as a result of such loss.

[12] In this context, what is lost can be any of the following items: living organisms, including human beings; objects; places; experiences; and opportunities (Tschakert et al, 2017).

[13] As a result, knowledge about climate change impacts is a precondition for conducing an assessment of losses.

3.1 Framing the assessment

To a greater or lesser extent, decision-making metrics overlook climate change-driven loss (Barnett et al, 2016). In some cases, loss is considered, but assessments are inadequate and response measures are insufficient or absent (Box 3.2). More frequently, however, the decision-making process neglects loss altogether.

BOX 3.2

A preventable loss?

In 2016, Australia's Queensland state government reported the extinction of *Melomys rubicola*, a small rodent species endemic of Australia's Great Barrier Reef. The species lived on the sandy banks of Bramble Cay, a tiny, flat island on the northernmost tip of the Great Barrier Reef. In 2009, a survey team found fewer-than-average individuals, and noted that most vegetation on the island had been washed away, possibly by a storm surge. Subsequent surveys failed to track any individuals. The Queensland state government first, and Australia's federal government in 2019, declared that the species had been lost to climate change. A recovery plan, drafted in 2008 and involving captive breeding, was never implemented for lack of funding.

When public policy does consider loss, and assessments of loss are planned, care should be taken to ensure that the design of the assessment takes the following four issues into account:

- **Epistemologies.** As is the case with other areas of public policy, in an assessment of loss the perspectives of disenfranchised groups may be underrepresented or excluded entirely. Typically, the main disenfranchised groups are minorities – whether they are cultural, ethnic, religious, or linguistic – and, in some cases, women. Failure to include these groups' perspectives leads to an assessment of loss that is incomplete at best and meaningless at worst. Giving these groups a voice often requires that a well-respective entity – for example, a faith-based congregation or an elders' council – intercedes, to break inertias and power imbalances.

- **Definitions**. In a policy context, categorisation of loss is useful, because it makes it easier to identify policy goals and allocate management responsibilities. Unfortunately, in many situations the boundaries between different types of loss are blurry. For example, in the case of culturally important species, biodiversity loss overlaps with cultural-heritage loss. Similarly, loss of human mobility and territory, and loss of sense of place and social cohesion are often intertwined. In these situations, a pragmatic approach is called for, which involves defining boundaries on a case-by-case basis. Such definitions should be arrived at through a transparent process, and the agreed boundaries should be clearly documented and available to all interested parties.

- **Objectives**. The objective sought with an assessment of loss influences the approach to the assessment. Obtaining an overview of loss – whether loss has already occurred or is expected to occur in the future – is the most common objective. Such an objective requires that the assessment focuses on both "hard" and "soft" adaptation limits. In contrast, when delaying and – if possible – preventing loss is the objective of the assessment, all emphasis will have to be placed on mapping "soft" limits to adaptation, and appraising whether the institutional capacities required to act on those limits are available. In addition to ability to mobilise finance, the latter involves human and analytical capacities, and conducive regulatory frameworks.

- **Drivers**. Potentially, the drivers of loss are manyfold. Cultural heritage is a case in point, with loss arising because of conflict, development, neglect, or natural disaster, in addition to climate change impacts. Because no individual driver is more important than the rest, assessments of loss should ideally consider all drivers. Nonetheless, assessments should seek to establish causality – that is, they should pinpoint the extent to which a given driver is responsible for the loss assessed. The lack of information about causality hampers efforts to prevent and manage loss.

3.2 Assessment steps

This section describes the steps that are recommended for an assessment of losses. They are introduced in the order in which they ought to be conducted: developing indicators, collecting data, identifying relevant locations, and selecting data sources.

It is important to note that collecting data is done twice: after the development of indicators and after the selection of data sources. Nevertheless, the methods to collect data are the same and, therefore, they are only described once (Section 3.2.2).

3.2.1 Developing indicators

As mentioned in the opening paragraphs, an assessment of loss entails determining the extent to which the negative shocks associated with climate-change impacts put people's values at risk. For example, a culturally important landscape, such as a glacier, is something most people value and, for this reason, its disappearance would represent a loss for the people who value it. It follows that a list of "what people value" could be used to guide assessments of loss.

