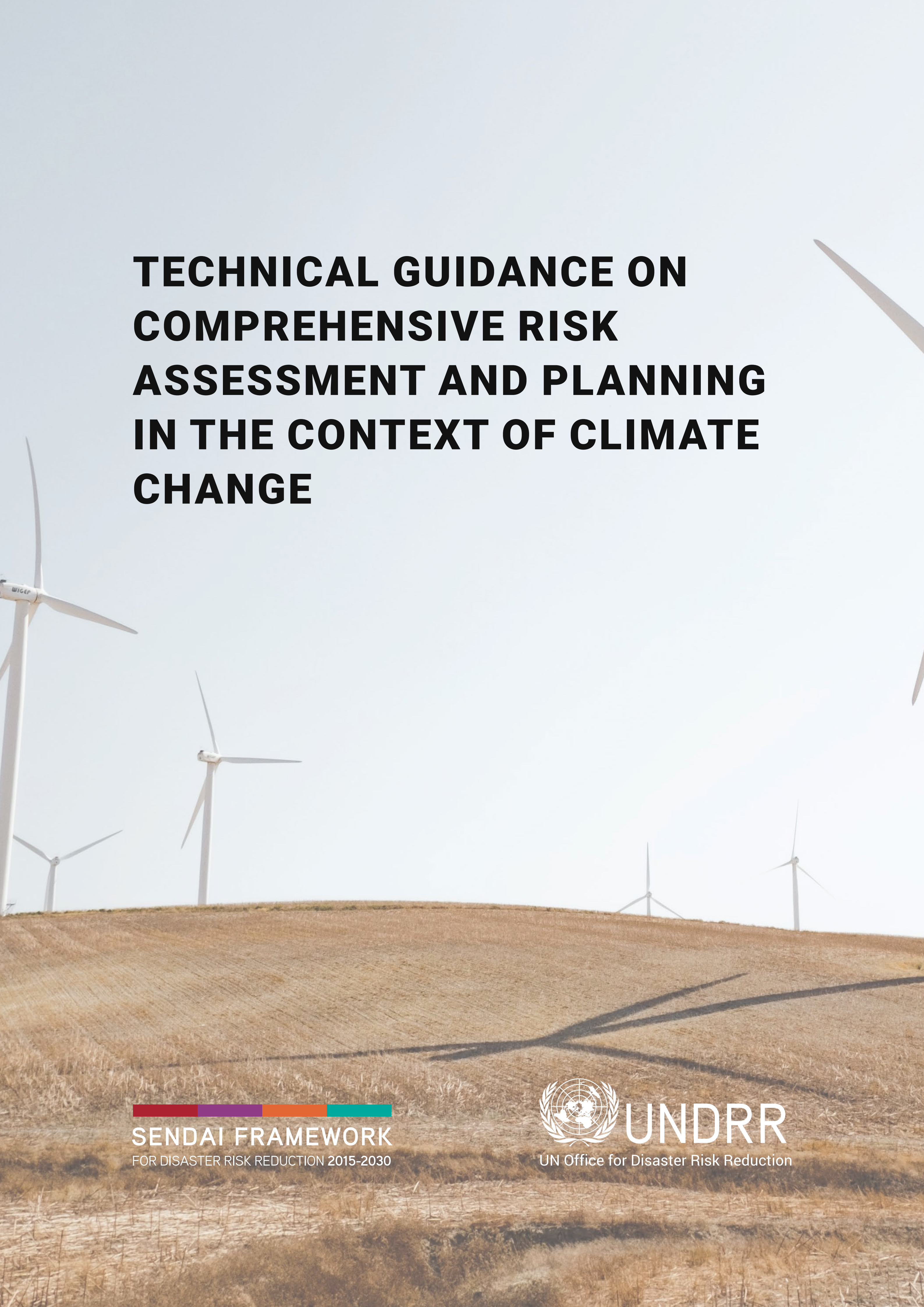

TECHNICAL GUIDANCE ON COMPREHENSIVE RISK ASSESSMENT AND PLANNING IN THE CONTEXT OF CLIMATE CHANGE

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

UNDRR
UN Office for Disaster Risk Reduction

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For additional information, please contact:

United Nations Office for Disaster Risk Reduction
7bis Avenue de la Paix
CH1211 Geneva 2, Switzerland
E-mail: undrr@un.org
Website: www.undrr.org

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This guidance is also a key contribution to the Plan of Action of the Technical Expert Group on Comprehensive Risk Management of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts.

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- **Consultants: Marc Zebisch, Massimiliano Pittore, Kathrin Renner** and **Rachel Woolfe** (Eurac Research); and **Alicia Natalia Zamudio** and **Janak Pathak** (UNDRR).
- **Advisory group members: Paul Desanker** (United Nations Framework Convention on Climate Change); **Reinhard Mechler** (International Institute for Applied Systems Analysis); **Adelle Thomas** (Climate Analytics); and **Maarten van Aalst** (Red Cross Red Crescent Climate Centre).
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EXECUTIVE SUMMARY

Climate change is increasing the magnitude, frequency, duration and severity of climate-related hazards. It has become a major driver of disaster losses and development achievement setbacks.

Climate and disaster risks arise due to compounding and cascading hazards and impacts, leading to complex and interconnected adverse consequences for various ecological and human systems. At the same time, other underlying risk drivers such as poverty, demographic development, land degradation or conflicts are aggravating exposure and vulnerability to climate-related hazards. Therefore, risk assessment and management in the context of climate change requires a comprehensive, systemic perspective on risk and its underlying drivers due to the complex and partly systemic nature of climate-related risks.

The Technical Guidance on Comprehensive Risk Assessment and Planning in the Context of Climate Change provides orientation on how risks in the context of climate change can be comprehensively and systemically addressed through risk assessment. Decision-making, planning, and integrating disaster risk reduction (DRR) and climate change adaptation (CCA) perspectives and approaches while simultaneously linking to other goals and targets (e.g. the Sustainable Development Goals (SDGs)) are also discussed. The guidance deepens understanding and supports implementation of comprehensive risk management laid out by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with a 2019 conceptual brochure, Comprehensive Climate Risk Management, and in line with the United Nations Office for Disaster Risk Reduction (UNDRR) Global Assessment Report on Disaster Risk Reduction 2019.

The guidance targets experts, decision makers, stakeholders and practitioners operating in the fields of DRR and CCA. It provides a framework and inspiration on how to apply comprehensive risk assessment and planning. The use and application of this guidance can be made context specific and customized, based on country realities.

The guidance acknowledges that risks in the context of climate change are complex and systemic due to non-linear interactions among system components and the need for improved risk governance. The understanding of complex risks is thus a priority. The guidance is part of the Plan of Action of the Technical Expert Group on Comprehensive Risk Management and was jointly committed to by expert group members (Climate Analytics, International Institute for Applied Systems Analysis, International Federation of Red Cross and Red Crescent Societies, and UNDRR) and a non-member (GIZ). As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

This guidance was jointly developed by The United Nations Office for Disaster Risk Reduction (UNDRR) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH with support by the German Federal Ministry for Economic Cooperation and Development (BMZ).

TEN KEY PRINCIPLES FOR A COMPREHENSIVE APPROACH FOR RISK ASSESSMENT AND PLANNING IN THE CONTEXT OF CLIMATE CHANGE

1. PUTTING RISK TO HUMAN AND ECOLOGICAL SYSTEMS AT THE CENTRE BY CONSIDERING:

- The dynamic interaction among hazards, vulnerability, exposure and underlying risk drivers when assessing risk and seeking solutions (risk reduction and adaptation)
- CRA as a foundation and integral part of the overall risk management process
- A common understanding of the broad risk perspective and of the value added of bringing closer together DRR and CCA communities of practices, including a mind shift towards prevention and preparedness
- Risk as a value-based concept

2. FULLY ACCOUNTING FOR THE CONTEXT OF CLIMATE CHANGE BY CONSIDERING:

- Climate change as an underlying risk driver that modifies climate-related hazards, and also vulnerability and exposure, today and in the future
- The full spectrum of climate-related hazards (extreme events and slow-onset processes and trends), as well as their interaction with and implications on non-climatic hazards
- Current climate risk as well as future climate risk, insofar as they are relevant to their respective sectors and systems and the decision-making and planning process to ensure adaptive planning and dealing with different timescales

3. RECOGNIZING THE COMPLEX AND SYSTEMIC NATURE OF RISKS BY CONSIDERING:

- Effects of multiple hazards, compound events, cascading hazards, impacts and risks, as well as linkages among risks across sectors, with the objective of understanding how these cascades could be interrupted by risk reduction measures
- Risks to a wide range of interrelated human and ecological subsystems (including ecosystems and other natural systems, physical assets, humans and livelihoods, and societal sectors)
- The “non-quantifiability” and high uncertainty in understanding important parts of complex risks, which require the application of hybrid, qualitative and participative methods for risk assessment and flexible approaches for risk management towards more resilient systems

4. APPLYING INCLUSIVE RISK GOVERNANCE BY:

- Engaging and partnering with multiple stakeholders, adopting a whole-of-government and whole-of-society approach (public, private, communities, knowledge centres, media, etc.), and strengthening the involvement of decision makers and populations at risk in order to increase buy-in and facilitate implementation

5. USING MULTIDISCIPLINARY APPROACHES TO IDENTIFY AND SELECT MEASURES BY CONSIDERING:

- A wide portfolio and combination of risk reduction and risk management measures (DRR, CCA, etc.), engaging various sectors and systems, to address multiple and context-specific risks
- Diverse information and knowledge sources by including at risk population

6. USING THE CONCEPT OF RISK TOLERANCE TO:

- Evaluate risks according to their tolerability to spur action
- Inform the identification and selection of appropriate risk reduction and risk management measures

7. ADDRESSING, MINIMIZING AND AVERTING RISKS THROUGH NBSS BY CONSIDERING:

- The role of ecosystems and their services: as part of the risk (climate impacts on ecosystem and their services cause risks for human systems, degradation of ecosystem services increases vulnerability to climate risks)
- The approach to be adaptable to different spatial scales, including transboundary as part of the solution

8. INTEGRATING RISK ACROSS SECTORS AND LEVELS BY CONSIDERING:

- Synergies and trade-offs across multiple levels, linking local realities with national and international processes
- A wide range of planning instruments, “game-changers” such as financial instruments and their timing

9. STRENGTHENING RISK COMMUNICATION, INFORMATION AND KNOWLEDGE SOURCES BY CONSIDERING:

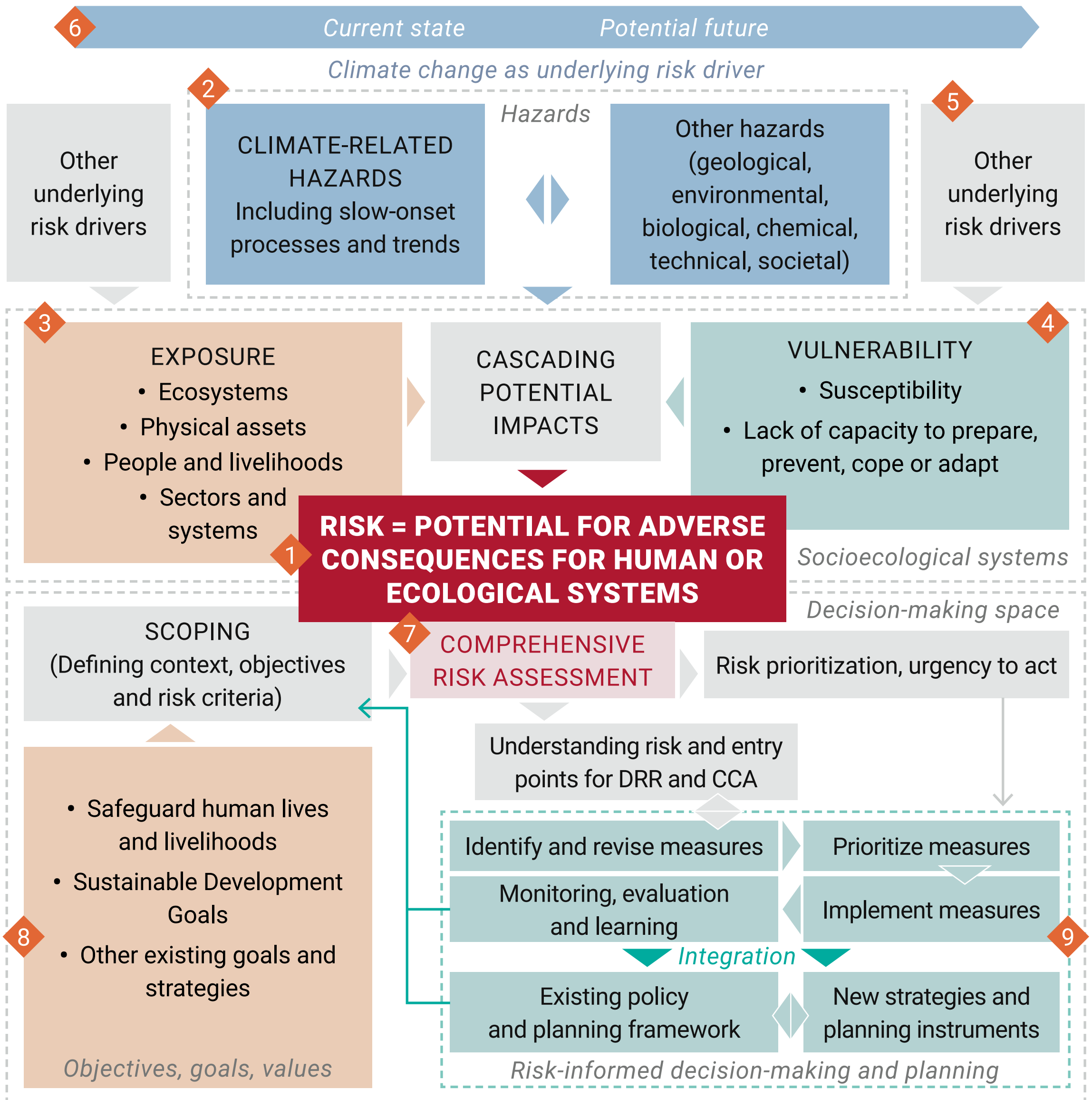
- A combination of diverse information sources, methods and knowledge to include scientific, traditional, local and indigenous knowledge, facilitating knowledge co-creation processes and designing measures
- Gaps in and needs for climate information and services (CISs) and strengthening them
- To keep the end users in mind throughout the assessment and integration process, tailoring risk information
- The potential of behaviour change and individual responsibility

10. USING ITERATIVE AND FLEXIBLE PROCESSES BY CONSIDERING:

- Adaptive management and planning based on robust MEL frameworks, feeding into an iterative and dynamic process to allow adjustments to planning and implementation
- The value added of the overall process itself as a way to help fill capacity gaps, improve information sharing and coordination mechanisms

The guidance proposes a comprehensive risk framework (see figure 1) based on 10 key principles (see box). The framework is centred around risk (1, in figure 1). Risk is the potential for adverse consequences for human or ecological systems triggered by climate-related hazards in combination with other hazards (2), leading to cascading potential impacts. Risk is determined by exposure (3) and vulnerability (4) factors in addition to hazards. Climate change and other underlying risk drivers (5) are already altering hazards, vulnerability and exposure. Risk assessment and risk-informed decision-making and planning can be linked to this framework. Risk for the current state and for potential future states (6) is assessed in a comprehensive risk assessment (7). Explicit objectives, goals and values are the target system against which risks are assessed (defining context, objectives and risk criteria for a risk assessment) (8). The risk assessment is co-designed and implemented within the context of risk-informed decision-making and planning and focuses on identifying and integrating risk reduction measures (9).

Figure 1. Framework for comprehensive risk assessment and planning in the context of climate change

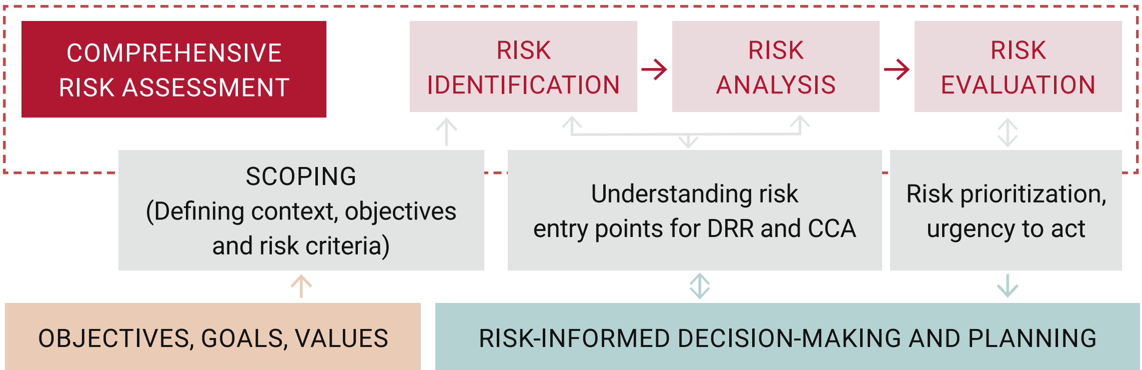


COMPREHENSIVE RISK ASSESSMENT

The guidance provides specific recommendations on how to comprehensively assess risks and reduce and/or address them through planning in the context of climate change. It follows the general workflow for risk assessments from International Organization for Standardization standard 31000 with its main phases of scoping, risk identification, risk analysis and risk evaluation (see figure 2).

A good scoping phase means to design a risk assessment in such a way that it supports decision-making and planning by taking into account existing objectives, goals, values, and the existing policy and planning framework. Risk identification aims to identify relevant risks starting from existing knowledge and expert input. In risk analysis, the risk components (hazards, exposure and vulnerabilities) and their interlinkages, resulting cascading impacts and the potential for adverse consequences for selected human or ecological systems are explored and analysed using quantitative and qualitative methods. Risk levels are assigned (e.g. from very low to very high). Risk evaluation then identifies urgent actions and risk reduction measures based on the levels of risk tolerability defined by the communities and key stakeholders.