Because values vary across individuals and even across communities, comprehensive lists of values are of little use, not least because such lists would be impracticably long. However, typologies of values, which do exist (Tschakert et al, 2019), can help structure an assessment of loss by providing an overview of the types of issues that the assessment should cover.

Table 3.1 Examples of values, by category

Categories of values		Main associated values	
A.	Human mobility and territory	A.1: A.2: A.3: A.4:	ability to move freely self-determination and influence sovereignty identity and territory
B.	Cultural heritage and indigenous knowledge	B.1: B.2: B.3: B.4: B.5:	material and immaterial heritage culturally important landscapes and sites ways of living and ways of thinking indigenous and local knowledge traditions, religion, and custom
C.	Life and health	C.1: C.2: C.3: C.4	emotional and psychological distress dignity ability to lead a healthy life physical and mental wellbeing
D.	Biodiversity and ecosystem services	D.1: D.2:	biodiversity and species habitats and ecosystem services
E.	Sense of place and social cohesion	E.1: E.2: E.3:	sense of belonging ability to solve problems collectively social bonds and relations

Source: adapted from Tschakert et al (2019)

For each of the five categories of values introduced above (Box 3.1), and drawing on case studies reported in the scientific literature, Table 3.1 provides examples of values that underpin loss. Using these examples, indicators can be identified to suit the bio-geographic and socio-economic contexts concerned. It is worth noting that these must be "state" indicators, as opposed to "pressure" or "response" indicators (OECD, 1994).[14] Desk studies and expert interviews are needed to identify these indicators (Section 3.2.2).

For example, the Shinto community in the Lake Suwa area, in Japan, is gradually losing a religious ritual named *Omiwatari* (or "God's crossing"), because the formation of ice ridges on the lake's surface, without which the ritual cannot take place, is becoming rare. Thus, in Japan's Lake Suwa region, a relevant state indicator for "B.5: traditions, religion, and custom" might be: extent to which Shinto community rituals are being lost to climate change.

[14] "Pressure" and "response" indicators account for, respectively, harmful anthropogenic impacts on a system, and the corrective measures undertaken to avert these impacts. "State" indicators describe the system's level of resilience at a given time.

First assessment step

For each of the sub-themes in Table 3.1, and drawing on desk studies and expert interviews, develop indicators that reflect national conditions, including those of disenfranchised groups are minorities.

3.2.2 Collecting data

The following paragraphs describe five data collection methods: desk studies, expert interviews, semi-structured interviews, focus-group discussions, and story-telling.[15] Table 3.2 summarises the main applications of each of these methods across the entire assessment process.

Table 3.2 Applications of the various data collection methods

Method	Applications		
	Develop indicators (Section 3.2.1)	Identify relevant locations (Section 3.2.3)	Assess climate change-driven loss Section 3.2.5)
Desk studies	√	√	√
Expert interviews	√	√	√
Semi-structured interviews		√	√
Focus group discussions			√
Story-telling			√

Desk study

Critical background information can be obtained through a desk study. The study should focus on two types of data: qualitative or semi-quantitative reports published in the scientific and grey literatures, and modelling estimates. The desk study can be conducted prior to travelling to the location(s) concerned.

The scientific and grey literatures are likely to contain information about the hazards that affect the location(s) concerned. Whereas information about the residual climate change impacts resulting from those hazards may not be available for the location(s) concerned, proxies drawn from literature that reports on other, comparable locations will in some cases be available.

Modelling estimates of likely-future climate change impacts in the location(s) concerned are unlikely to be available. Commissioning purpose-developed estimates is reasonably inexpensive. However, the quality of the estimates that can be produced will vary greatly from one location to another (Section 3.4).

Expert interviews

Although data collection efforts by necessity will focus on one or several individual communities (Section 3.2.3), input from individuals outside these communities will nonetheless be needed. For example, information on changes in climatic conditions, whether they respond to slow-onset or extreme events, may have to come from scientists, whereas information about past and planned efforts to increase resilience to climate change impacts in a given location may have to be provided by government officials and the most concerned actors in the relevant communities.

The key role that such actors play in assessments of climate change-driven loss should be self-evident. What may be less evident is that their contribution is also indispensable to interpret the location-specific input collected through the desk studies, the semi-structured interviews and the focus-group discussions. Their input may be needed both ex-ante

[15] The list of methods reported in this document is adapted from the list proposed by van der Geest and Schindler (2017).

(for example, to obtain a list of past extreme events) and ex-post (notably, to put responses into the broader socio-economic, geographic, and cultural context).

Semi-structured interviews
Interviews are the main source of data for assessing losses. In locations where population size is around 100 or less, and in locations where subsistence livelihoods are the norm, household-level interviews are preferable. In all other instances, interviews can be conducted individually with each person in the sample, which, depending on the scale, should include representatives of groups and stakeholders or individuals affected.

A questionnaire, including both factual and open-ended question, provides a useful aid to conducting the interviews. Factual questions can be used to collect information about the interviewee (notably, demographic, educational and livelihood-related data) and about the main climatic hazards affecting the location (for example, observed gradual changes in climatic conditions, impacts suffered under recent extreme events, and measures taken in the face of both). Ideally, responses to the factual questions should be amenable to categorization and counting. Open-ended questions can be used to expand on the responses obtained through the factual questions. Examples of open-ended questions include: what constitutes loss, why loss matters, what can be done to prepare for inevitable irreversible loss, and what can be done to cope with irreversible loss that has already occurred.

Different interviewees will have different views on what constitutes irreversible loss – and, indeed, about whether loss has occurred in the first place. For this reason, it is useful to conduct a few pilot interviews first, to identify the main types of losses that are likely to be reported. Following such pilot interviews, the actual interviews can be conducted. During the course of the actual interviews, interviewees can be asked to rank (for example, in a scale of one to five) the different types of losses reported in the pilot interviews. Such a ranking allows the interviewer to collect information about why, in the view of each interviewee, a certain change in the status quo constitutes a, say, five-point loss whereas a related change constitutes a, say, two-point loss only. This kind of semi quantitative assessments can help frame responses to loss, which is likely to be a key objective of the assessment (Section 1).

Focus-group discussions
Bringing different interviewees together through a focus-group discussion helps identify the values that underlie the various losses reported. Not least, such discussions can help generalise the feedback gathered within a single community, by highlighting linkages between types of losses and parameters such as gender, age, educational level, and occupation, among others. As such, focus group discussions are an indispensable element of the assessment.

Organising and facilitating focus group discussions is challenging in most contexts. Whereas the desirable outcomes outlined above are more likely to be achieved with heterogeneous groups, power imbalances (along status, age, and gender lines, for example) are likely to hamper the formation of such groups. If formed, a frank exchange within such groups will be constrained by the limited ability to putting forward their arguments that many participants are likely to have.

It follows that careful preparation and strong facilitation are required for focus group discussions to produce meaningful outputs. Facilitation is best undertaken by an entity that is widely respected and perceived as neutral. In some communities, such entity may be a faith-based organisation, a public authority or a council of elders. In most settings, a structure that allows for anonymised individual contributions, obtained ahead of the actual discussion, may help kick-start the conversation.

Story-telling
Through the semi-structured interviews mentioned above, paradigmatic cases of climate change-driven loss are likely to emerge. Documenting such cases through narratives – in the form of case studies – that provide comparatively more context is useful

from a communications point of view, to help those not involved in the assessment understand the nature and implications of climate change-driven loss.

Because of their closer attachment to nature, indigenous communities are especially vulnerable to the impacts of climate change and, therefore, are more likely to experience climate change-driven loss. For these communities, loss has a comparatively deeper life-changing impact, and the way loss is expressed is likely to escape non-indigenous narratives. For these reasons, and to ensure that the various dimensions of loss are fully captured, story-telling is advisable.

Second assessment step

With the data collected through the desk studies and the expert interview, review the list of indicators (see "first assessment step", above).

3.2.3 Identifying relevant locations

Climate change-driven losses can be assessed retrospectively or prospectively. A retrospective assessment focuses on losses that have already occurred, and entails different assessment methods compared to a prospective assessment, which focuses on likely-future losses.

Retrospective assessments

Two types of residual impacts can be distinguished (Section 1): those that result from adaptation measures being insufficient or ineffective, and those that result from limits to adaptation being exceeded. In this document, damages are equated to the former, and losses are equated to the latter (Section 1). Therefore, a retrospective assessment of losses involves identifying locations where past hazards led to exceedances of adaptation limits. The data required to identify these locations can come from two sources: reports produced in the context of the obligations that national governments acquire when adopting the Sendai framework for disaster-risk reduction (hereinafter, disaster-tracking reports), and meteorological records.