Figure 2. Phases of a risk assessment according to ISO 31000 and the relationship with risk-informed decision-making and planning

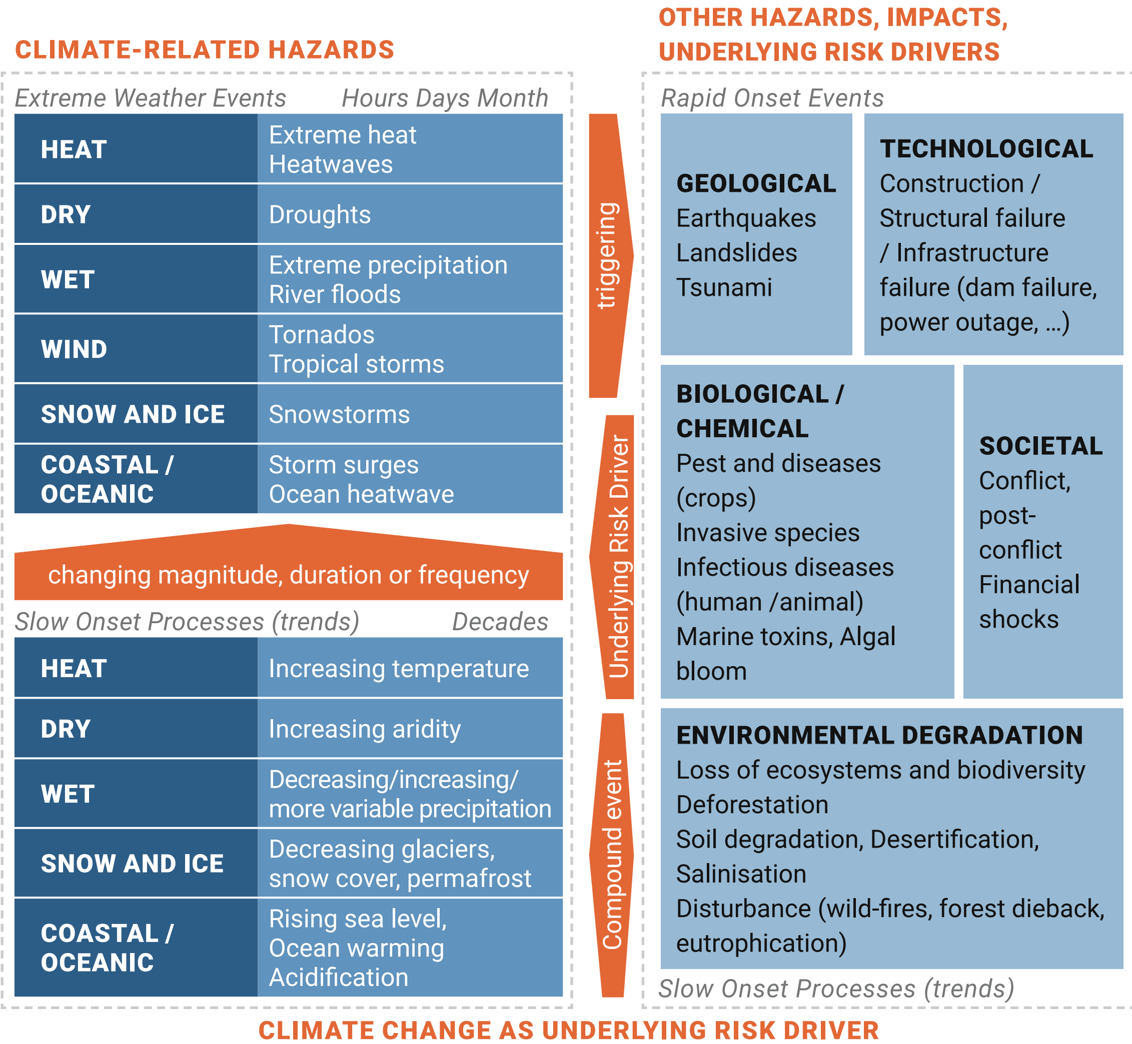


To comprehensively analyse complex risks, a structured conceptualization with so-called "impact chains" is recommended. Impact chains are conceptual systemic models that follow the comprehensive risk framework for specific climate risks in a given context. Impact chains are co-developed in an inclusive and participatory approach with experts and stakeholders and serve as the backbone for a risk assessment. They are structured along the core elements of risks (hazard, exposure and vulnerability), and include representations of multiple hazards and cascading impacts through different exposed subsystems. Impact chains can also serve as a basis for discussion on potential risk reduction measures early in the risk assessment process by pointing to vulnerabilities, adaptation gaps and risk mechanisms.

A comprehensive risk assessment should be as spatially explicit as possible by mapping hazard, exposure and vulnerability components, as well as the resulting impacts and risk to spatial systems such as administrative units or ecozones.

To analyse climate-related hazards (extreme weather events, slow-onset processes and trends), their relationships with other non-climate-related hazards should be considered (see figure 3). Slow-onset processes or trends due to the changing climate (such as sea-level rise or increasing aridity) are hazards in themselves but are also leading to changing and often increasing magnitude, duration or frequency of extreme weather events. Non-climate-related hazards such as earthquake-induced landslides, land degradation or pandemics can be triggered by climate-related hazards, occur as compound events or act as underlying risk drivers that increase vulnerability to climate-related hazards. Analysing extreme events, together with slow-onset processes and trends in the context of climate change, brings methodological challenges. Probabilistic approaches with a focus on events and their statistics based on past observations are falling short in the context of climate change. Options discussed are the introduction of climate impact-related thresholds and the more-qualitative concept of severity to compare different types of hazards and their impacts.

Figure 3. Key hazards and their relationship that could be considered within a comprehensive risk approach

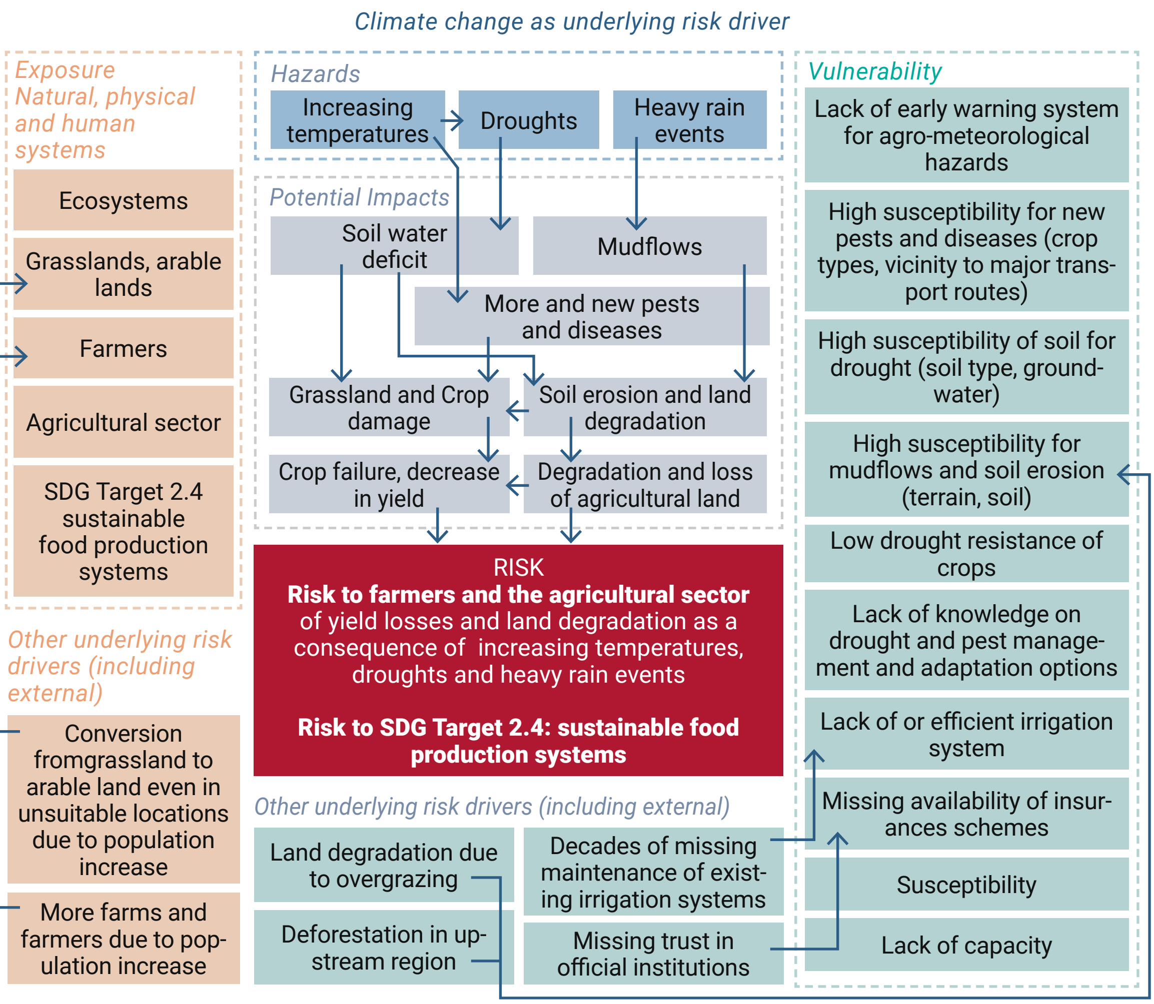


When analysing exposure, the guidance recommends considering a sequence of exposed systems (e.g. ecosystems, infrastructure, human lives and livelihoods, and social sectors) to model and understand the cascading impacts from natural systems to the society (figure 4). This means widening the perspective of approaches that focus mainly on human lives and physical assets. Exposure is a highly dynamic risk factor that requires the consideration of current trends in population, socioeconomic development and environmental factors. The underlying risk drivers affect exposure and can possibly contribute to an increase of climate-related risk even more than a single hazard.

Analysing vulnerability should include all relevant environmental, physical, technical, social, cultural, economic, institutional or policy-related factors that contribute to susceptibility and/or lack of capacity to prepare, prevent, cope or adapt. Understanding vulnerability is a key element in analysing entry points for adaptation and risk reduction options. As for exposure, underlying risk drivers such as land degradation, poverty or conflicts may affect vulnerability today or in the future, to an extent that could possibly contribute to an increase of climate-related risk even more than the single hazard.

How to model or analyse potential cascading impacts as a result of the interrelation of hazards, exposure and vulnerability and how to describe the resulting potential for adverse consequences on human or ecological systems depend significantly on the complexity of the selected risks and the resources available (e.g. data, models, knowledge, experts and time available). Risk assessments for complex risks are often based on hybrid approaches that describe hazards, exposure and vulnerability with a mix of quantitative, spatially explicit models, semi-quantitative, proxy-based indicators and qualitative information in narrative form. Compared to single risk assessment approaches, methods cannot be as quantitative and have to consider more elements, value-based decisions and qualitative conclusions.

Figure 4. Example of an impact chain that conceptualizes risks to farmers and the agricultural sector



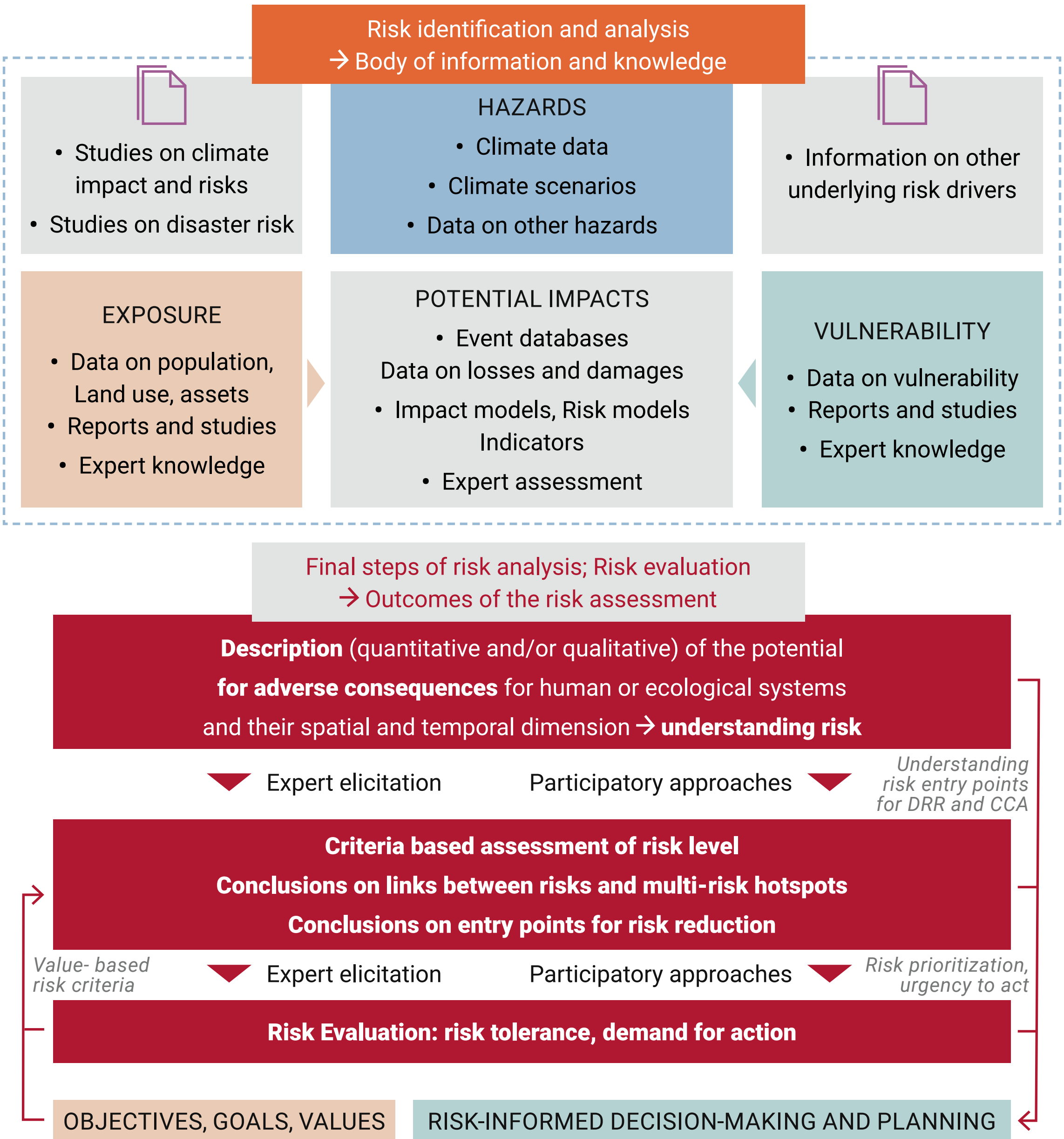
Risk assessments in the context of climate change are subject to a high degree of uncertainty due to the complexity and the systemic nature of risks and the uncertainties of future scenarios. A qualitative assessment of sources of uncertainty and the confidence of main statements is recommended.

The final step of the risk analysis is to assess the risk by assigning risk levels (e.g. from very low to very high). This assessment is a value-based process that needs an agreed and value-based target system and for which stakeholders from different target groups should be involved, ensuring an inclusive and participatory approach. Multiple risks can be compared across sectors, systems, spatial units or timescales.

Although the concept is still underdeveloped in climate risk assessments, this guidance includes risk evaluation to guide the identification of urgent actions based on the tolerability of risks – acceptable, tolerable and intolerable. How a risk evaluation supports the identification of potential measures is also discussed (see figure 5).

Results can be presented in a comprehensive risk report that addresses the risks from different hazard types as well to human and ecological systems. The report and other dissemination activities should be co-designed with the stakeholders that operate the systems and sectors for which the risk assessment has been implemented, together with vulnerable people at risk.

Figure 5. Pragmatic approach for the finalization of a CRA



INTEGRATING RISK ASSESSMENT RESULTS AND RISK INFORMATION INTO DECISION-MAKING AND PLANNING PROCESSES

While a risk assessment helps to understand the nature of risks, the integration of risk assessment results into decision-making and planning processes is needed to address the risks. This gives decision makers and planners the opportunity to take the assessed risks into consideration in choosing and prioritizing actions towards reducing risks and adapting to changes. They can then make the necessary adjustments to policies, plans, programmes and financial instruments, in order to implement these actions and increase overall resilience. However, despite growing knowledge on the urgency of the climate emergency, translating this knowledge to redirect resources and change behaviours is not yet happening on a wide scale. Limited resources, time and capacities, different approaches and terminology used by scientists and decision makers, a culture of working in siloes and a lack of political will are all posing significant challenges.

The guidance provides recommendations on how existing good practices and models, based on the 10 underlying principles for a comprehensive risk approach, can help overcome some of the common challenges for risk-informed decision-making and planning in the context of climate change.

By putting risk to human and ecological systems at the centre of comprehensive risk management, the comprehensive assessment, calibrated and designed based on the policy and planning objectives, provides the necessary base to identify risk reduction and adaptation measures, aiming to reduce vulnerability and strengthen resilience to multiple shocks. This broad risk perspective demands a widening of responsibility for action across all of society, helping to break long-standing siloes in planning processes. While there is growing convergence around this risk perspective, a mind shift from response and recovery towards prevention and preparedness (or averting and minimizing risks), more closely linking the DRR and CCA communities of practice, is still needed. Evidence shows investing in risk prevention is less costly, reduces losses and saves lives. It also generates economic and development co-benefits.

Inclusive risk governance systems and institutional arrangements are at the core of comprehensive risk management. Institutional arrangements with clear roles and responsibilities are needed to enable collaboration among a broad range of stakeholders, including marginalized and at-risk populations. Defining modalities early on for how to engage with risk assessment teams during the planning process and adopting gender-sensitive planning approaches help to ensure risk results are usable and tailored to the needs of end users, including decision makers.

Planning across multiple temporal and spatial scales is important to comprehensively manage risks. This will help to identify actions in the short, medium and long terms to account for present and future risks. Calibrating the risk assessment scope and the type of risk information needed, such as climate forecasts and projections, according to the needs of the specific policy and planning processes, is a step in that direction. Other steps include combining climate and development scenarios, diversifying information sources, considering low- or no-regret options applicable across spatial scales, and strengthening capacities to use and act based on forecasts, thus helping to overcome data and information gaps.

Addressing the systemic nature of risks in the context of climate change, which can lead to cascading crises, requires a holistic understanding of the interconnected, complex and non-linear cause–effect relationships within a system, to identify appropriate responses. This is facilitated by reviewing how past disasters have unfolded and how they were handled to inform future planning exercises, shifting from single-hazard to multi-hazard and system perspectives, and identifying measures based on multidisciplinary and inclusive approaches. It is also important to prioritize measures that can avert, minimize and address cascading impacts as early as possible in the impact chains, applying them from a wide portfolio of good practices and blended approaches. These can include strategies from the fields of DRR, adaptation planning, ecosystem management, nature-based solutions and social protection. Moreover, to address complex risks, often a combination of measures through layering, sequencing and integrating risks across different policy and financial instruments is needed, including considering the timing of risk financing.

Additionally, risks need to be integrated across sectors and multiple levels. This includes integrating risks into a wide range of national policies, sectoral or subnational strategies, plans, financial systems, programmes, projects and other planning instruments, as well as focusing on game-changers or on areas with the potential to multiply effects, such as public financial systems and the education sector. Analysing synergies and trade-offs among these policy objectives echoes the policy coherence agenda at the international level to attain the SDG, DRR and climate targets in the 2015 international agreements, for example the Sendai Framework for Disaster Risk Reduction 2015–2030, the Paris Agreement and the Transforming our World: the 2030 Agenda for Sustainable Development. Local realities need to be better linked with national and international processes and vice versa, combining bottom-up and top-down approaches, and fostering vertical and horizontal risk integration.

Adaptive management and planning based on strong monitoring, evaluation and learning frameworks, feeding back into an iterative integration process, are needed to flexibly adjust implementation, and inform future decisions and resource allocations, given the dynamic and context-specific nature of risk. This helps ensure plans remain responsive to needs and provide the enabling environment for timely and appropriate actions that will help reduce vulnerabilities of communities and systems.

Moreover, the integration process itself can be used to help fill identified capacity gaps and improve information-sharing and coordination mechanisms. In particular, this includes improving climate and disaster information services, partnering with knowledge brokers, and tailoring and communicating risk information throughout the planning and implementation processes.

CHALLENGES FOR COMPREHENSIVE RISK APPROACHES AND WAYS FORWARD

Risk approaches promoted by science and policy (e.g. by the Intergovernmental Panel on Climate Change and UNDRR) are becoming more comprehensive. However, for practical applications, some challenges need to be addressed, and further research and development is required. There is a need for:

- Pragmatic approaches for addressing the complexity and systemic nature of risks in the climate change context
- Proper consideration of current risks, and the dynamic nature of risk drivers including climate change, as well as future risks
- Improvement in the availability and accessibility of data on hazards and impacts, and also on vulnerability and exposure factors
- Consistent concepts on how to assess and manage risks related to slow-onset processes
- Reflection on the appropriateness and relevance of some risk metrics such as the concept of likelihood in the context of slow-onset processes and future scenarios
- Better scenario concepts, including storylines, for future reduction of exposure and vulnerability

CONTENTS

ABBREVIATIONS AND ACRONYMS

ADAPTool	Adaptive Design and Policy Assessment Tool
ARClim	Climate Risk Atlas of Chile
CCA	climate change adaptation
CCORAL	Caribbean Climate Online Risk and Adaptation tooL
CEDRIG	climate, environment and disaster risk reduction integration guidance
CIS	climate information and services
COVID-19	coronavirus disease 2019
CRA	comprehensive risk assessment
CRiSTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods
CRM	comprehensive risk management
CRVA	climate risk and vulnerability assessment
CSI	climate services for infrastructure
DRM	disaster risk management
DRR	disaster risk reduction
EWS	early warning system
FbF	forecast-based financing
FIPAT	Food Security Indicator & Policy Analysis Tool
FLORES	Flood Resilience System Framework and Model
FRMC	Flood Resilience Measurement for Communities
GAR2019	Global Assessment Report on Disaster Risk Reduction 2019
GIDRM	Global Initiative on Disaster Risk Management
GIS	geographical information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GRAF	Global Risk Assessment Framework
IPCC	Intergovernmental Panel on Climate Change
IRM	integrated risk management
ISO	International Organization for Standardization
L&D	loss and damage
LAPA	local adaptation plan for action
LCCAP	local climate change adaptation plan
LDCRC	local disaster and climate-resilient committee

LDCRP	local disaster and climate-resilient plan
LDRRMF	Local Disaster Risk Reduction and Management Fund
LDRRMP	local disaster risk reduction and management plan
M&E	monitoring and evaluation
MEL	monitoring, evaluation and learning
NAP	national adaptation plan
NAPA	national adaptation programme of action
NASA	National Aeronautics and Space Administration
NbS	nature-based solution
N/LDRRMF	National/Local Disaster Risk Reduction and Management Fund
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration
PfR	Partners for Resilience
PLACARD	Platform for Climate Adaptation and Risk Reduction
RA10121	Republic Act 10121 (Philippines)
RCP	representative concentration pathway
SDG	Sustainable Development Goal
SSP	shared socioeconomic pathway
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
ZFRA	Zurich Flood Resilience Alliance

1. INTRODUCTION

1.1 BACKGROUND

Climate change is increasing the magnitude, frequency, duration and severity of climate-related hazards. It has become a major driver of disaster losses and setbacks of development achievements (UNDRR, 2019a).

Climate and disaster-related risks arise due to compounding and cascading hazards and impacts, leading to complex and interconnected adverse consequences for various ecological and human systems. At the same time, other underlying risk drivers such as poverty, rapid and unplanned population growth, land degradation or conflicts are aggravating exposure and vulnerability to climate-related hazards. Therefore, risk assessment and management in the context of climate change require a comprehensive, systemic perspective on risks and its underlying drivers due to the complex and systemic nature of climate-related risks (Renn et al., 2020).

The landmark 2015 United Nations frameworks and agreements – the Sendai Framework for Disaster Risk Reduction 2015–2030 (hereafter termed the Sendai Framework; United Nations, 2015), the Paris Agreement and the Transforming our World: the 2030 Agenda for Sustainable Development (2030 Agenda) – have set the agenda for reducing risks associated with all types of hazards. Climate change is recognized as an important risk driver by all three frameworks. Coherence among the agendas has been pursued at the policy level and is supported by initiatives such as the Global Initiative on Disaster Risk Management (BMZ, 2018). However, integration will likely remain partial due to the different priorities of the individual agendas.

Even though innovative concepts have been developed to better link climate change adaptation (CCA) and disaster risk reduction (DRR), specific methods and tools to help operationalize approaches such as comprehensive risk management (CRM) on the ground at the country and subnational levels are often in their infancy (Schinko et al., 2017). Two aspects are relevant here: on the one hand, guidance and approaches to treat disaster risks and climate risks together are still rare, and on the other hand, DRR and CCA are usually managed by separate institutions and instruments on the national to subnational scales. This makes comprehensive approaches difficult to implement.

1.2 AIM, CONTEXT, TARGET AUDIENCE AND STRUCTURE OF THIS GUIDANCE

This document provides guidance for comprehensive risk assessment (CRA) and integration into plans. CRM puts risk to human and ecological systems at the centre, fully accounting for the context of climate change, recognizing the complex and systemic nature of climate risks and integrating risks across sectors and levels. There are 10 key principles for a comprehensive approach for risk assessment and planning in the context of climate change:

- Putting risks to human and ecological systems at the centre of CRM
- Fully accounting for the context of climate change
- Recognizing the complex and systemic nature of climate risks
- Applying inclusive risk governance
- Strengthening risk communication, information and knowledge sources
- Using multidisciplinary approaches to identify and select measures
- Using the concept of risk tolerance
- Addressing, minimizing and averting risks through nature-based solutions (NbSs)
- Integrating risks across sectors and levels
- Using iterative and flexible processes

The guidance contributes to the topic of CRM in the context of climate change. It covers two key aspects of CRM: (a) CRA in the context of climate change and (b) integration of CRA with decision-making and planning. The guidance integrates perspectives and approaches from DRR and CCA while simultaneously linking to other goals and targets (e.g. the Sustainable Development Goals (SDGs)).

The guidance supports a wide range of applications, from focused risk assessment and management for single sectors and systems (e.g. climate risks to agriculture) to broader and more-strategic multi-risk and multi-sector assessments, and a wide range of spatial scales, from national to local levels. Its focus is on supporting action-oriented risk assessment and management on the ground rather than on comparative or strategic assessments in an international context.

The guidance targets experts, decision makers, stakeholders and practitioners operating in the fields of DRR and CCA. It provides a framework and inspiration on how to make risk assessment and risk management more comprehensive. Applications need to be made context specific and customized.

It follows the idea of systemic and complex risks, acknowledged by the international community and the need for improved risk governance for which understanding of complex risks is a priority. The guidance was jointly committed to by members of the Technical Expert Group on Comprehensive Risk Management, including the United Nations Office for Disaster Risk Reduction (UNDRR), the International Federation of Red Cross and Red Crescent Societies, the International Institute for Applied Systems Analysis and Climate Analytics) and a non-member of the Technical Expert Group on Comprehensive Risk Management (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH), as part of their

Plan of Action. The document was developed in response to the decision of the 25th Conference of the Parties (United Nations Climate Change Conference) to develop technical guides on "Risk assessments, including long-term risk assessments, of climate change impacts" (United Nations, 2020), and for consideration of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts.

The guidance deepens the understanding and supports the implementation of CRM laid out by GIZ with a conceptual brochure in 2019 (GIZ, 2019), and in line with the UNDRR **Global Assessment Report on Disaster Risk Reduction 2019** (GAR2019; UNDRR, 2019a).

Following this introduction, Chapter 2 provides a comprehensive risk perspective, with a comprehensive risk framework. It discusses the consequences of a comprehensive risk perspective on the relationship between risk assessment and decision-making and planning. Chapter 3 gives recommendations for a CRA, with a workflow, methodologies and approaches for a CRA that cover a wide range of climate-related hazards and their relationships with non-climatic hazards. It addresses current and future climate risks. Chapter 4 discusses a comprehensive approach for integrating risk assessment results and risk information in decision-making and planning processes. Chapter 5 presents challenges for comprehensive risk approaches and ways forward. Annex 1 presents case studies showcasing how to partially apply a CRM approach to assessment and planning in the context of climate change from existing initiatives, and Annex 2 gives examples of existing CRM frameworks and a summary of existing resources and guidelines.

A COMPREHENSIVE RISK PERSPECTIVE

2.1 A COMPREHENSIVE RISK FRAMEWORK IN THE CONTEXT OF CLIMATE CHANGE

KEY MESSAGES

The comprehensive risk framework proposed in this guidance builds on common DRR and CCA concepts and extends them towards a comprehensive risk perspective. This perspective acknowledges the complex and systemic character of risks in the context of climate change, covers the full spectrum of climate-related hazards (extreme events, slow-onset processes and trends) as well as their interaction with and impact on non-climatic hazards, takes the current as well as potential future states into account, and acknowledges the value-based aspects of risk.

2.1.1 Climate and disaster risks and their impacts

In the context of climate change and disasters, risk can be defined as "the potential for adverse consequences for human or ecological systems" (IPCC, 2019a), triggered directly or indirectly by hazardous events or trends. "Adverse consequences" include potential loss of life, injury, or destroyed or damaged assets (United Nations, 2016), and also loss and damage (L&D) to service provision, ecosystems and environmental resources (IPCC, 2019a). There is a common understanding in the DRR and CCA communities that climate and disaster risks result not only from a hazard as a direct trigger, but also from dynamic interactions among hazards with exposure and vulnerability of the potentially affected human or ecological systems.

2.1.2 Climate and disaster risk perspectives

The Intergovernmental Panel on Climate Change (IPCC) adopted the concept of risk from the DRR field in its fifth assessment report (IPCC, 2014). This set the basis for integrating disaster risk and climate risk assessment and management into a comprehensive risk approach. On a policy level, coherence between DRR and CCA has been widely achieved, and reports such as the UNDRR global assessment reports or the IPCC assessment reports promote a comprehensive risk perspective. However, in many practical national to subnational applications, both disciplines are applying risk concepts with rather different foci, which makes integration more challenging than the use of a common concept might suggest:

- Conventionally, DRR has often focused on the consequences of specific disastrous events for humans and physical assets. The key questions for a disaster risk assessment have been what are the potential consequences of a specific event, and how likely are they? Disaster risk assessments mainly address the current situation based on past observation and probabilistic approaches, assuming stationarity in time. Inclusion of potential future changes due to climate change or changes in other underlying risk drivers in the analysis is emerging, but it is not yet a common standard. Risk is commonly described by a "risk from hazard" perspective (e.g. risk from floods). Often, relatively rare but highly severe events (e.g. a flood with a 100-year return period) are taken as design events for risk assessment and risk management, assuming that a system which is prepared for such severe events can also cope with events of the same type that are less severe but more frequent (e.g. floods with a 10-year return period). Vulnerability often focuses on physical vulnerabilities with some aspect of social vulnerability when it comes to impacts on humans and their livelihoods. Risk management focuses on preparedness as well as prevention, while considering risk transfer, and coping and recovery strategies and measures.
- CCA focuses on the potential impacts of climate change on various human and ecological systems. CCA activities mostly include current climate risks in the assessment and management approach. However, the main goal is to address future changes. For future climate risks, the key question for a climate risk assessment is what would happen if …, by addressing the potential adverse consequences of climate change for different potential future states (e.g. middle of century or end of century) and different global warming scenarios (caused by high emissions or low emissions). As climate scenarios per se have no likelihood, no actual likelihood can be assigned to the description of consequences, at least not for future periods and not across scenarios. Risks are commonly described as a range of adverse consequences for different human and ecological systems ("risk to system" perspective). Adverse consequences considered in CCA are usually long-term deteriorations of a system triggered by long-term trends in extreme events (e.g. floods that are more severe and/or more frequent) as well as slow-onset processes (e.g. sea-level rise or salinization). Such consequences can be caused by a complex interplay of cascading direct and indirect impacts and dynamics of exposure, vulnerability and underlying risk drivers. The focus of risk reduction is on (anticipatory) adaptation to the potential new situation. Where adaptation cannot reduce risks to a tolerable level, other options (e.g. risk transfer or transformation) are discussed.

Starting with the development and adoption of the Sendai Framework and strongly expressed in GAR2019 (UNDRR, 2019a), there has been a paradigm shift in the DRR field towards a comprehensive, forward-looking approach to risk assessment and management. This approach acknowledges that risk is complex, dynamic and driven by global processes such as climate change, loss of biodiversity, globalized economic development or other global shocks such as the coronavirus disease (COVID-19) pandemic. Risk reduction processes are linked in several ways with climate change mitigation, adaptation and vulnerability reduction, and yet few DRR plans take these connections into account (UNDRR, 2019a).

CCA and DRR are converging; however, gaps remain, mainly in practical applications. A consistent risk approach, which fully considers the context of climate change and other underlying risk drivers for the current situation and relevant potential future states and an integration of the CCA approach into the existing practice of disaster risk management (DRM) and vice versa, is still not a common standard.

2.1.3 Systemic risk perspective

Understanding the systemic nature of risk can involve identifying the subsystem from which they originate and assessing a wider set of cascading impacts on the interdependencies of the sub-elements. This makes risks highly complex. The origin of systemic risk from the subsystem and the impact chains within the other subsystems can affect the whole system and even go beyond political boundaries. So, assessing the spatial extent of systemic risk (i.e. considering its transboundary nature) may be required because of the interconnectedness of the globalized world. Assessing interconnectedness and non-linearity in the cause–effect relationship of systemic risk and identifying critical subsystems within the system that have the potential to fail or even reach a tipping point, are essential attributes in evaluating systemic risk (Schweizer and Renn, 2019).

It is critical to understand how humans influence systemic risk. Interlinkages among social, ecological, technical and urban environments influence systemic risk on different scales and intensities, which brings up system transition or transformative approaches. This guidance advocates a systemic risk perspective by conceptualizing risks with impact chains in the risk assessment phase and by considering the systemic nature in decision-making and planning.

2.1.4 Risk as a value-based concept

While "adverse consequences" and partly also the "potential for adverse consequences" are tangible and relatively objective aspects that can be measured, modelled, described or estimated (e.g. the potential for yield losses due to a drought), risk itself is neither tangible nor objective. Risk is instead an expression of a value-based assessment of how "relevant" or "critical" or "harmful" or "tolerable" or "acceptable" the potential of specific adverse consequences could be for specific values at stake. Consequently, risk is reported in a unit-less scale (e.g. from very low to very high) and often split into risk classes.

For climate-related risks, there are no standard criteria to describe what a "very low" or a "very high" risk means. The definition of criteria has to be made explicit and context specific based on agreed values (e.g. safeguarding human lives and livelihoods) and objectives (what should be avoided or what should be achieved). The International Organization for Standardization (ISO) standard 31000 definition takes the value-based character into account by defining risk as "the effects of uncertainty on its objectives" (ISO, 2018). Values, objectives or goals differ among different groups of actors. SDGs could be considered as one set of agreed objectives against which risks could be assessed (e.g. to what extent climate-related risks are undermining specific SDGs).

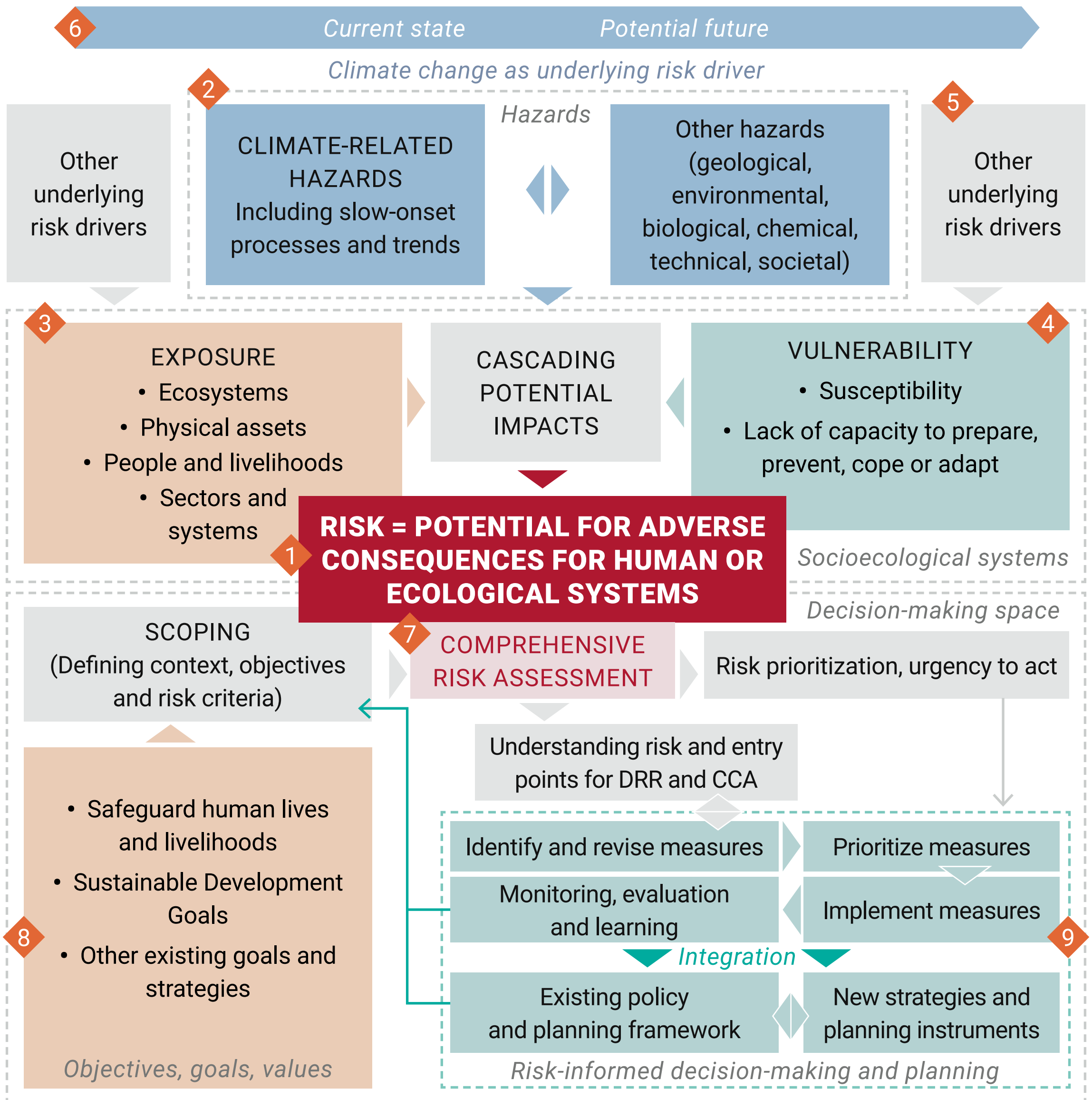
2.1.5 Framework for comprehensive risk assessment and planning

Based on the considerations above, a comprehensive risk framework (figure 1) is proposed that builds on the common concepts of DRR and CCA. It extends existing concepts towards a comprehensive risk perspective, acknowledging the complex and partly systemic character of risks in the context of climate change. This perspective is reflected in the Global Risk Assessment Framework (GRAF) being rolled out by UNDRR to assist United Nations Member States to make better use of risk data, including climate data. Moreover, it considers the full spectrum of climate-related hazards such as extreme events, slow-onset processes and trends, as well as their interaction with non-climatic hazards (figure 2). It also takes the current and potential future states into account and acknowledges the value-based aspects of risk.

The framework is centred around risk and understands risk as the potential for adverse consequences for human or ecological systems triggered by climate-related hazards in combination with other hazards, leading to cascading potential impacts. Risk is determined by exposure and vulnerability factors, in addition to hazards. Climate change and other underlying risk drivers are already altering hazards, vulnerabilities and exposure.

Risk assessment and risk-informed decision-making and planning can be linked to this framework. Risk for the current state and for potential future states is assessed in a CRA. Explicit objectives, goals and values are the target system against which risks are assessed (defining context, objectives and risk criteria for a risk assessment). The risk assessment is co-designed and implemented within the context of risk-informed decision-making and planning and focuses on identifying and integrating risk reduction measures.