Disaster-tracking reports

Although disaster-tracking reports are concerned with damages, the same hazards that led to the damages described in those reports may have led to losses. Stated differently, the locations affected by the hazards included in disaster-tracking reports may have experienced not only damages, but also losses. Finding out whether this is the case entails one and, in some instances, two sets of activities (Box 3.4): an initial screening based on purpose-developed indicators and, if the results of the screening suggest so, an in-depth analysis conducted in situ.

Meteorological records

Meteorological data can be used to identify deviations from average climatic conditions – for example, unusually high temperatures or extreme precipitation levels. Such deviations can be mapped against the events included in disaster-tracking reports, with a view to identifying hazards that did not lead to damages and, therefore, are not tracked in those reports. Once identified, checking whether those events may have led to losses can be done through the sets of activities referred to above (Box 3.4).

BOX 3.4

Assessing whether past hazards led to losses

For a given location, did a past climatic hazard lead to climate change-driven loss? To answer this question, a qualitative analysis must be carried out for the location concerned, covering separately each of the various values of relevance to that location (Table 3.1).

As a first step, such analysis involves reviewing the extent to which, in the location concerned, any of the indicators in the national set (Section 3.2.1) suggests that there may have been values at risk from climate change. For example, sea-level rise leading to coastal erosion may threaten culturally important (coastal) landscapes.

As a second step, data must be collected using the methods described above (Section 3.2.2). Initially, desk studies and expert interviews will be sufficient. If the data thus collected confirms that losses might have been incurred, semi-structured interviews will be needed, to reach a conclusive answer.

Prospective assessments

To conduct a prospective assessment, estimates of likely future residual impacts that exceed the limits to adaptation (Section 1) are required. These estimates must be geo-referenced and of high resolution, because losses maniwfest themselves at the local level.

Obtaining such estimates entails four sets of tasks: projecting likely-future climatic conditions, projecting likely-future climatic hazards, assessing residual impacts, and identifying residual impacts that exceed adaptation limits. The following paragraphs provide background on each of these sets of tasks.

Projecting likely-future climatic conditions

So-called downscaling methodologies provide high-resolution geo-referenced estimates of likely future climatic conditions (Box 3.5). Like any other set of projections, downscaled estimates are subject to a multiplicity of uncertainties. For this reason, using several models – to assess uncertainty ranges – is advisable. Choosing among the models that participate in the Coupled Model Intercomparison Project, a World Climate Research Programme-sponsored collaborative effort that is entering its seventh phase, helps increase the comparability of the results. Similarly, to increase comparability among downscaled estimates from different regions, it is advisable to build the projections within the framework of the so-called representative concentrations pathways, an internationally agreed set of greenhouse gas concentration trajectories that describe plausible ranges of future global warming (Moss et al, 2010).[16]

[16] The representative concentration pathways constitute a departure from previous practice in climate change scenario development, in that they are articulated around concentrations instead of emission levels. This change makes it easier to explore the role that technological and socio-economic developments play in mitigating climate change and adapting to it. Four pathways have been developed, corresponding to four progressively higher values of radiative forcing that are considered plausible for year 2100. Radiative forcing (or climate forcing) refers to the difference between insolation received and given back to space by the Earth and is measured in watts per square metre.

BOX 3.5

Downscaling global climate projections

Computer-based models can be used to simulate likely changes in atmospheric and ocean fluid conditions, not least changes driven by emissions of climate forcers. Ability to produce such simulations has made these models the tool of choice for estimating likely future climatic conditions under different warming scenarios. Because the dynamics of the atmosphere and the oceans are entirely linked, the first such models were global in scope. However, over time regional models have also been developed.

Global- or regional-level estimates of climatic conditions are of limited use for managing climate change impacts at the local level. To overcome this shortcoming, the low-resolution estimates produced by global or regional models can be used to infer high-resolution estimates. The analytical procedures used to do so are called downscaling.

There are two main types of downscaling procedures: dynamical downscaling relies on high-resolution regional models, whereas statistical downscaling is based on statistical relationships between high- and low-resolution climate variables, such as temperature or wind speed.[17] Although both types of procedures appear to perform equally well in reproducing historical climate conditions, statistical downscaling is used comparatively more frequently, because it does not require a pre-existing model that describes the region concerned.