Figure 1. Framework for CRA and planning in the context of climate change: risk and its root causes (upper part) and risk assessment and risk-informed decision-making and planning (lower part)

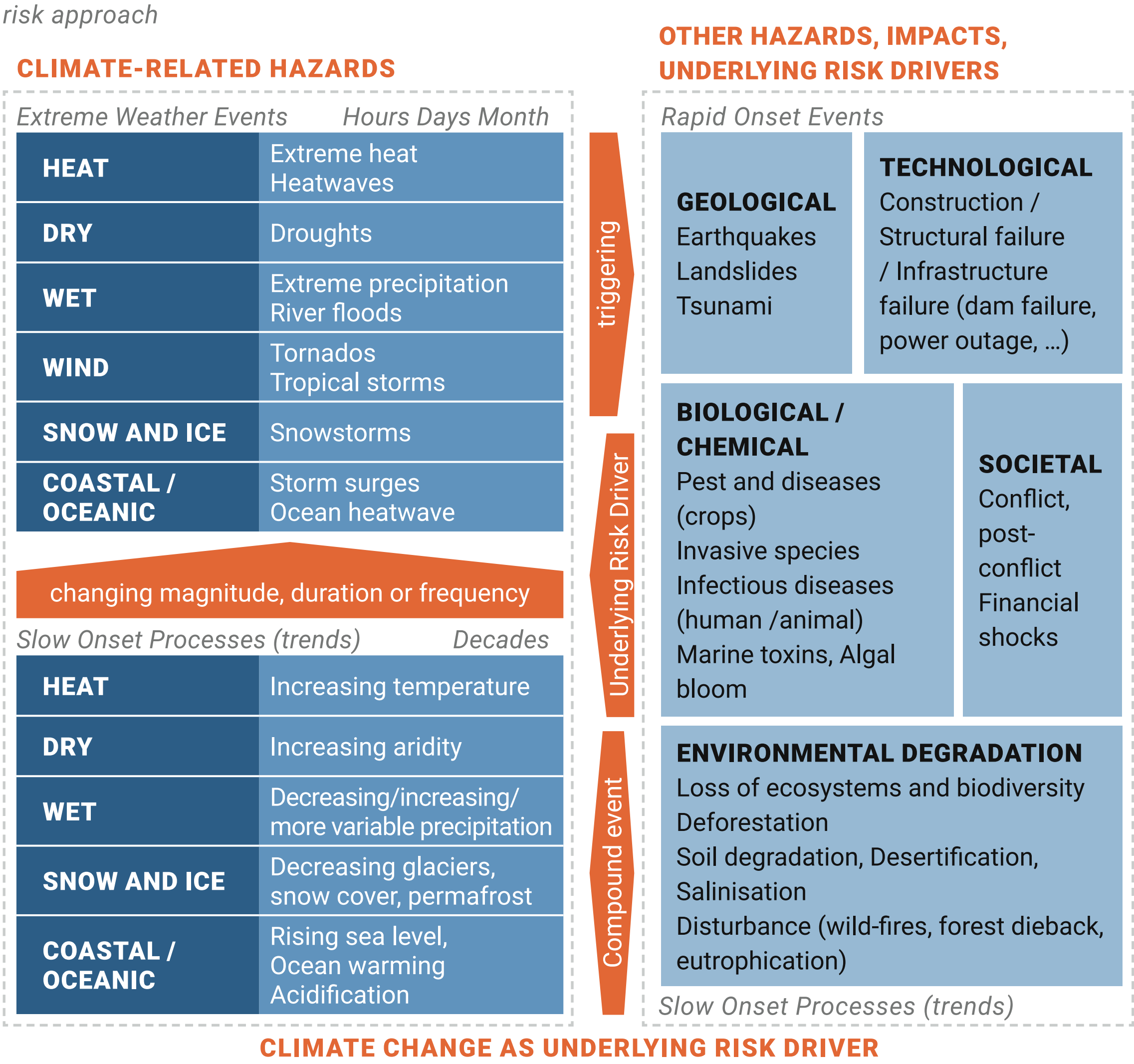


Note: The framework is centred around risk (1). Risk is the potential for adverse consequences for human or ecological systems triggered by climate-related hazards in combination with other hazards (2), leading to cascading potential impacts. Risk is determined by exposure (3) and vulnerability (4) factors in addition to hazards. Climate change and other underlying risk drivers (5) are already altering hazards, vulnerabilities and exposure. Risk for the current state as well as for potential future states (6) is assessed in a CRA (7). Explicit objectives, goals and values are the target system against which risks are assessed (defining context, objectives and risk criteria for risk assessment) (8). The risk assessment is co-designed and implemented within the context of risk-informed decision-making and planning and focused on identifying and integrating risk reduction measures (9).

2.1.6 Hazards that could be considered within a comprehensive risk approach

Some of the most important aspects to make a risk approach more comprehensive are consideration of the effects of climate change, the full spectrum of hazards[1] related to extreme events and rapid-onset events to slow-onset processes and trends, and the interrelationships among climate-related hazards and other hazards, impacts and underlying drivers (figure 2).

Figure 2. Key hazards and their interrelationship that could be considered within a comprehensive risk approach



1 UNDRR and the International Science Council have classified a wide list of hazards (UNDRR, 2020a).

2.2 COMPREHENSIVE RISK ASSESSMENT SUPPORTING RISK-INFORMED PLANNING AND DECISION-MAKING IN THE CONTEXT OF CLIMATE CHANGE

KEY MESSAGES

While a risk assessment helps to understand the nature of risks, dealing with current and future risks in the context of climate change requires designing and deciding on appropriate risk reduction and risk management strategies and measures. Integrating risk assessment results into decision-making and planning is key to realizing agreed values, objectives and goals, and increasing overall resilience.

A CRA can support evidence-based and risk-informed decision-making and planning in the context of climate change. This can also be understood as managing risks, whereby “Plans, actions, strategies or policies to reduce the likelihood and/or magnitude of adverse potential consequences, based on assessed or perceived risks” are designed (Reisinger et al., 2020). This is also commonly referred to as the “risk treatment” phase by the ISO standards used for this guidance (IRGC, 2017; ISO, 2018, 2019).

For risk assessment to be useful, it is important to reverse the concept and ask what additional information is needed to avert, minimize and address climate and disaster risks, reach existing and future development goals and ensure policy and development pathways do not create new risks. In the scoping phase, the policy and planning processes define the purpose, scope and type of risk assessment needed in the context of climate change. The risk identification and risk analysis phases aim to understand risks and vulnerabilities and identify them through collaboration with risk management practitioners providing clear entry points for action. The risk evaluation phase identifies risk hotspots, prioritizes risks and defines the urgency to act (facilitating decision-making and planning processes). In this way, risk assessment, design and implementation of risk reduction measures are not part of a sequential process (first the assessment, then the identification of measures), but a value-driven, iterative and communicative process that respects and builds upon existing risk management practices and the decision-making and planning context.

2.3 COMPREHENSIVE RISK MANAGEMENT

Given that CRM is broad, this guidance presents recommendations that contribute to the wider discourse and practice on CRM by focusing on risk assessments and planning in the context of climate change. CRM is one of the areas identified under the Paris Agreement that can help governments enhance understanding, action and support in averting, minimizing and addressing L&D associated with the adverse effects of climate change. In the context of climate change, CRM provides a lens to build resilience to multiple risks linked to climate-related and non-climate-related hazards, and their interactions with other socioeconomic factors. Rather than a series of individual measures, or approaches, it combines innovative tried-and-tested measures including the fields of CCA, DRM, ecosystem management and social protection into a full package (i.e. a comprehensive approach). These measures aim to manage risks by avoiding, reducing, transferring, retaining or transforming risks linked to the hazards’ spectrum, including extreme weather events and slow-onset processes (GIZ, 2019; Mechler et al., 2019; UNFCCC, 2019).

CONDUCTING COMPREHENSIVE RISK ASSESSMENT

3.1 GENERAL WORKFLOW AND APPROACHES

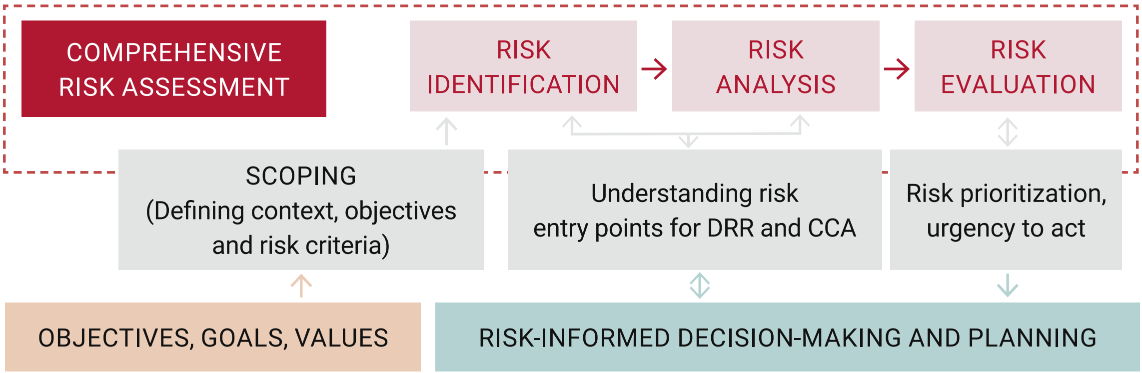
KEY MESSAGES

A CRA addresses the complexity and deals with the uncertainty related to a comprehensive risk perspective. It applies a mix of quantitative, semi-quantitative and qualitative approaches. It is case specific and action oriented, with a significant participative element.

3.1.1 Recommended phases: scoping, risk identification, risk analysis and risk evaluation

With ISO 31000 on risk management (ISO, 2018) and its more specific guideline on risk assessment techniques – ISO 31010 (ISO, 2019) – a well-accepted generic standard workflow for risk assessment exists that is taken up to a large degree in disaster risk and climate risk guidelines, studies and reports. The ISO 31000 workflow proposes the following phases of a risk assessment (figure 3): scoping (to prepare the risk assessment), risk identification, risk analysis and risk evaluation. The risk assessment finally prepares the phase of risk treatment, which refers to selecting and implementing options for addressing and reducing risk. Risk communication and consultation are conducted throughout the whole process. The recommendations in this guidance are structured along the usual steps of any risk assessment.

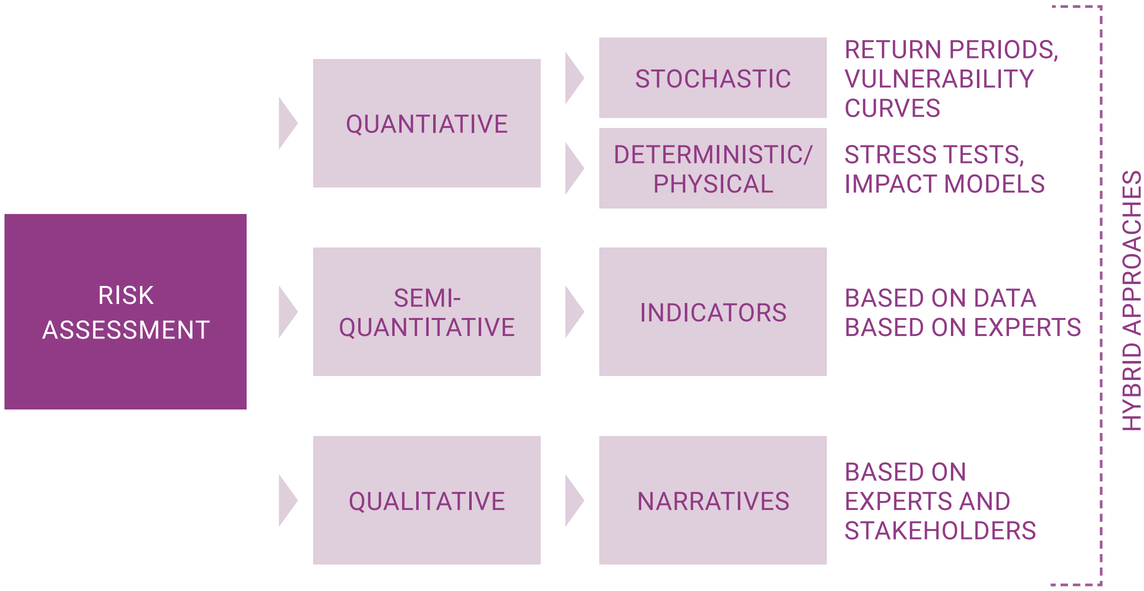
Figure 3. Phases of a risk assessment according to ISO 31000 and the relationship with risk-informed decision-making and planning



Note: Scoping is preparing the risk assessment. The risk assessment itself is structured into risk identification, risk analysis and risk evaluation.

General approaches of a risk assessment can be divided into quantitative, semi-quantitative and qualitative approaches (see figure 4), which are described briefly in the subsections below.

Figure 4. General approaches to risk assessment



3.1.2 Quantitative approaches

Quantitative approaches aim at providing quantitative estimates of risk with respect to a set of given loss metrics, including for instance, direct economic consequences (e.g. due to physical damage to the exposed assets or to business interruption), number of casualties/fatalities/displaced people and loss of capacity of infrastructure. Quantitative approaches are usually based on observations and statistical approaches (for the past and current situation) or on models of physical impacts. They require high-quality data, technical information and skills in multiple disciplines.

Impact models for modelling the direct physical impact of climate change and their spatial distribution have been successfully applied at various spatial scales in hydrology (e.g. modelling water availability, water quality, floods or droughts), in the cryosphere (e.g. glacier melt or snow melt), for natural hazards (e.g. landslides or mudflows), in agriculture and forestry (e.g. impact of climate change on vegetation), in biodiversity (e.g. impact on phenology), for human health and others.

While physical models implicitly consider some aspects of vulnerability (mainly susceptibility to direct damage), they usually do not model consequences for exposed elements. Therefore, they provide only a part of the information necessary to assess risks. Furthermore, for many relevant climate impacts such as landslides and mudflows, pest and diseases in agriculture or human health, risk models either do not exist or are not yet accurate enough.

Quantitative models from the insurance sector estimate financial losses and damages with statistical approaches typically as a function of hazard and vulnerability based on historical impact observations. While such models might give useful information for risk prioritization, they have a limited suitability for understanding future risks and for spatially explicit risk analysis. Therefore, they are less suited for identifying entry points for risk reduction and adaptation in the context of climate change.

3.1.3 Semi-quantitative approaches

Semi-quantitative approaches often use indicators as a means to measure risk and its underlying components and factors. Indicators can be populated with data but can also be populated through expert- or stakeholder-based knowledge elicitation. Indicators are a common approach when information from different sources and of a different nature must be combined. Indicators can be aggregated in a school-grade-type approach to composite indicators including methods such as using arithmetic or geometric means, often applying a weighting scheme to address the different relevance of single factors for an overall result. Examples of risk assessments based on composite indicators on the global scale are the INFORM risk index (Marin-Ferrer et al., 2017) or the global climate risk index (Eckstein et al., 2019).

The GIZ *Vulnerability Sourcebook* (Fritzsche et al., 2014; Zebisch et al., 2021) and its *Risk Supplement* (Zebisch et al., 2017) propose a bottom-up indicator-based approach using impact chains that are developed in a participative manner and that are case study specific. Indicator-based approaches require several subjective decisions on how indicator values are normalized, aggregated and weighted. At the same time, indicators are often the only way to compare, process and aggregate heterogenous information for single risk components in at least a semi-quantitative way.

3.1.4 Qualitative approaches – expert- and stakeholder-based assessment

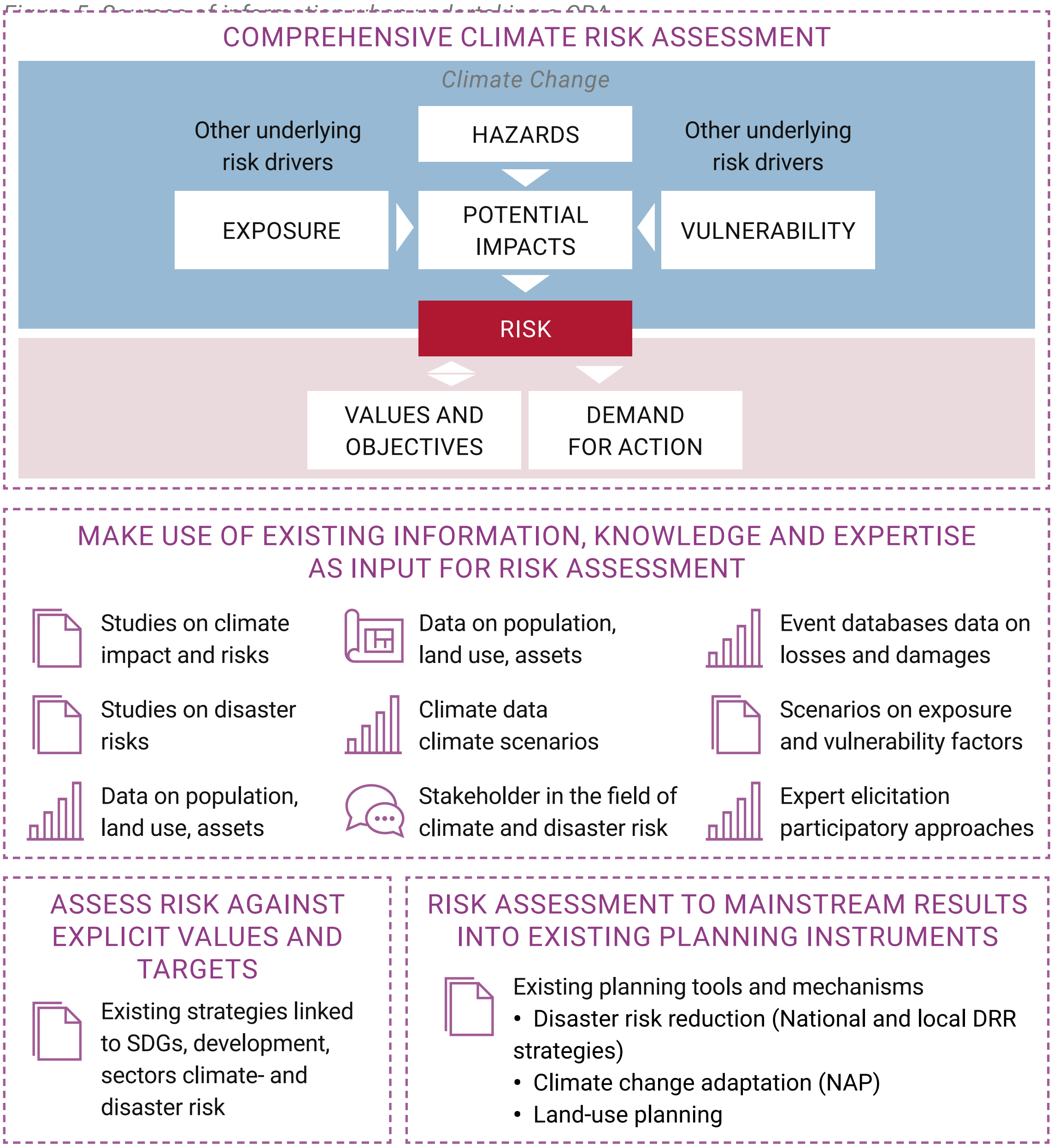
Expert elicitation processes, as well as techniques such as systematic reviews, are useful to summarize and evaluate findings or help to fill knowledge gaps where insufficient data are available. Any expert approach should be as structured and transparent as possible with respect to the selection of experts, the data-collection technique, the elicitation mode (e.g. in-person, online or hybrid) or the process for synthesizing individual elicitations into a group judgment (Zommers et al., 2020).

Expert elicitations have some challenges such as the potential bias of the expert(s) (which could be avoided by involving several experts and stakeholders from different target groups), the high effort required and the limitations in replicability. Despite these challenges, structured expert elicitation approaches are increasingly being used in a variety of fields including environmental and climate science. The key risks and burning embers diagram within the IPCC Working Group II process (Zommers et al., 2020) is another good example for an expert-based risk assessment. Several national climate risk assessments (e.g. New Zealand and the United Kingdom of Great Britain and Northern Ireland) and sector-specific assessments (e.g. the climate-resilient water, sanitation and hygiene sector by the United Nations Children's Fund and the Global Water Partnership) base their analysis strongly on expert involvement (Warren et al., 2016; UNICEF and Global Water Partnership, 2017; Ministry for the Environment, 2019).

3.1.5 Hybrid approaches – the reality in risk assessment of complex systems

With a deeper understanding of the complexity and the systemic character of risk, there is a paradigm shift away from probabilistic modelling of single hazards towards hybrid approaches. "There is no doubt that the nature of risk information is and will continue to be quantitative, but the focus on probabilistic modelling and homogeneous data sets is giving way to a future that is less definitive and more accurately representative of the world as it is" (UNDRR, 2019a). Despite many advances in risk quantification, expert judgment remains at the heart of the assessment, when it comes to aggregating and synthesizing information and to drawing conclusions. Objective risk data, for instance on hazard or physical impacts, require subjective prioritization and normative judgments (figure 5). In this process, it is important to understand the underlying assumptions and limitations of a risk assessment. This requires transparency and close interaction between those who conduct the risk assessment and those who commission or use it (Adger et al., 2018).

Figure 5. Sources of information when undertaking a CRA



Notes: Risks are assessed and evaluated against existing strategies and targets and the risk assessment is designed in a way that allows results to be mainstreamed into existing planning instruments. NAP = national adaptation plan.

3.2 COMPREHENSIVE RISK ASSESSMENT AND ITS SPATIAL COMPONENT

KEY MESSAGES

Most of the information analysed in a risk assessment has a spatial component, and can and should be mapped. Maps are an efficient means to help understand and communicate risk and its underlying factors, to compare regions and to prioritize actions. Hazard and exposure data are usually available quantitatively and can be visualized directly on maps. Some of the vulnerability data are available as qualitative information such as narratives, which can be mapped through participatory approaches. Using an indicator-based approach allows spatial overlay of hazard, exposure and vulnerability maps in order to identify risk hotspots.

Single factors of a risk assessment (e.g. climate data, past hazard event locations and extents, population distribution, transport infrastructure, location of cropland and population demographics) can usually be characterized in a spatially explicit manner. Maps are an excellent tool for communicating different levels of risk in different areas and identifying spatial hotspots that may have a particular need for risk reduction or adaptation measures, and which should be analysed in more detail:

- Spatial information on the magnitude, frequency and duration of specific weather or climate-related events (hazards) for the current situation can often be retrieved from observations (e.g. weather station data), interpolated data or re-analysis data. Parameters of potential future weather or climate-related projections can be retrieved from climate models and their simulated climate scenarios. One limitation is the spatial resolution (scale), which is often too coarse (e.g. >100 km per grid cell) to capture the underlying spatial heterogeny adequately (e.g. in mountain regions). The limited ability of climate data to show extreme values with appropriate accuracy is another constraint. Non-climatic hazards can also be mapped, depending on the availability of national event databases or the suitability of global event databases.

- Exposure, for example in terms of the presence of exposed elements and their spatial density, can often be mapped well for the current situation based on existing statistical data or information derived from Earth observation. Options to map potential future exposed elements are still limited.

- Vulnerability is more complex. Certain aspects of physical vulnerability and susceptibility can often be mapped well. Social and economic vulnerability factors can be aggregated on the level of administrative units, even if the resolution is often not high enough to match the spatial representations of hazards and exposure. More hazard-specific vulnerability factors can often only be described qualitatively by means of narratives.

- Potential direct impacts (e.g. the impact of a drought on vegetation) can be mapped if specific direct impact measures are modelled (e.g. normalized difference vegetation index anomalies, soil moisture anomalies or vegetation status). Complex and indirect impacts can be assessed semi-quantitatively (e.g. with indicators) or qualitatively. In addition, in the latter case, it is recommended to assign potential impacts to geographical regions (e.g. eco-climatic zones).

- For local assessments based on highly participatory approaches, it makes sense to use hand-drawn maps or to draw on maps to locate areas where hazards occurred, or where vulnerability or risk to certain hazards (e.g. landslides) is high (figure 6). These approaches are in addition to generating information to understand the risk and risk factors that are highly valuable in raising awareness and generating acceptability.

- Using an indicator-based approach allows overlay of hazard, exposure and vulnerability maps in order to highlight regions with potentially critical risk characteristics (hotspots). To obtain risk maps that show the result of a consistent risk assessment and not the single underlying components only, it is necessary to have operational procedures to combine single factors (hazard, exposure, vulnerability or potential impacts) into a final risk map. Climate Risk Assessment for Ecosystem-based Adaptation gives good examples for such an indicator-based approach for risk mapping (GIZ, Eurac and UNU-EHS, 2018). Section 3.8 provides further information on how to assess the resulting risk.

Figure 6. Identifying and mapping regions prone to landslides on a map with local stakeholders

Source: © M. Zebisch

3.4 SCOPING – PREPARE A COMPREHENSIVE RISK ASSESSMENT

KEY MESSAGES

"Scoping" means to design a risk assessment in such a way that it can support decision-making and planning by taking into account existing objectives, goals and values and the existing policy and planning framework. For designing a CRA, applying the 10 principles for a CRA would be a good starting point. A very important aspect of scoping is to define a target system and risk criteria for the risk assessment (e.g. what are "adverse consequences" or what is a "very high" or "intolerable" risk?)

Scoping is possibly the most important phase to make a risk assessment comprehensive. In this phase, the risk assessment is linked to the context and the set-up is defined. Scoping can be organized around some key questions (figure 7).

Figure 7. Key questions and considerations for the scoping phase

IDENTIFYING CONTEXT, OBJECTIVES

Policy context: existing risk management strategies and plans, NAP, other plans and strategies. How does this risk assessment relate to these documents?

Underlying objectives, goals, values → risk criteria:

Which values do you want to protect?

Which targets (e.g. SDGs) do you want to achieve that might by impended by climate-related hazards?

Which adverse consequences should be absolutely avoided?

→ criteria to decide if a risk is high or low or, if it is tolerable or intolerable and if action is required

Output of risk assessment: Which process should the risk assessment inform?

Which requirements does this imply for the risk assessment?

DESIGNING GOVERNANCE AND PARTNERSHIP

Risk assessment governance: Involve decision maker from administration that are committed to DRR and CCA

Stakeholder involvement: weather service, line ministries, external experts, universities, DRR and CCA practitioners, …

Resources, time frame: time and persons available. A comprehensive risk assessment can take from several months up to 3 years

DEFINING SCOPE AND METHOD SET-UP

Hazards: focus on specific hazards?

Human and ecological systems: focus on specific systems and/or sectors? e.g. ecosystems, water, infrastructure, agriculture, human health, energy, transport, …

Spatial scale: e.g. national, district, municipality, …

Spatial units: e.g. eco-climatic zones, administrative units, regular grid …

Temporal reference: e.g. 30-year periods: reference (1961–1990),

current situation (1991–2020), future situation (2031–2060), (2071–2100)

Methodological set-up: hybrid, data driven, Indicator based, mainly bottom-up / participative …

UNDERSTANDING DATA AVAILABILITY AND DEVELOPING A DATA MANAGEMENT PLAN

Existing data

- Climate data and climate scenarios
- Data on non-climate hazards
- Event and impact data
- Data on exposure (population, infrastructure, ecosystems, …)
- Data on vulnerability (socio-economic data, …

Common data infrastructure and data management plan

The main challenge is to find the right balance between a targeted approach and a wider approach while considering the objectives, time available and resources. A CRA can take from several months up to 3 years to complete. Scoping is best conducted through a combination of desktop research and scoping workshops with stakeholders and experts.

For a CRA in the context of climate change following the 10 key principles given in section 1.2, in the scoping phase, it is particularly important to:

- Define the objectives and risk criteria in a way that reflects existing goals and targets such as SDGs, national or local development goals and the demand for climate risk information from a decision-making and planning perspective. Key questions include:
  - Which values should be protected (e.g. human lives, ecosystems, social cohesion)?
  - Which targets (e.g. SDGs) should be achieved but which might be impeded by climate-related hazards (e.g. food security)?
  - Which adverse consequences should be absolutely avoided (e.g. loss of food security)?
- Design the risk assessment as a highly participative process and involve experts and stakeholders from a wide range of disciplines and all levels. In addition, traditional, local and indigenous knowledge should be considered. Stakeholders responsible for adaptation planning and risk reduction and implementation should be involved in the risk assessment from the beginning to:
  - Include stakeholder knowledge and expertise.
  - Create a common understanding and a common evaluation of risk.
  - Support commitment for risk management and the transition from understanding risk to risk reduction actions.
- Consider in the set-up a wider perspective regarding hazards (extreme events, slow-onset processes and trends) and exposed systems and sectors.
- Put risks to human and ecological systems rather than risks from hazards in the centre of the assessment (Reisinger et al., 2020).
- Be aware that a complex risk analysis has to be based on hybrid approaches with some quantitative elements (e.g. for analysing hazards and direct impacts), some semi-quantitative elements based on indicators, and a lot of qualitative approaches such as storylines and structured assessments in order to understand and assess the complex interactions of hazard, exposure and vulnerability factors, potential impacts and risks.
- Always start by assessing current risks and decide carefully which risks and which risk elements (hazard, exposure, vulnerability) can and have to be projected into the future (e.g. risks related to sectors and systems with long-term decision horizons such as infrastructure, land-use planning or forestry).
- Design the risk analysis to be spatially explicit if the spatial scope requires this. Spatial units should be selected in such a way that they represent relatively homogeneous zones with respect to expected impacts and risks. Eco-climatological zones (e.g. mountains, coasts and urban areas) are recommended.

The set-up of a risk assessment can be different depending on the objectives and the context of the assessment. Table 1 compares the set-up of a typical disaster risk assessment (in a pre-Sendai Framework style) and a typical climate risk assessment. A CRA would integrate elements from both set-ups based on the specific context and the requirements defined by the decision-making and planning process.

Table 1. Comparison of typical set-ups for risk assessments (disaster versus climate risk)

AREAS OF COMPARISON	DISASTER RISK ASSESSMENT	CLIMATE RISK ASSESSMENT
Main focus and typical structure of assessment	Focus is on single risks related to specific hazardous events (e.g. floods, earthquakes or various human-made hazards). Risks are often reported per "capital" or "consequence categories" (e.g. people or assets). Focus is on physical vulnerability and exposure as potential entry points for DRR. Multi-risk assessments are (still) rare.	Wide focus; structured by direct impacts and related risks on natural systems (e.g. water, ecosystems, soil and terrain) and risks related to (indirect) impacts on societal sectors (e.g. agriculture, forestry, water management, built-up areas, infrastructure, transport, health and tourism). Strong focus on vulnerability and exposure as potential entry points for CCA. Consideration of multi-risk linkages across sectors and multi-risk hotspots.
Type and character of hazards and impacts	Focus is on well-defined hazardous events, their likelihood (expressed by return period or recurrence time) and their impacts (often quantified in terms of L&D, usually in monetary units).	Various types of climate-related hazards (from extreme weather events to slow-onset processes) and their climate change dynamics. Focus is on their magnitude as well as their duration and frequency. Potential impacts are mainly addressed by their magnitude. An explicit analysis of L&D is usually lacking.
Time period / time reference	Usually no specific time reference. Implicitly: past and current conditions under the assumption of stationarity (no changes over time) as a precondition for a probabilistic assessment.	Typically, 30-year time slices, for example: ◆ World Meteorological Organization (WMO) reference (1961–1990); ◆ Current conditions (e.g. 1991–2020); ◆ Near future (e.g. 2031–2060); ◆ Far future (e.g. 2071–2100) (only if relevant for the specific decision-making and planning context).

Spatial focus/ spatial units	Depend on hazards. Can be focused on areas affected by a given event (e.g. floods and earthquake) or aggregated to larger areas.	Full area (e.g. country), often split into geographic subunits (e.g. provinces). Recommended: eco-zones (e.g. mountains, foothills, coast) and azonal units (e.g. cities).
Methods	Preferably impact models and probabilistic assessment based on past observations and stochastic simulations, complemented by expert assessments.	Hybrid approaches of climate and impact models, indicator-based approaches, and expert and participatory approaches.
How uncertainty is addressed	Uncertainties are often accounted for at the hazard level and propagated to subsequent assessment stages. Uncertainty in vulnerability and especially in impact measures is seldom considered thoroughly.	Uncertainty on future climate is addressed by using climate scenarios. Model uncertainty in climate models is reflected through climate model ensembles allowing median and upper and lower boundaries (e.g. through percentiles) to be reported. Hardly any uncertainty information on exposure, vulnerability or impact is considered. Uncertainty of final assessment can be addressed by qualitative confidence levels.
How risk is measured and evaluated	Quantitatively as a likelihood of a specific type and level of consequence. Risk levels (e.g. high, medium, low) might be assigned in a risk matrix as a function of the likelihood of a consequence versus the consequence itself. However, clear risk criteria are often missing.	Mostly severity of consequences, expressed qualitatively in risk levels through a comprehensive expert or indicator-based evaluation based on heterogeneous input information (impact models, scientific knowledge, expert knowledge, stakeholder knowledge). No established concepts to express likelihood. No standards for a final evaluation. Options include concepts like “relevance of the risk” or “urgency to act”.

3.5 RISK IDENTIFICATION

KEY MESSAGES

"Risk identification" aims to identify relevant risks starting from existing knowledge and expert input. In addition, key affected sectors and geographic regions where to conduct an in-depth analysis are selected, an initial list of suitable data sources is created and potential future changes are determined.

Risk identification starts with a first identification of the relevant risk(s) with a wider focus based on existing knowledge, such as reports, event databases and expert knowledge. It ends with a selection of hazards, impacts and risks that will be considered in the risk analysis phase (figure 8). Risk identification can be organized in a desktop-based format and should always include a workshop with the stakeholders identified in the scoping phase (figure 9). Box 1 provides some questions that were put together to guide the discussions on this phase.

BOX 1. KEY QUESTIONS FOR THE RISK IDENTIFICATION PHASE

Which hazards, impacts and risks are relevant?

- Which climate-related hazards, impacts and related risks occurred in the past?
- Which additional hazards, impacts and related risks are likely to gain importance in the future?
- Which hazards, impacts and related risks should be considered more in-depth in the risk assessment?

Who and what is at risk? What are the exposed elements? Which values are at stake?

- Natural and physical systems (e.g. ecosystems, water and infrastructure)
- Humans and their livelihoods (including gender aspects and social groups)
- Societal sectors, for example, agriculture, tourism and energy production
- SDGs

Figure 8. Example of results of risk identification steps: list of relevant hazards, their impacts, affected sectors, affected regions, potential data sources, potential future change and an evaluation of relevance for the risk assessment

STUDIES ON DISASTER RISKS

EVENT DATABASES DATA ON LOSSES AND DAMAGES

STUDIES ON CLIMATE IMPACT AND RISKS

EXPERT AND STAKEHOLDER INPUT (workshops, interviews, questionnaires)

CURRENT STATE						POTENTIAL FUTURE STATE		RELEVANCE FOR RISK ASSESSMENT
Hazard (including magnitudes, frequency, trends, …)	Observed impacts (including magnitudes, frequency, trends…	Link to climate-related hazards and climate change	Where? Affected regions	Affected systems and sectors	Potential data and information sources	Potential future evolution	Potential data and information sources	
Droughts (frequent, increasing duration)	Yield losses (frequent, increasing), water shortage (severe)	Triggered by reduced precipitation and higher evapotranspiration	Mountains, lowlands,	Agriculture, water sector	Hydro-Met Service, EM-DAT	Increasing droughts and related impacts (more frequent, higher magnitude, longer duration)	National climate impact report	High
Vector-borne diseases (common)	Malaria and dengue fever cases	Supported by increasing temperatures	Lowland, coastal regions. Only local hotspots	Human health	World Health Organization, national health service	Increasing risk from malaria	--	Moderate

Figure 9. Risk identification by stakeholders in Pakistan for a mountainous region

Source: © M. Zebisch

3.6 RISK ANALYSIS – GENERAL CONCEPTS AND CONCEPTUALIZATION WITH IMPACT CHAINS

KEY MESSAGES

"Risk analysis" is about analysing the risk components (hazards, exposure and vulnerabilities), understanding their interrelationships as well as the resulting cascading impacts, describing the potential for adverse consequences for selected human or ecological systems and assigning risk levels (e.g. from very low to very high). For a "comprehensive" risk analysis of complex risks, a clear conceptualization of risks with so-called "impact chains" is recommended.

Risk analysis analyses each selected risk, the underlying and interrelated risk factors (hazards, exposure factors and vulnerabilities) and assesses the resulting risk with data-driven, semi-quantitative and qualitative methods. Box 2 provides some questions that were put together to guide the discussions on this phase. The subsections below discuss considerations on how to implement the risk analysis.

BOX 2. KEY QUESTIONS FOR THE RISK ANALYSIS PHASE

What is causing the risk? Understanding risks (current and potential future states).

- Which factors and processes lead to specific risks posed to specific human or ecological systems (hazards, exposure and vulnerability)?
- How are hazards, impacts and risks interlinked (what leads to what – cascades, compounds and feedbacks)?
- What is the effect of climate change on raisk factors (including the current state)?
- What are the other internal and external underlying risk drivers affecting vulnerability and exposure (e.g. land degradation, socioeconomic trends, population development and conflicts)?

How adverse are the potential consequences (risk) and factors (current and potential future states)?

- How "severe" are hazards and impacts (regarding potential adverse consequences)?
- How exposed is the system (number and density of exposed elements, economic value and relevance)?
- How vulnerable are the exposed elements (generic and specific to hazards/impacts)?
- How adverse are the potential consequences?

Is it possible to address likelihood and confidence?

- How well understood is the potential for adverse consequences to occur, and how much does this potential depend on climate change, policy design or socioeconomic variables?
- Is it possible to quantify the likelihood of occurrence of consequences? If not, can the potential be characterized in some other way that helps stakeholders decide whether to take this potential seriously, and how it compares with potential adverse consequences from alternative courses of action?
- How confident are the risk assessment statements? What are sources of uncertainty?

3.6.1 Concept of impact chains

For risk identification and risk analysis, the use of impact chains is recommended to conceptualize complex risks (figure 10). Impact chains are conceptual models that follow the comprehensive risk framework. Impact chains are the core element in the climate risk assessment approach of the GIZ *Vulnerability Sourcebook* and its *Risk Supplement* (Fritzsche et al., 2014; Zebisch et al., 2017, 2021). Usually, impact chains are developed in a context- and case-specific manner, through a participatory approach (e.g. during risk identification workshops) (figure 11). They can be refined and validated for risk analysis. Impact chains can be used to understand risks from a conceptual perspective and can serve as a structure for semi-quantitative assessment (e.g. with composite indicators or a structured qualitative assessment). Overall, impact chains have been applied in more than 20 national and subnational climate risk assessments, with one of them being the climate risk assessment for Madagascar showcased in Annex 1 of this guidance.