[17] Statistical downscaling requires high-quality time series of historical meteorological data, ideally going back no less than 30 years.

Projecting likely-future climatic hazards

Based on the likely climatic conditions in a given location and future year, so-called climate impact models can be used to determine the likely level of a specific climatic hazard that the location may experience in that future year.[18] Most impact models can incorporate measures of exposure to the calculations, thus providing the information needed to assess likely future climate change impacts.[19]

For example, the Dynamic Interactive Vulnerability Assessment (DIVA) model can be used to assess the likely future level of a specific hazard – sea-level rise. The model is built around a database of coastline segments, the individual length of which is determined by parameters such as coastal morphology, population density and tidal type. Simply stated, a segment ends and a new one begins when any of these parameters vary beyond a certain pre-determined level. Using more detailed local-level data, the length of the individual segments can be shortened, thus increasing the resolution of the model, which makes it possible to estimate hazard levels locally. If disaggregated information about exposure to the hazard is available, model outputs provide the information needed to assess likely climate change impacts associated with sea-level rise in the location and future year concerned.

[18] The Intergovernmental Panel on Climate Change defines hazard as the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

[19] The Intergovernmental Panel on Climate Change defines exposure as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected by climate change.

Assessing residual impacts

Estimates of climate change impacts can be obtained by combining the outputs of climate impact models with information about likely vulnerability levels in the locations and years concerned.[20] Vulnerability levels are contingent upon development pathways and levels, poverty incidence and inequity patterns, and governance arrangements. Therefore, vulnerability can be appraised through two sets of tasks, which need to be conducted individually in each location of interest. First, an assessment of the extent to which livelihoods are sensitive to climatic changes, and access to basic services and resources is secured. Second, an assessment of the extent to which governance arrangements are successful at safeguarding environmental protection and social justice.

Most national governments have experience with conducting these two sets of tasks at the national level. Local-level assessments are easier for the first set of tasks, because aggregation can largely be foregone. Conversely, they are comparatively more complex for the second set of tasks, because disaggregated datasets are rare. Semi-quantitative surveys can be used to overcome the lack of data, especially in small communities.

Once estimates of climate change impacts have been obtained, the size of residual impacts relative to avoided impacts must be determined (Section 1). To do so, assumptions about adaptation levels in the locations and years concerned, and for the hazard concerned, are needed. Some climate impact models integrate these assumptions with assumptions about exposure levels. Arguably, considering assumptions about adaptation levels after having considered assumptions about vulnerability levels results in more robust estimates of residual impacts, because vulnerability factors effectively constrain the scope and effectiveness of adaptation options.

[20] The Intergovernmental Panel on Climate Change defines vulnerability as the propensity or predisposition to be negatively affected by a certain hazard because one is highly exposed to it, and/or one has limited ability to adapt to it.

Identifying residual impacts that exceed adaptation limits

The scientific literature distinguishes between two types of limits to adaptation (IPCC, 2022): soft limits "occur when additional adaptation may be possible if constraints [can] be overcome", whereas hard limits "occur when no additional adaptation is possible". It follows that, lacking action to overcome adaptation constraints, soft limits become hard limits (Barnett et al, 2015). The case described in Box 3.2 illustrates this point.

Regarding hard adaptation limits, identifying likely-future residual impacts that exceed those limits can be done through a two-stage process. First, the indicators referred to above (Section 3.2.1) must be identified and assessed. Second, using desk studies, expert interviews and semi-structured interviews (Table 3.2), in-depth assessments must be conducted.

Regarding soft adaptation limits, the procedure described in the previous paragraph also applies. The difference lies in the need for regular monitoring, to avoid soft limits becoming hard limits.[21]

Third assessment step

For retrospective assessments, use disaster monitoring programmes and meteorological records to identify potentially relevant locations, and confirm the relevance of these locations through desk studies, expert interviews and, if warranted, semi-structured interviews.

For prospective assessments, use downscaled projections and impact models to identify potentially relevant locations, and confirm the relevance of these locations through desk studies, expert interviews and, if warranted, semi-structured interviews.

[21] To set up such monitoring programmes, an understanding of whether limits are soft or hard is needed. They are soft when corrective measures can be adopted which prevent loss (for example, an endangered species), and they are hard in all other instances (for example, a melting glacier).