Figure 10. General structure of an impact chain

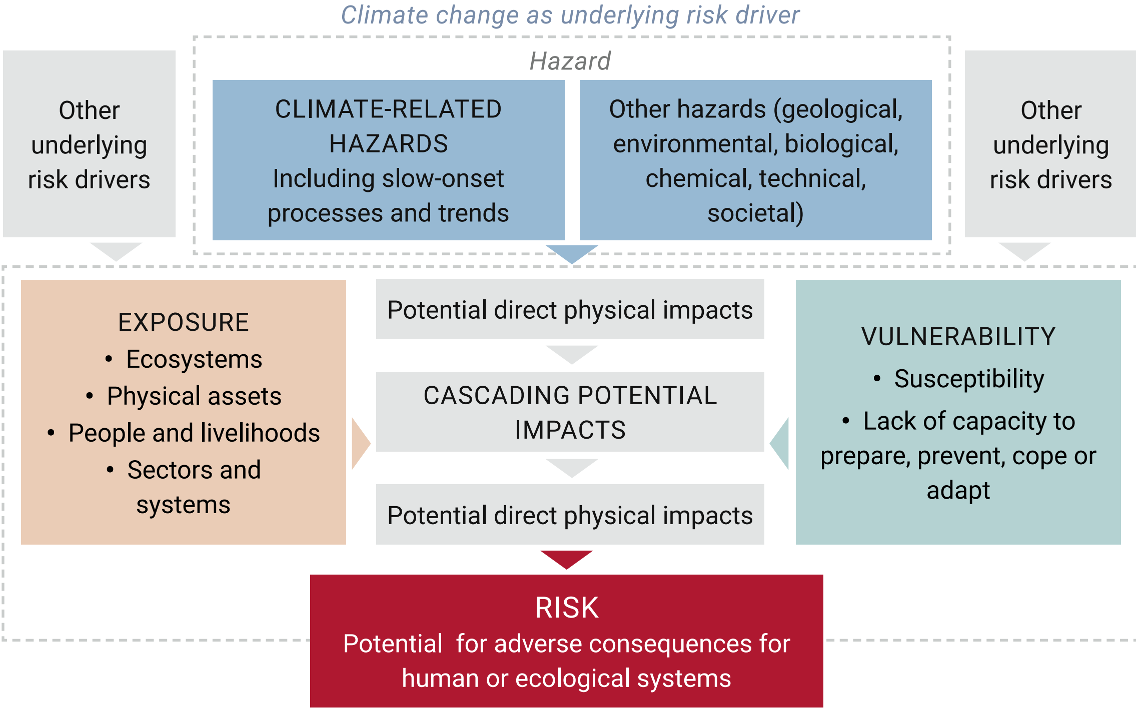


Figure 11. Developing impact chains during a workshop with stakeholders in Japan

Source: © M. Zebisch

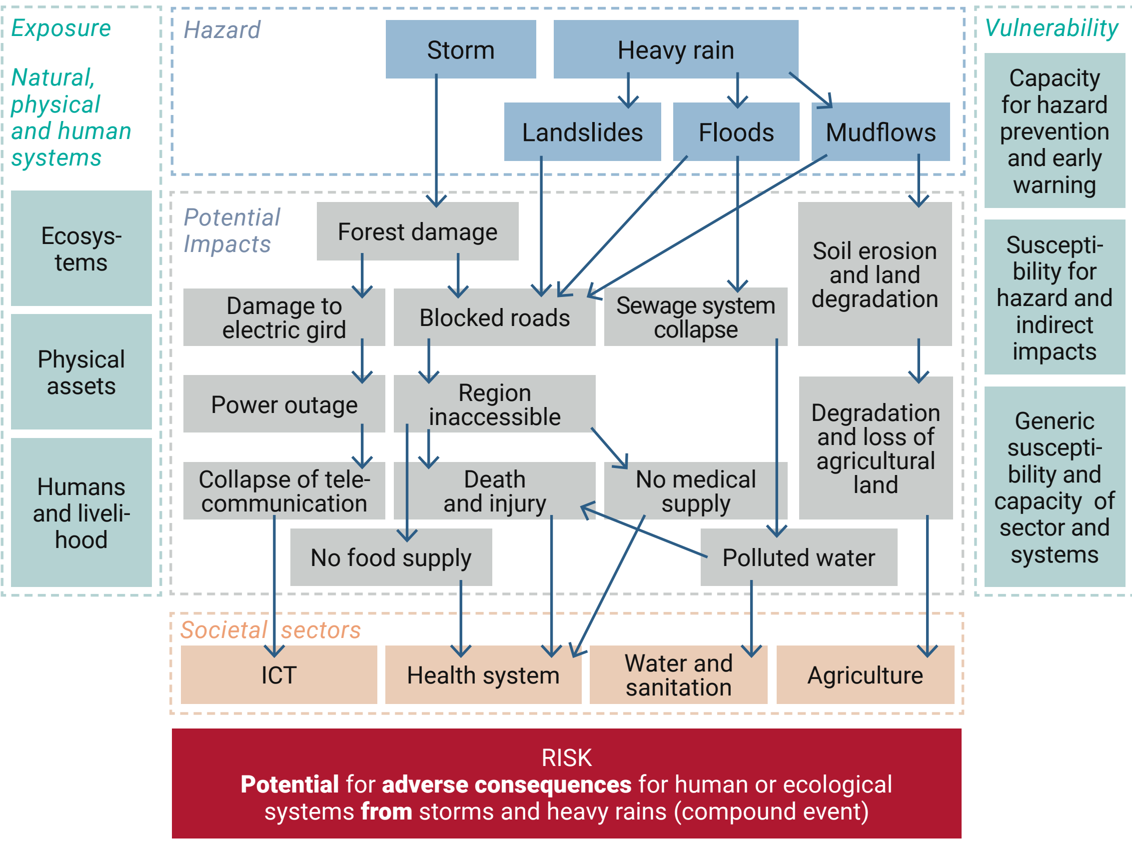
3.6.2 Conceptualization of cascading and compounding hazards, impacts and risks

Hazards and risk are not limited to a single factor-to-factor relationship. Even a single hazard is usually characterized by cascading effects of direct and indirect impacts, which are in turn affected by several vulnerability and exposure factors (figure 12). Often, more than one hazard (multi-hazard) affects a single system (at the same time). Hazards can trigger other hazards and cause impact cascades that lead to impacts and risks to multiple natural, physical and human systems including humans, their livelihoods and societal sectors. Whether an event or process should be addressed as either a hazard or an impact often depends only on the perspective. An impact of one hazard can again become another hazard. An impact turns into a risk if the adverse consequences on human or ecological systems that pertain to it are relevant to a risk assessment.

Risks are often related to each other and lead to a multi-risk situation. For instance, the agricultural sector is exposed to multiple interrelated risks from increasing temperature, droughts and heavy rain events.

If multiple hazards occur simultaneously or in a sequence, they are often defined as compound events. Compound events can be: (a) two or more extreme events occurring simultaneously or successively, (b) combinations of extreme events with underlying conditions that amplify the impact of the events or (c) combinations of events that are not themselves extremes, but which lead to an extreme event or impact when combined. The contributing events can be of similar (clustered multiple events) or different type(s) (IPCC, 2012).

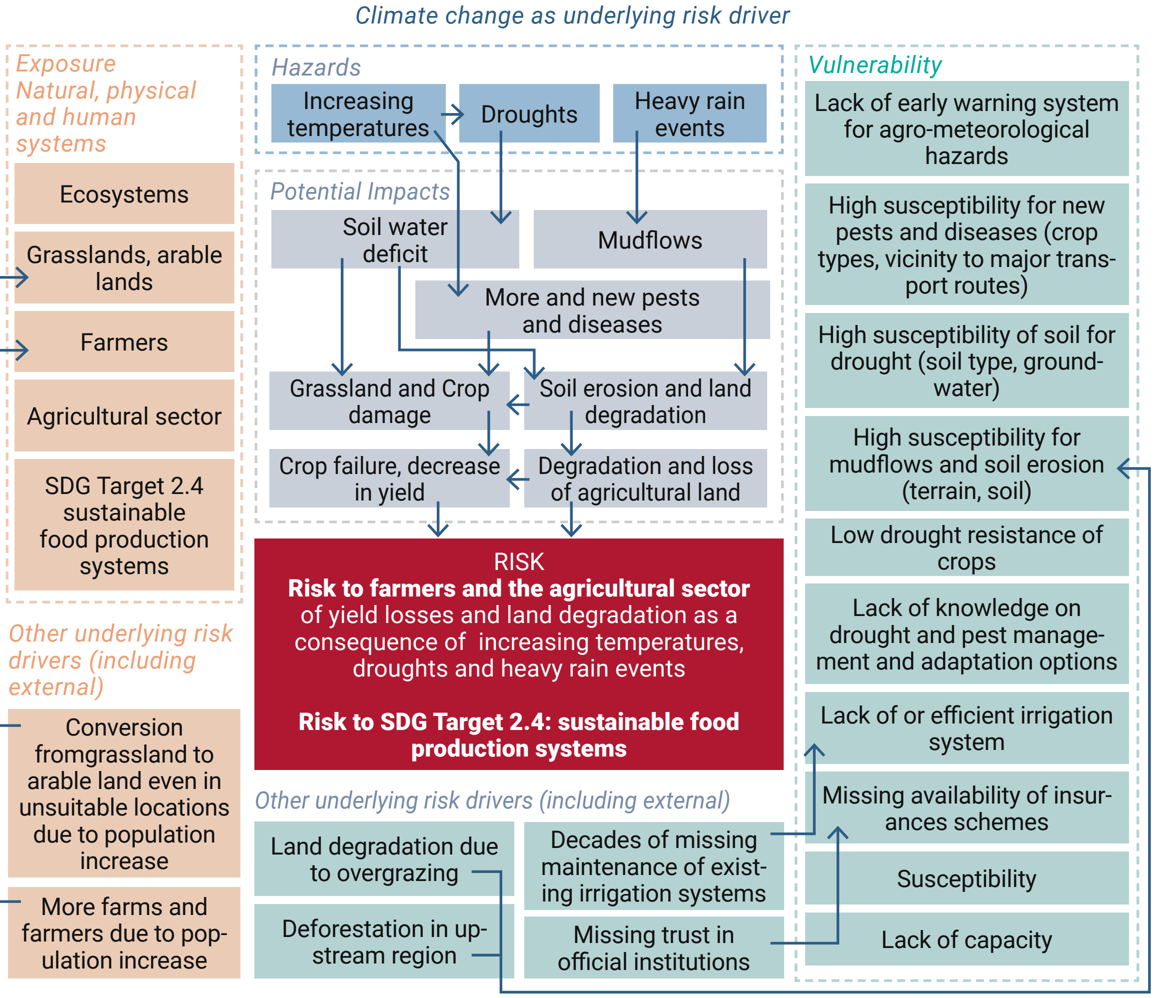
Figure 12. Conceptualization of cascading and compounding hazards and impacts and their adverse consequences for various human and ecological systems within an impact chain



Note: This impact chain represents a "risk from hazard" perspective with a focus on extreme events as typical in the DRR field.

Figure 13 shows an example of an impact chain that conceptualizes climate risks to farmers and the agricultural sector in a comprehensive way. It is based on a real case from Central Asia where mudflows, droughts and increasing temperatures are leading to increasing risks of crop failure and loss of agricultural land for farmers through a chain of cascading hazards and impacts. While the risk is triggered by climate-related hazards, it is also strongly determined by the vulnerability of the agricultural sector in this region. The sector is affected by a high physical and ecological susceptibility (e.g. high susceptibility to soil erosion and droughts), a lack of capacity (e.g. lack of efficient irrigation systems and lack of knowledge on drought management) and high exposure (high density of farms in the region). High exposure and vulnerability are accelerated by external risk drivers such as land degradation due to overgrazing, as well as the increasing conversion of grassland to arable land due to in-migration. The agricultural sector has been chosen as the main system of interest for this specific risk assessment (risk to agricultural sector). This risk can also be interpreted as a risk in the context of SDG target 2.4 on "sustainable food production systems".

Figure 13. Example of an impact chain that conceptualizes risks to farmers and the agricultural sector



Note: Grasslands and agricultural fields in a mountain valley in Central Asia are highly vulnerable to climate-related hazards due to overgrazing, soil erosion and land degradation. Relevant hazards include increasing temperatures and droughts as well as heavy rain events. All three hazards trigger different hazard and impact cascades that lead to direct and indirect impacts that are promoted through ecosystems and agricultural systems. This impact chain represents a "risk to human or ecological systems" perspective, typical for the CCA context and recommended for a comprehensive risk perspective.

3.6.3 Considerations when conceptualizing complex risks with impact chains

The key question when formulating risk factors is what leads to the risk? Factors should be formulated as precisely as possible (e.g. “increasing temperature” or “high temperatures” and not just “temperature”). Vulnerability factors relating to a lack of capacity should be identified as a “lack of …” (e.g. “lack of knowledge on drought management”).

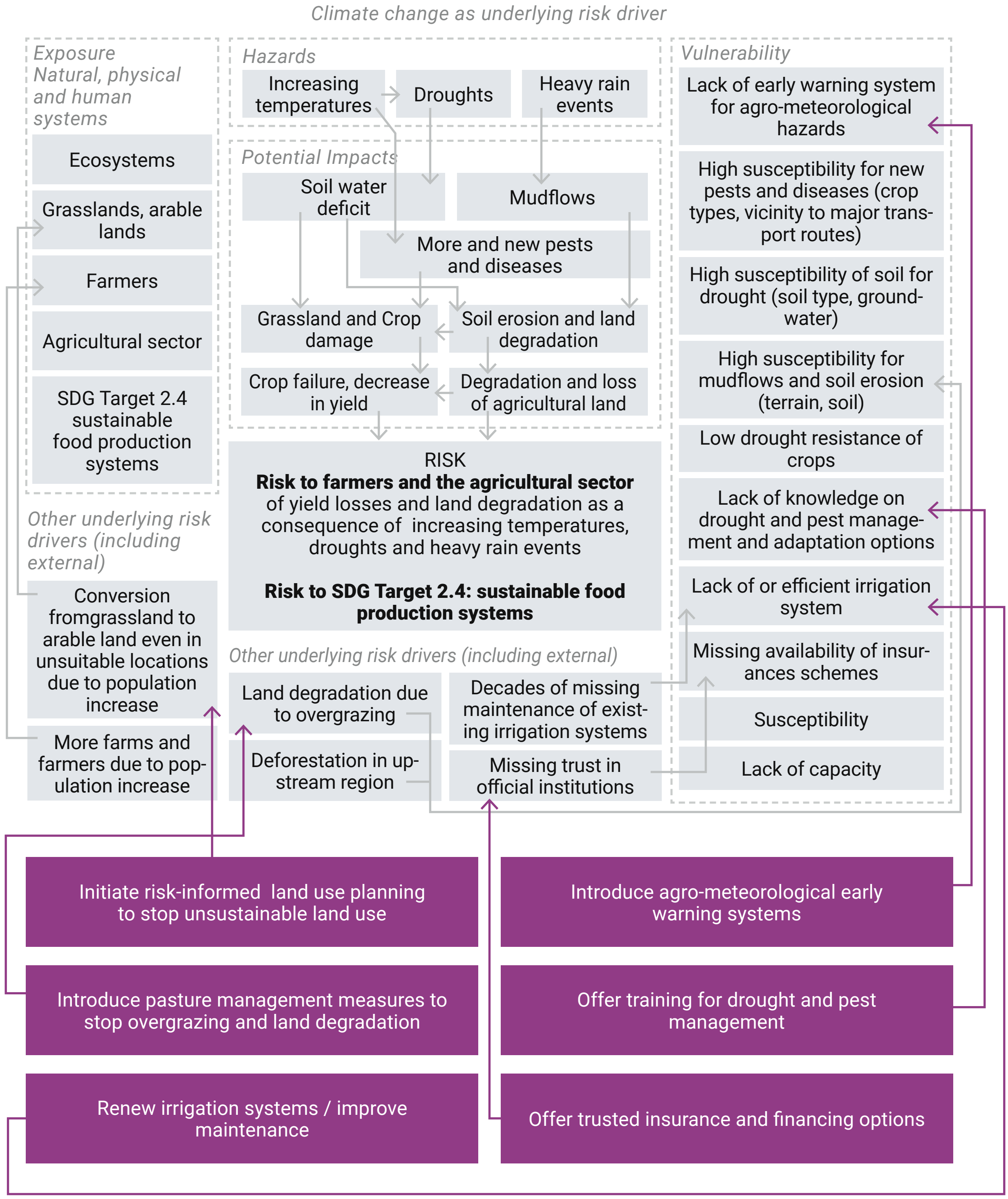
Multiple risks can be broken down into parts to keep the complexity manageable. However, in a synthesis phase, the interrelationships of risks within one sector or even across sectors should be considered and evaluated.

It is important to conceptualize cascades through the systems. Often, climate-related hazards have direct impacts on ecosystems (e.g. soil erosion) that then indirectly affect human systems (e.g. the agricultural sector). Conceptualizing these cascades is important to allow identification of risk reduction and adaptation options that can interrupt these cascading effects.

3.6.4 Identifying adaptation and risk reduction options with impact chains

If developed in a context-specific manner with stakeholders and validated by experts, impact chains can serve as a basis for discussion on risk reduction and adaptation options – even without the need to further quantify the individual risk factors. Impact chains often reveal weak spots in the system or relevant underlying risk drivers that could be controlled better. Due to the conceptualization of hazard and impact cascades, measures of different types can be identified, such as early warning systems (EWSs), ecosystem-based adaptation (pasture management), capacity-building (training), technical measures (improved irrigation systems) or economic measures (offering trusted, relevant and affordable climate risk or agricultural insurance or other types of risk finance instruments and financing options). Figure 14 continues the example of an impact chain for unpacking the risk to farmers and the agricultural sector due to increased temperature, droughts and heavy rain events with adaptation options.

Figure 14. Example of how impact chains can be used to initiate a discussion on adaptation options to reduce the risk to the agricultural sector (figure 13)



3.7 RISK ANALYSIS – HAZARDS, EXPOSURE AND VULNERABILITY

To analyse hazards, climate-related hazards (extreme weather events, slow-onset processes and trends) as well as their relationship with non-climatic hazards should be taken into account. Analysing extreme events, slow-onset processes and trends in the context of climate change brings methodological challenges. Probabilistic approaches with a focus on events and their statistics based on past observations are falling short in the context of climate change. Options discussed are the introduction of climate-impact-related thresholds and the qualitative concept of severity to compare very different types of hazards and their impacts.

When analysing exposure, consideration of a sequence of exposed systems (e.g. the ecosystem, infrastructure, human lives, livelihoods and social sectors) to be able to model and understand the cascading impacts from natural systems to society is recommended. Exposure is a highly dynamic risk factor that requires consideration of current trends in population, socioeconomic development and environmental factors.

Analysing vulnerability should include all relevant environmental, physical, technical, social, cultural, economic, institutional or policy-related factors that contribute to susceptibility and/or a lack of capacity to prepare, prevent, cope or adapt. Understanding vulnerability is a key element in analysing entry points for adaptation and risk reduction options. As for exposure, underlying risk drivers such as land degradation, poverty or conflicts may affect vulnerability today or in the future, to an extent that could possibly contribute to an increase of climate-related risk even more than a single hazard.

How to model or analyse potential cascading impacts as a result of the interrelation of hazards, exposure and vulnerability and how to describe the resulting potential for adverse consequences on human or ecological systems depend significantly on the complexity of the selected risks and the resources available (e.g. data, models, knowledge, experts and time available).

3.7.1 Analysing hazards

Extreme weather events and slow-onset processes

The basis of a CRA in the context of climate change is the analysis and assessment of climate-related hazards. Climate-related hazards refer to complex physical processes which have spatio-temporal footprints that continuously vary in terms of the space in which they occur – from a city district (e.g. hail) to the planetary scale (e.g. El Niño) – and in the time they take to occur – from minutes (e.g. lighting) to centuries (e.g. sea-level rise).

When classifying climate-related hazards, it is recommended to distinguish between:

- Extreme weather events, in which the duration can vary from minutes to seasons, in some cases even to multiple years (e.g. heavy rain events, storms, floods, heatwaves or droughts). Extreme weather events are extreme deviations from a long-term normal, they have a start and an end, and can be described by their duration, magnitude and frequency. Frequencies can be translated into return periods/probabilities. Extreme weather events can be defined either as statistical extremes (e.g. days with precipitation above the 95th percentile) or by absolute thresholds (e.g. days with precipitation above 100 mm). Absolute thresholds are often defined in association with their potential negative impacts.
- Slow-onset processes (or trends) are long-lasting monotonic changes from a long-term normal (baseline) related to the effects of climate change (e.g. increasing temperature, aridity or sea level). Slow-

onset processes can be described by their change rate (e.g. 0.1°C warming per decade).

The term "slow-onset events" used in the policy context of the United Nations Framework Convention on Climate Change (UNFCCC) Warsaw International Mechanism Executive Committee for specific trends such as increasing temperatures or sea-level rise is somewhat misleading, as such processes are not an event that can be described by duration or frequency/probability, at least not on the timescale of decision-making. These processes are already taking place and will, unfortunately, last for the next hundred years at least and have a probability of 100%. Therefore, throughout this guidance, the term "slow-onset processes and trends" is used instead of "slow-onset events". These processes include increasing temperatures, desertification, loss of biodiversity, land and forest degradation, glacial retreat, ocean acidification, sea-level rise and salinization.

With climate change, extreme events are superimposed by and interlinked with, slow-onset processes, and can no longer be assumed as stationary. Increasing temperatures (trend) lead to increasing magnitude, frequency and duration of heatwaves (extreme event). An increasing sea level (trend) leads to increasing frequency and magnitude of storm surges. An increasing aridity (trend) increases the magnitude and duration of drought events. It is of utmost importance that the hazard assessment recognizes the effects of climate change on magnitude, frequency and duration of extreme weather events, which are already observable and have to be taken into account when assessing climate-related risks, even for the current state.

Relationship between climate-related and non-climate-related hazards

Non-climate-related hazards (e.g. geophysical or human made) should be considered in a comprehensive climate risk assessment insofar as they have a relationship with climate-related hazards or contribute to the vulnerability of socioecological systems.

Non-climate-related hazards can for instance:

- Be triggered by climate-related hazards (e.g. a heavy rain event can trigger landslides)
- Act as an underlying risk driver that increases vulnerability to climate-related hazards (e.g. soil degradation increases vulnerability to droughts, or infectious diseases or a pandemic might further increase the social and economic vulnerability to climate impacts)
- Occur concurrently with climate-related hazards and lead to so-called compound events (e.g. during a storm, flash floods, strong wind gusts and landslides might occur concurrently at the same spots, leading to compound effects)

Non-climate-related hazards can be classified according to the *Hazard Definition & Classification Review* (UNDRR, 2020a) into geological, environmental, technological, biological, chemical and societal hazards (figure 2, right side).

An important consideration when assessing climate-related hazards in a comprehensive climate risk assessment is the scale of frequency and duration in focus. DRR approaches often focus on high-impact low-frequency events (e.g. floods with a 100-year return period). This assumes that assessing risks related to such rare but severe "design events" and developing risk reduction measures for these design events can provide a buffer for preparing to confront all events of low magnitude but which are more frequent (e.g. floods with a 5-year return period).

In the context of climate change, this approach is often not useful. First, because the return periods of the past are no longer applicable for the future, and second, because the many adverse consequences of climate change are not the result of single high-magnitude events but of a generally deteriorating situation. In a specific region, increasing aridity might lead to droughts of relatively low magnitude every year. This constant stress might lead to long-term yield declines and loss of food security, which might force farmers to outmigrate.

To address this problem in a risk assessment, a focus on drought events with a 100-year return period would not make sense. Instead the focus could be laid on the complete picture of complex, accumulated and long-term impacts of events ad trends of all magnitudes.

Hazards in the context of current climate change

Climate change as an underlying risk driver is already altering the magnitude, frequency and duration of many climate-related hazards. Consequently, the DRR approach of using return periods of hazards based on historical observations to plan risk reduction measures for the future is not applicable in the standard way. Any quantitative and analytical method should take current trends and climate projections, at least for the near future, into account. Furthermore, hazards with a timescale longer than days (e.g. droughts) are better described by their duration and magnitude than by their frequency or return period. For trends such as increasing temperatures, neither frequency nor duration make sense. There are not yet established methods for quantifying and comparing hazards of various types, in a climate change context.

Theoretically, slow-onset processes can be reconducted to an event-based, probabilistic framework, for instance by setting thresholds on continuous parameters (e.g. on sea-level rise) and referring to the possible exceedances of the thresholds as individual events. However, caution should be exerted in extending this paradigm, since, for instance, concepts such as duration, frequency and probability might be ill defined.

In the context of DRR, this can be overcome by carrying out comparisons at the level of resulting impacts (i.e. focusing on the expected adverse consequences rather than on the hazardous process). Many of the loss metrics commonly used in probabilistic risk assessment such as average annual loss are independent of the underlying hazards and can therefore be used for multi-hazard risk comparison and assessment, at least for the current situation. Furthermore, this allows exposure and vulnerability factors to be considered specifically for the location of interest. However, not all hazards can be addressed consistently in a probabilistic framework, and an analytical approach might be too complex and resource intensive.

A more viable and simpler alternative is to apply a concept of "severity" to a hazard. Severity entails the potential for adverse consequences, although in a much less specific way with respect to analytical risk. To address the severity of a hazard means to implicitly already consider exposure and vulnerability of a system, which is not always done in a transparent way. A hazard of a given magnitude (e.g. a flood) could be severe for one system (e.g. critical infrastructure), but less severe for another system (e.g. agriculture). Categories (e.g. high, medium and low) can be introduced to indicate the severity levels associated with different extents of consequences. Such categories can efficiently group together different combinations of hazard parameters (e.g. intensity and duration) or analyse them independently if the hazard is a rapid-onset event or a slow-onset process or trend.

For instance, it could be decided that a sea-level rise (a trend) of more than 20 cm would be "highly severe" because thousands of people could lose their homes and land. In the same way, a drought that lasts longer than 1 month within the vegetation period could also be classified as "highly severe" as it could lead to crop failure. This categorization strongly depends on the specific location and related environmental conditions, as well as the considered hazard, since careful calibration and validation for operational use is required. By applying thresholds, trends are converted into events, which would potentially even allow probabilities or likelihoods (at least within one climate scenario) to be expressed. This calibration can be based on expert knowledge elicitation or empirical observations, or it might exploit analytical risk assessment tools, depending on the application and the available resources and time frame.

Impact-oriented hazard thresholds might allow different hazards to be compared in an intuitive way and enable the design and implementation of EWSs with the advantage of a comprehensive consideration of the different risk components.

Potential future evolution of climate-related hazards

For climate-related hazards, climate scenarios can serve as input for projections about hazard development and potential future states. Several aspects should be considered when using climate scenarios for the projection of extreme events. Critical aspects include:

- Single climate models are often unreliable when it comes to extremes, and the use of multi-model ensembles is mandatory
- For extremes, applying bias-adjusted climate model outputs, in particular if absolute thresholds are used to define extremes (e.g. hot days are days with mean temperatures > 30°C), is recommended
- Using statistical approaches to define extremes (e.g. temperatures above the 99th percentile) is more robust but these need to be applied with care when comparing extreme events between time periods
- The projection of precipitation extremes is less reliable than for temperature extremes
- In general, climate models are good at modelling and projecting global trends for temperature and precipitation. On the regional to local scale, information on temperature is robust and models agree on trends, while data on precipitation status and trends have a higher uncertainty. This is because precipitation depends on complex multi-scale processes such as global circulation effects, regional effects (e.g. from mountains chains) and local effects such as in the case of convective events (thunderstorms). Other climate variables such as windspeed, snowfall or soil moisture are more complex, and results from climate models for such variables are even more uncertain. Results on climate extremes are always more uncertain than information on status and trends for mean values.

Data sources for hazard assessment

Hazard data can be sourced from national and regional hydrological and meteorological services or from global sources such as those listed in table 2. Impact data providers are government ministries such as environment, social welfare, health, public works, energy, water, civil protection and national disaster management authorities.

Table 2. Selection of hazard data sources with global coverage available online and open access

INSTITUTION/ PROJECT OR DATABASE NAME	DESCRIPTION	DIRECT LINK

UNDRR and International Science Council	Hazard definition and classification review	https://www.undrr.org/publication/hazard-definition-and-classification-review
WMO	World weather and climate extremes archive	https://wmo.asu.edu
National Oceanic and Atmospheric Administration (NOAA)	Collection of climatic data	https://www.ncdc.noaa.gov/cdo-web/datasets
Copernicus Climate Change Service	Past, present and future climate information in Europe and the rest of the world	https://climate.copernicus.eu
International Research Institute for Climate and Society	Climate data library	https://iri.columbia.edu/resources/data-library/
UNDRR: DesInventar	National disaster loss databases	https://desinventar.net/
Emergency Events Database (EM-DAT)	International disaster database	https://www.emdat.be/database
Dartmouth Flood Observatory	Flood event archive	http://floodobservatory.colorado.edu/
United States Geological Survey Earthquake catalog	Earthquake catalogue	https://earthquake.usgs.gov/earthquakes/search/
Global Centroid-Moment-Tensor project	Earthquake events: date, location, intensity	https://www.globalcmt.org/
Northern California Earthquake Data Center	Earthquake events: date, location, intensity	http://www.ncedc.org/anss/
GEM Global Active Faults Database	Global database of active faults	https://github.com/GEMScienceTools/gem-global-active-faults

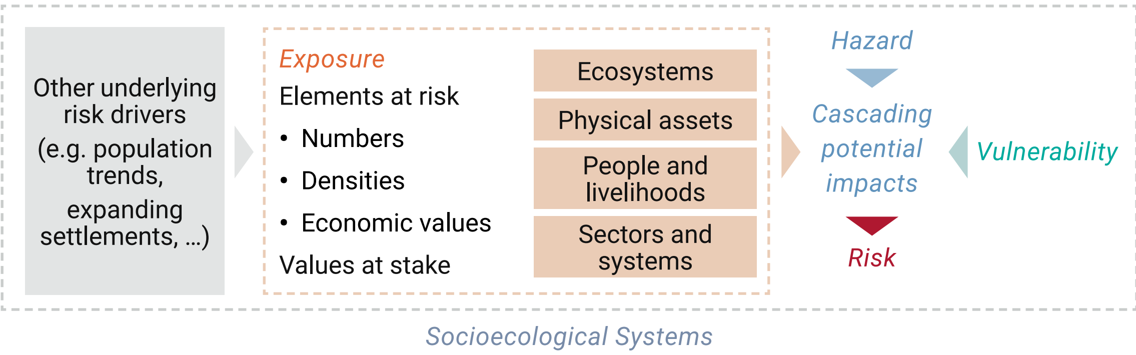
NOAA	Global historical tsunami database	https://www.ngdc.noaa.gov/hazard/tsu_db.shtml
Smithsonian Institution Global Volcanism Program	Global historic volcanic eruptions	https://volcano.si.edu/search_eruption.cfm
European Space Agency	ATSR World Fire Atlas	http://due.esrin.esa.int/page_wfa.php
National Aeronautics and Space Administration (NASA)	Global landslide catalogue	https://data.nasa.gov/Earth-Science/Global-Landslide-Catalog/h9d8-neg4

3.7.2 Analysing exposure

Exposure generally describes which elements of value are at stake. Exposure can be expressed by the presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, by the infrastructure, or by the economic, social or cultural assets in places and settings that could be adversely affected (figure 15). Exposure describes the elements of value exposed to one or more hazards and subject to loss (United Nations, 2016; Pittore et al., 2017).

In CRA, it is recommended to consider all exposed systems (e.g. ecosystems, physical assets, infrastructure, human lives and livelihoods, social sectors) necessary to conceptualize and assess direct and cascading impacts, from natural systems on society in the form of "exposure layers".

Figure 15. Elements of exposure



The inclusion of ecosystems and even more notably of social sectors and systems as exposed elements and systems is a significant extension compared to the traditional DRR approach, which usually focuses on human (displaced, injuries and fatalities) as well as physical assets (infrastructure and housing) and the related economic damage. The systemic perspective representing the socioecological system and its exposure layers is one of the key aspects of a CRA and one that puts human and ecological systems at the core.

Exposed elements can usually be mapped well, which is one of the key aspects of a spatially explicit risk assessment. Exposure can be described in terms of objective indicators that are relatively easy to define, retrieve and map (e.g. number of people and economic values exposed, aggregated over regular grids or administrative boundaries). Exposure is a highly dynamic risk factor. People are constantly migrating from rural areas to cities and changing land use is transforming exposure. Settlements are encroaching into flood-prone areas. Underlying risk drivers are affecting exposure and can often contribute to increasing climate-related risks more than the increasing hazard. For the assessment of potential future climate risks, it is therefore essential to take climate scenarios and exposure scenarios into account.

Unfortunately, there are few established methods or data sets on the evolutions of exposure for most of the exposure factors. The exception is population development, for which rough estimates exist (European Commission, Joint Research Centre, 2018). For context-specific exposure scenarios, the only option would be to develop approximate expert-based scenarios to at least gain an idea about the potential effect of exposure dynamics on future climate risks. IPCC uses so-called shared socioeconomic pathways (SSPs), which provide a narrative description of global socioeconomic conditions associated with each greenhouse gas emission scenario. These SSPs provide a set of boundary conditions upon which potential future exposure scenarios can be developed, for instance in terms of population (Jones and O'Neill, 2016) or land use (Doelman et al., 2018). Modelling such future exposure scenarios can be resource intensive and is affected by significant uncertainty, also due to the mutual dependency between SSPs and CCA measures. Participative bottom-up scenario techniques may be more appropriate for subnational or local applications. However, scenario building for exposure remains an underdeveloped but relevant field of action.

Identifying exposure and vulnerability data sets means first knowing what problems the hazard(s) under consideration cause. For instance, for flooding and earthquakes, the exposure and vulnerability indicators must be specific to the robustness of buildings. When data are not available, proxy indicators can be used. See table 3 for a selection of available global exposure data sets.

Table 3. Selection of sources of exposure information with global coverage

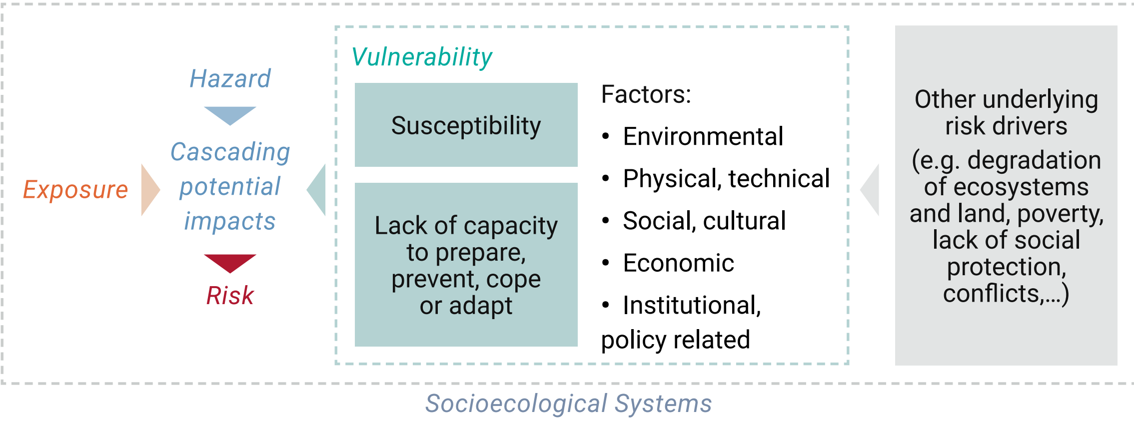
DATABASE OR MODEL NAME	DESCRIPTION	DIRECT LINK
WorldPop	Global 100 m gridded population estimates	https://www.worldpop.org/methods/populations
Buildings	Building types (residential, commercial, industrial)	If no national data available: Gridded building patterns for 51 African countries: https://wopr.worldpop.org/?/Buildings OpenStreetMap: http://download.geofabrik.de/

Agriculture	Crop and land-use types	European Space Agency GlobCover (300 m resolution): http://due.esrin.esa.int/page_globcover.php European Space Agency CCI Land Cover - S2 Prototype Land Cover 20m map of Africa 2016: http://2016africalandcover20m.esrin.esa.int/?utm_source=due_web&utm_medium=banner&utm_campaign=launch
Transportation	Road, rail and air infrastructure	If no national data available: OpenStreetMap: http://download.geofabrik.de/
Ecosystems	Global ecosystems map	https://www.usgs.gov/centers/gecsc/science/global-ecosystems?qt-science_center_objects=0#qt-science_center_objects
Large loss facilities	Sport facilities and stadia, schools, marketplaces and other high population density places	If no national data available: OpenStreetMap: http://download.geofabrik.de/
Critical facilities	Hospitals and health sites, bridges, telecommunications, airports, energy systems	If no national data available: OpenStreetMap: http://download.geofabrik.de/

3.7.3 Analysing vulnerability

Vulnerability is the propensity or predisposition to be adversely affected.[2] It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2019a). Vulnerability in a comprehensive climate risk assessment includes all relevant environmental, physical, technical, social, cultural, economic, institutional or policy-related factors that contribute to susceptibility and/or lack of capacity to prepare, prevent, cope or adapt (figure 16).

Figure 16. Elements of vulnerability



Vulnerability is not a function of poverty alone. Location, age, gender, income group, disability and access to social protection greatly affect the choices people have to make to anticipate, prevent and mitigate risks (UNDRR, 2019a). Hence, understanding vulnerabilities is a key element in analysing entry points for adaptation options, as reducing vulnerability is the most relevant of all adaptation strategies. Social factors such as inequality, poverty, no access to social protection and no access to information or markets can be major underlying drivers to understanding and reducing climate-related risks. Other underlying risk drivers that increase vulnerability are related to ecosystems and their services. A major factor here is land degradation (e.g. land degradation due to overgrazing in figure 13), which increases the vulnerability of ecosystems and related human systems by increasing the risk of drought, soil erosion or landslides. Understanding the role of the vulnerability of ecosystems within complex risks to human systems is key to identifying options for ecosystem-based adaptation measures.

Due to its complexity and the number of factors contributing to vulnerability, it is challenging to choose a pragmatic but relevant system limit and a set of vulnerability factors that could be assessed in a data-driven or expert-driven manner. To include vulnerability factors not based on data availability but on relevance or priorities is of utmost importance. If a factor is relevant, it should be included in the assessment. If it cannot be measured quantitatively, other approaches such as expert-based or participatory and narrative approaches should be used.

The physical vulnerability of a given system to a hazard can be described by concepts such as susceptibility (to damage), sensitivity or fragility. These concepts are well established in the

2 Vulnerability is defined as "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (United Nations, 2016).

DRR field for local to regional analysis. Fragility curves can describe the relationship between the intensity of a flood (inundation height, flow velocity, etc.) and the expected impact on buildings in terms of physical damage. However, approaches using a calibration of such models depend on good empirical knowledge based on past hazards and their impacts. They are data intensive and often do not consider the climate and climate change component (e.g. heavy rain as a trigger of landslides is not considered in landslide susceptibility models). In the climate change context, physical impact models (e.g. hydrological models) include a representation of physical processes that implicitly relate vulnerability factors (e.g. terrain, soil type or land cover) with hazard (e.g. heavy rainfall) and impact (e.g. a flood). Physical models can be fed with climate scenarios to give indications about potential future impacts.

To describe socioeconomic vulnerability, a broader approach is often chosen, based on factors such as poverty levels or proxy indicators for poverty and inequality (e.g. INFORM) (Marin-Ferrer et al., 2017). Such factors are relevant and can be retrieved from national statistical offices, from social protection registries or by conducting household surveys. Data on literacy rate, institutional and governance arrangements (e.g. voice and accountability, rule of law, political stability, government effectiveness and control of corruption) are often difficult to obtain for the subnational level. Vulnerability indicators such as access to infrastructure, health care and electricity can be calculated in a geographical information system (GIS).

However, particularly at the subnational scale, more hazard and risk-specific socioeconomic vulnerability factors (e.g. inadequate irrigation systems or the specific situation of a vulnerable group) are relevant in understanding and reducing the risk. Such information is much harder to retrieve or assess; information is often more narrative than data based. For some aspects of physical vulnerability, modern data-driven technologies such as Earth observation could step in (table 4).

Table 4. Selection of vulnerability information sources available online

DATABASE OR MODEL NAME	DESCRIPTION	DIRECT LINK
VULNERABLE GROUPS		
WorldPop: Population age and gender	Population disaggregated by age and gender	https://www.worldpop.org/geodata/listing?id=87
Uprooted people	Number of displaced people (refugees and internally displace persons) Partially subnational available	http://www.internal-displacement.org
EM-DAT: Population affected by shocks the last three years		http://www.emdat.be/

Famine Early Warning Systems Network: food security		https://fews.net/
SOCIOECONOMIC VULNERABILITY		
Human development index	Partially subnational available	http://hdr.undp.org/en/composite/HDI
Global multidimensional poverty index	Partially subnational	https://ophi.org.uk/multidimensional-poverty-index/

"Lack of capacity" is an important category of vulnerability. This already points towards adaptation options, since a lack of capacity could be overcome through targeted adaptation measures. Inversely, an existing or developing capacity would reduce vulnerability. The missing capacities could include:

- Lack of (specific) knowledge
- Lack of (specific) technology or lack of access to technology
- Lack of financial resources
- Lack of (specific) institutional structures and resources
- Lack of (specific) legal frameworks, regulations or strategies

Capacities could also refer to the major approaches of risk reduction, namely, the capacity to prepare, prevent, cope and adapt. As for exposure, it would be relevant to consider vulnerability scenarios when assessing potential future risks. However, due to the higher complexity of vulnerability factors compared to those of exposure, examples that take vulnerability scenarios in climate risk assessments into consideration are rare. Again, tailor-made and context-specific scenario or foresight approaches (Leitner, 2017) only could be applied to consider the extent of different vulnerability scenarios affecting potential future climate risk.