3.2.4 Selecting data sources

As mentioned above, loss is a subjective concept. For this reason, the occurrence of loss can only be ascertained by enquiring people about their individual experiences. When an entire country is concerned, which is the typical case in public policy, enquiring all people is clearly impracticable. In such a situation, enquiries have to focus on a sample of the population.

Two types of samples can be considered: all members in one or two small communities that have been exposed to a severe climate hazard ("deep and narrow"), or a selection of individuals in different communities exposed to the same hazard ("broad and shallow"). It is worth noting that the enquiry should ideally consider both types of samples simultaneously. Table 3.3 outlines the pros and cons of each type of sample.

Finally, whereas the members of a community are easy to define in isolated settlements, this may not be the case in other settings. In these cases, and lacking a census registry, criteria related to societal- and livelihood-related networks, such as schools and local markets, can be used. The selected criteria should be specified in the documentation describing the enquiry.

Table 3.2 Sample type pros and cons

	Pros	Cons
Deep and narrow	no need for sampling criteria and methods	representativeness across communities may be limited
Broad and shallow	ability to capture a comparatively broader set of issues	difficulty of selecting representative samples in each community

Deep and narrow

The "deep and narrow" approach involves one single set of sampling decisions: determine who, if anyone, should be excluded from the enquiry. Four categories of individuals are relevant in this regard:

- **Children**. Getting input from children is indispensable, as their values are likely to be quite different from those of adults. The age above which children can be a part of the enquiry has to be decided on a case-by-case basis. Irrespective of the age chosen, three ethical issues must be resolved prior to conducting the enquiry (Hill, 2005): how children can give informed consent, how power dynamics may be countered, and how children's well-being can be protected.

- **Elderly**. The rationale for, and the approach to, including elderly people in the enquiry are analogous to those related to children: their input is necessary and recruitment choices require case-by-case assessments. Ethical issues too are similar (Harris and Dyson, 2001). However, in the case of the elderly, obstacles related to cognitive impairment add to the list of issues that must be resolved prior to conducting the enquiry.

- **Non-residents**. A technocratic approach to defining the sample would exclude all non-residents. Yet, inclusion of two types of non-residents merits consideration: people who live elsewhere, but work in the community concerned; and people who used to live in the community and no longer do, but keep strong ties with it. Here too, recruitment choices require case-by-case assessments. Purposive sampling can be used to inform these choices (Emmel, 2013).[22]

- **Travellers**. Individuals who live in the community targeted but were absent at the time an extreme event hit the community will have perceptions that differ from those who were not absent, in that travellers did not experience the event, which might have proved traumatic, but do suffer the consequences of it. Including travellers in the enquiry helps assess the mental health impacts associated with the event.

It is worth noting that, in the case of extreme events, the four categories of individuals listed above are relevant. Conversely, in the case of slow-onset events, only the first two categories (children and elderly) are relevant.

Broad and shallow

The "broad and shallow" approach involves two sets of sampling decisions: determine a statistically representative sample size, and select individuals in a way that does not introduce biases. Methods for doing so are well-established. The challenge lies in understanding which method is most appropriate, given the type of population concerned and the goals of the enquiry.

The first sampling decision can be synthesised through the following question: what is the sample size that one can deem representative of the community from which the sample is drawn? What the best method to answer this question is will depend on the specifics concerning three design features of the enquiry (Box 3.3). With information about these design features, which is best provided by the person in charge of the enquiry (namely, a climate change specialist), a statistician can identify the appropriate sampling method. In practice, a statistician will provide the person in charge of the enquiry with a set of tables listing, for each population size, and for various levels of acceptable error margins, representative sample sizes.

[22] Purposive sampling is one of several types of non-probability sampling methods (in contrast to probabilistic methods such as random sampling or stratified sampling). Purposive sampling relies on prior knowledge to handpick the individuals that are likely to be more relevant for inclusion in the enquiry. In this case, the prior knowledge would be that of the community members, as opposed to the analyst's.

BOX 3.3

Enquiry design features that affect the choice of sample size estimation method

Primary variable of measurement. The variable that is of primary interest in the context of the enquiry can be continuous or discontinuous.[23] A one-to-ten score that respondents give to a question is an example of the former, whereas a choice between two dichotomous options (for example, irreversible versus non-irreversible loss) is an example of the latter. Primary variables that are continuous require comparatively smaller sample sizes. In practice, an enquiry may consist of several primary variables, possibly including mixes of continuous and discontinuous variables. Methods exist to accommodate this possibility.

Error estimation. The premise behind the notion of "representative samples" is that, by enquiring only a sub-set of a population, one can arrive at the results one would obtain by enquiring the totality of that population. In reality, one can only achieve an approximation that minimises errors such as attributing a difference (for example, across genders) when in fact there is none. By convention, acceptable error margins are set at five percent for enquiries where the primary variable is discontinuous, and three percent in the case of continuous variables. In situations where decisions based on the enquiry are critical, error margins are set at one percent.

Variance estimation. The variance of a population reflects its heterogeneity. In principle, there are four ways of estimating the variance: conducting the enquiry in two steps, using the first step to determine the variance; conducting pilot studies; drawing on existing estimates from previous studies; and relying on prior knowledge of the population to make an informed guess. In a non-research setting, the latter is likely to be the only workable option. For primary variables that are continuous, one must determine the inclusive range of the scale, and then divide by the number of standard deviations that would include all possible values in the range. For discontinuous variables, 0.5 is conventionally used

Source: Kotrlik and Higgins (2001).

The second sampling decision can be synthesised through the following question: how can one select a bias-free sample of the population? Methods to answer this question fall under one of two categories: probabilistic or non-probabilistic. Probabilistic methods are best suited for enquiries that seek to infer results applicable to the entire population. In contrast, non-probabilistic methods are more appropriate for exploratory work. Ideally, a case study that draws on input from a sample selected through non-probabilistic methods will be conducted first, and its outputs will be used to design of a more ambitious enquiry targeting a sample selected using probabilistic methods.

Describing the various sampling methods is outside of the scope of this document. Nonetheless, and even though individual methods are not explained, suggestions about the pros and cons of the various methods are given (Table 3.3).

Fourth assessment step

Select your data sources, ideally using a combination of "deep and narrow" and "broad and shallow" sample types:

- for "deep and narrow" samples, determine exclusion thresholds on a case-by-case basis, and ensure to disclose the decisions made and the rationale behind them;
- for "broad and shallow" samples, use the methods described above to determine a representative sample size and a bias-free recruitment methods.

[23] In certain contexts, a discontinuous variable is also referred to as "categorical", because it is defined through discrete options or categories.

Table 3.3 Pros and cons of the main sampling methods

Sampling method	Especially relevant applications, if any	Pros (P) and cons (C)
Probabilistic methods		
Random	Very large samples	P: robustness and transparency C: cost
Systematic	Very large samples	P: speed C: limited representativeness
Cluster	Samples already segmented along ethnic, gender, or other lines	P: precision C: difficulty
Multistage	Samples that can be segmented along (small) ethnic, gender, or other lines	P: reasonably inexpensive C: difficulty
Stratified	Samples including one or more minority groups	P: representativeness C: difficulty
Non-probabilistic methods		
Voluntary	Samples that are made up of easily accessible individuals	P: inexpensive C: limited representativeness
Snowball	Samples including hard-to-reach or stigmatized groups	P: inclusiveness C: slow and possibly biased
Quota	Samples including both primary and secondary target groups	P: representativeness C: possibly biased
Judgement	Samples drawn from a well-known community	P: effective C: possibly biased

Source: adapted from Daniel, J. (2011).

3.2.5 Assessing climate change-driven loss

Once locations where losses have occurred, or are likely to occur, have been identified (Section 3.2.3), and population samples have been selected (Section 3.2.4), the assessment of losses can be initiated. Ideally, the assessment should use all data collection methods described above (Table 3.2).

Lack of published evidence may mean that desk studies are of limited or no use. To determine whether this is so, a review of the literature should be conducted in all cases. Similarly, expert interviews may prove elusive, especially in countries with limited institutional capacities and in the case of poorly studied impacts or communities. In most countries, government agencies will have an overview of whether the relevant expertise exists.

Provision must be made for compensating the individuals whose input is elicited. Although cash payments are often preferred, compensation can also be made through a voucher. The amount of the compensation depends on the time required to elicit the input sought and the average income in the region concerned. For example, time-consuming enquiries in remote developing country areas can be budgeted at US$ 2 per individual (van der Geest and Schindler, 2017).

Photo: Marcus Kauffman, Unsplash

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