3.8 OUTCOMES OF THE RISK ASSESSMENT – FINAL STEPS OF RISK ANALYSIS AND RISK EVALUATION

KEY MESSAGES

The final step of "risk analysis" is to assess the risk, by assigning it to risk levels (e.g. from very low to very high), based on the description of adverse consequences and, if possible, their likelihood. This assessment is a value-based process that needs an agreed and value-based target system that should have been defined already in the scoping phase. "Risk evaluation" means drawing conclusions out of the risk assessment with respect to the demand for risk reduction measures. The concept of risk evaluation is underdeveloped in climate risk assessments. This guidance discusses some current approaches such as "the urgency for action" or the concept of "acceptable, tolerable and intolerable risks".

Findings from the analysis of hazards, exposure and vulnerability are summarized, assessed and evaluated in the risk analysis and the subsequent risk evaluation phase. This allows description and quantification of risks, and evaluation of risk priorities, risk tolerance levels and urgency to act. There are no standards on how to achieve the outcome. The approaches should be context specific and designed to respond to risk information needs for decision-making and planning. In any case, it is highly recommended for this phase to first summarize the understanding of risk as objectively as possible. Any further value-based assessment and evaluation should be made explicit and follow explicit risk criteria that have been developed in response to explicit objectives, goals and values in the scoping phase.

In a standard DRR approach, the final step of a risk assessment aims to describe "risk from hazard" as a function of the potential consequences and their likelihood. The approach focuses on risks from well-defined disastrous events caused by well-defined and often single hazards. The outcome is often a risk classification into risk levels (e.g. from low to high) by applying established methods such as risk matrices and implicit or explicit value-based risk criteria. Such risk classifications can be compared across different risks from different hazards.

In a CRA, as reflected in GRAF, approaches need to be different as they focus on complex and systemic "risks to human or ecological systems" caused by the adverse consequences of multiple and cascading hazardous events and trends. The interactions and dynamics of hazards, exposure and vulnerability, as well as the resulting adverse consequences of complex risks, cannot be reduced in a meaningful way to single statements about one expected impact of one defined event and its likelihood. From an action-oriented perspective, it is more important to describe potential adverse consequences in a comprehensive way and to shed light on their underlying root causes. A risk classification with risk levels is still a useful element of a CRA, as it allows comparison and prioritization of risks, but it is not the main and only outcome of a CRA.

Here, it should be stressed again that risk in the context of climate change is more than the likelihood of an impact, but a value-based assessment of the potential of adverse consequences.

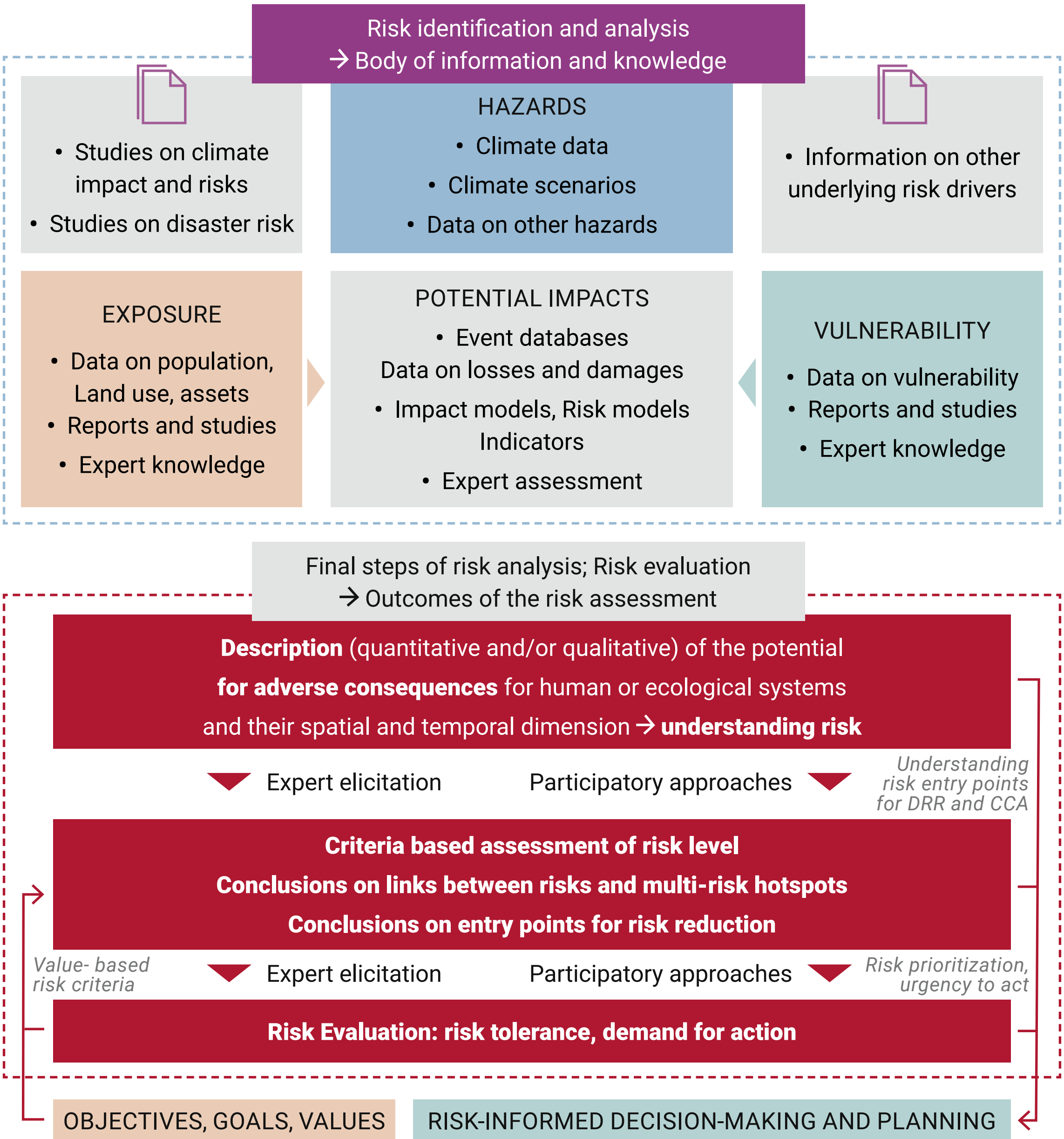
A pragmatic approach for the finalization of a CRA should be based on a complex body of information and knowledge collected during risk identification and risk analysis (figure 17). This body may be retrieved from heterogenous data and information and hybrid approaches for analysing and understanding hazards, vulnerability, exposure and cascading potential impacts.

The final assessment can comprise:

- A detailed and spatially explicit description of the potential for adverse consequences for specific human or ecological systems related to risk to specific sectors and systems
- An assessment of risk levels for each risk, and if possible, be spatially explicit based on agreed risk criteria and values
- Conclusions on linkages among risks across sectors and spatial multi-risk hotspots
- Conclusions on entry points for DRR and CCA
- A final risk evaluation on aspects such as risk tolerance levels or urgency to act

These steps are further described in the following subsections.

Figure 17. Pragmatic approach for the finalization of a CRA



3.8.1 Describing the potential for adverse consequences

The approach to model or analyse the potential for adverse consequences on human or ecological systems depends on the complexity of the selected risks and the resources available (e.g. data, models, knowledge, experts and time available). Methods cannot be as quantitative as in a DRR approach, or only for a certain part of the assessment (e.g. hazards and physical impact), and need to consider much more subjective elements, value-based decisions and qualitative conclusions.

Hybrid approaches

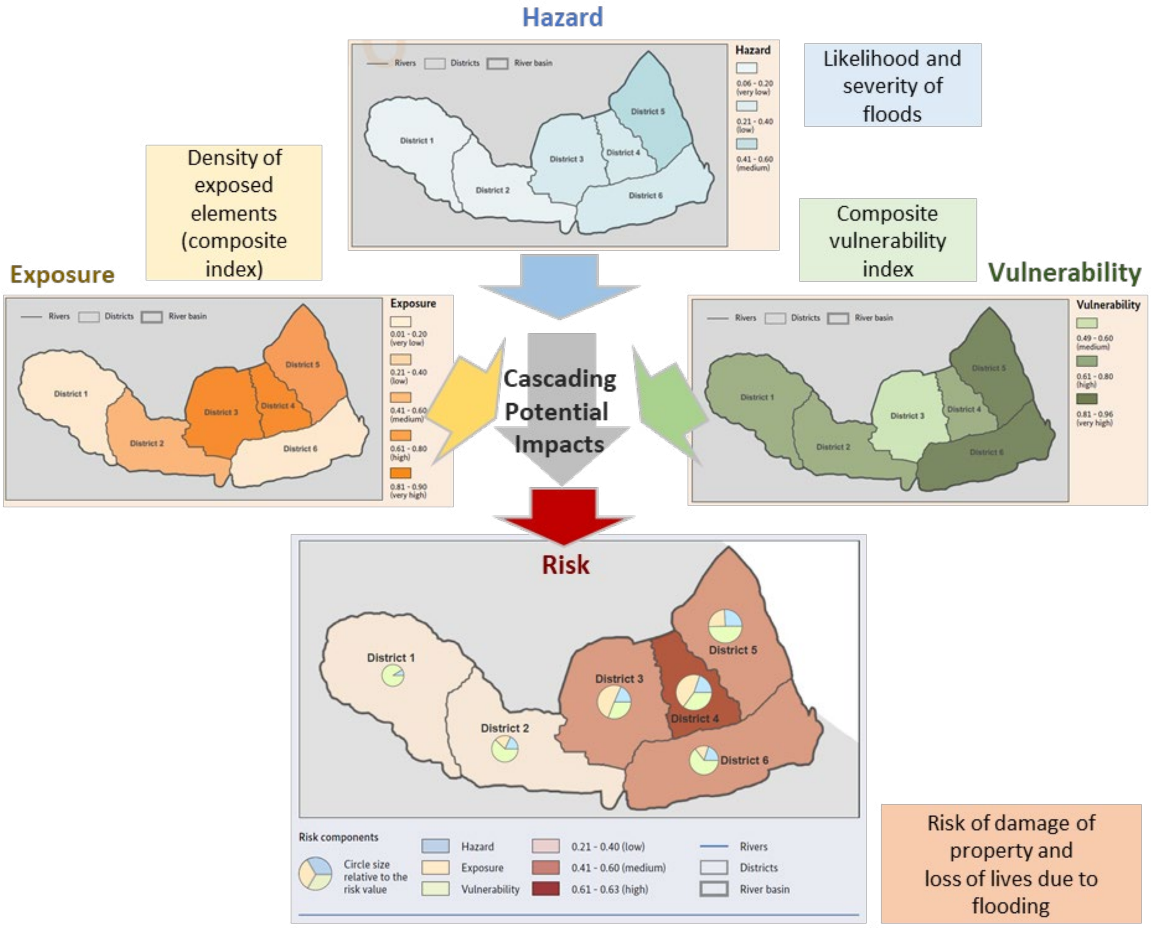
Therefore, risk assessments for complex climate-related risks tend to follow a hybrid approach with a mixture consisting of:

- Quantitative and spatially explicit descriptions of the hazard based on climate observations or models for the current situation, as well as on climate scenarios for potential future situations.
- Quantitative approaches for selected physical direct impacts (e.g. floods or landslides) for which established physical models exist. Potential future impacts can be modelled with the same physical models but fed with climate scenarios instead of climate observations.
- Semi-quantitative assessments, for selected exposure and vulnerability factors described by proxy indicators for the current situation.
- Storylines and narratives on underlying drivers, past trends, critical processes and vulnerabilities.

One way to bring the relevant information into a common assessment frame is the use of normalized indicators that are aggregated to composite indicators (e.g. for single components (hazard, vulnerability, exposure)) and are finally aggregated to a composite risk indicator. The advantage of composite indicators lies in the transparency of the evaluation steps and the comparability of results (e.g. across administrative areas). Furthermore, several indicators can be mapped, and the risk assessment can be made spatially explicit and conducted within a GIS environment (figure 18).

However, an indicator-based approach requires several normative decisions on the selection of indicators, the value-transfer scheme, normalization and weighting, and lacks some relevant components of a complex risk for which indicators cannot be defined. Indicator-based approaches are recommended for larger areas with many subunits and the need to assess risks in a spatially explicit manner. For smaller areas, an assessment that is more qualitative might be suitable. Examples of indicator-based approaches are the GIZ *Vulnerability Sourcebook* and its *Risk Supplement* (Fritzsche et al., 2014; Zebisch et al., 2017, 2021) or the INFORM framework (Marin-Ferrer et al., 2017).

Figure 18. Example of a spatially explicit integration of risk components to risk following an indicator-based approach



Source: GIZ, Eurac and UNU-EHS (2018)

Another, qualitative method is a structured, expert-based aggregation of the single pieces of information listed above. In this way, non-quantitative information can also be integrated into the assessment. Still, it makes sense to give an independent assessment of the single components of risk (hazard, exposure and vulnerability) or even to stress the contribution of relevant single factors. Zommers et al. (2020) document and discuss good examples of how to assess risks in a qualitative and structured way in the IPCC context. Various recent national climate risk assessments follow an elaborate and structured expert-based assessment (Stationery Office, 2017; Ministry for the Environment, 2020).

Describing the potential for consequence per "capital" or "exposure layer"

In DRR applications, the main target of a risk assessment is to describe and assess the combined extent of potential adverse consequences (e.g. in terms of L&D) and their likelihood. Such consequences are often assessed focusing on different "capitals" (or "assets" or "goods") such as (European Commission, 2019):

- Human impacts, in terms of fatalities, injuries and long-term illness, people evacuated or who have lost access to basic services and displaced and uprooted people.
- Economic impact, including financial and material losses, as well as economic losses from various sectors of the economy.
- Environmental impacts, considering impact on natural resources, protected areas and habitats (forests, terrestrial biodiversity, aquatic, marine ecosystems, etc.) and natural and urban environments. Impacts on cultural heritage can be included in this category.
- Political/social impact (including security), taking into account the disruption of daily life/use of critical facilities (energy, health, education, etc.), water and food security, loss of livelihood/income, social unrest, threats to social security, and the capacity to govern and control the country. Sometimes, this category includes psychological effects.

In a set-up of a CRA, these "capitals" could be represented by the specific exposure "layers" that have been defined in the scoping phase and in the conceptualization phase (impact chains), answering such questions as: which values should be protected (e.g. human lives, ecosystems or social cohesion), which targets (e.g. SDGs) should be achieved but which might be threatened by climate-related hazards (e.g. food security or poverty reduction) and which adverse consequences should be absolutely avoided (e.g. irreversible loss of ecosystems)?

Describing the magnitude of potential adverse consequences

Some of the impacts outlined above could be described quantitatively, for instance, in terms of number of deaths/injuries for "human capital" or economic values (e.g. physical damage to structures or business interruption), at least for the current situation.

Other impacts need to be described qualitatively or using narrative approaches. For potential future states, it will, in most cases, be impossible to describe adverse consequences on human and ecological systems in a quantitative way. Consequences can then be estimated either by semi-quantitative approaches with composite indicators, or purely qualitatively by expert- and stakeholder-based approaches.

Nevertheless, any potential consequence that might cause a high risk for society should be considered and not left out, just because a quantitative description is not possible. A decline in yield due to a rising frequency, duration and magnitude of droughts might force farmers to outmigrate. A warming and shrinking inland lake might threaten the livelihoods of local fishers. Climate-related in-migration into a mountain valley might lead to deforestation and erosion due to new land take. All these consequences can most likely not be quantified, but their description is important to design risk reduction and adaptation measures and should therefore be described as precisely as possible (table 5).

This requires the expertise of several experts in a guided discussion to reveal a combination of factors or cascades that may lead to high risk out of the analysis and where an intervention would be necessary and the most useful. The contributions of adaptation specialists and risk managers is important in this phase. The narrative should describe which factors and which underlying risk drivers lead to a specific risk, what is the impact of climate change on the risk, and if there are specific spatial or thematic hotspots or specific vulnerable groups. The assessment can also highlight vulnerabilities and lack of capacities that might be useful entry points for adaptation.

Qualitative criteria could be based on aspects such as the effect of a consequence on the functionality of a system (e.g. complete collapse = catastrophic), and subcriteria could be irreversibility and duration or the necessity for interventions.

Table 5. Example of classification of the magnitude of consequences

MAGNITUDE OF CONSEQUENCE	RISK CRITERIA/ACTION
1. Limited/insignificant	Minor L&D only that does not affect functionality; no external measures necessary
2. Minor/substantial	Minor reduction of functionality of system, minor L&D; support measures necessary
3. Moderate/serious	Serious reduction of functionality of system, moderate L&D; national support necessary
4. Significant/very serious	Long-term damage to functionality of system, high L&D; national support and intervention necessary
5. Catastrophic/ disastrous	Irreversible collapse of system, very high L&D; national and/or international intervention necessary

Note: Similar criteria could be used for risk classification, if the likelihood of impacts cannot be expressed.

Describing the likelihood of potential adverse consequences and why this is difficult in the context of climate change

In a classical DRR approach, the magnitude of the potential consequences alone does not describe the related risk. In fact, the likelihood of potential consequences should also be jointly considered. In a typical DRR framework, the likelihood of consequences is driven by a probabilistic description of the underlying hazard. In relatively constrained applications (mostly single hazards and considering quantitative impacts), likelihoods could be assigned to a hazard of a specific magnitude (e.g. a level 4 hurricane), for example extracted from stochastic models based on past observations. The likelihood for multiple levels of magnitude can be expressed by so-called probability density functions.

In the context of climate change, it is often difficult, impossible or simply not appropriate to describe the likelihood of a potential consequence for several reasons. Most of these are related to the fact that a likelihood can be assigned only to discrete events (and not to processes or trends). In the context of climate change, the focus is on describing complex adverse consequences of a mix of hazardous events, processes and trends. In addition to these methodological challenges, the high uncertainty of complex impacts, the missing information on uncertainty as well as the missing likelihood "tag" of different climate scenarios makes the assignment of likelihood across different climate scenarios impossible.

There is no established workaround for this problem. If, for some reason (e.g. for consistency with an existing disaster risk assessment), the "event" perspective and the description of likelihoods are required or desired, the only way is to transform the description of climate-related hazards and adverse consequences wherever possible in an "event" (e.g. by introducing critical thresholds) and estimate their likelihood for the current situation and for each climate scenario separately.

For example, the risk to farmers from drought impact, which is a continuum in reality, would have to be described by an event like "within at least 5 years of a 30 year period, at least 50% of yields are lost". For such an event, a likelihood could be estimated for the current period (e.g. unlikely) and for single representative concentration pathways (RCPs) for specific future periods (e.g. until 2050, "likely" for RCP 2.6 and "very likely" for RCP 8.5). However, such statements would be highly uncertain. Most importantly, they would describe only a limited part of the continuous space of potential consequences, which would not be helpful to understand the risks and identify risk reduction and adaptation options.

3.8.2 From adverse consequences to risk

A common concept in the DRR field is to apply a risk matrix that crosses the magnitude with the likelihood of consequences to describe risk with risk levels (e.g. high, medium and low). However, there is no standard to define what a high, medium or low risk exactly means, and which criteria have to be applied. Criteria are often chosen implicitly by defining criteria for likelihood and impact.

If it is not appropriate or not possible to describe potential adverse consequences as an event with a magnitude and a likelihood, a pragmatic approach that is more inductive has to be applied by an expert assessment of risk levels based on the complex description of potential consequences.

In this case, the potential adverse consequences are described in an as detailed, complete and spatially explicit manner as possible, with a mix of quantitative, semi-quantitative and qualitative information for every time slice and for every scenario (current situation and potential future scenarios for different emission trajectories). Wherever possible, the potential ranges of impacts and consequences are reported. Where possible, information about the confidence of statements should also be given.

Based on this complex information on the potential consequences, risk levels are assessed by a reasonable number of experts (e.g. more than 10) who first assess each risk for each spatial unit (e.g. district or ecozone) independently in a first round and discuss and harmonize results in a second round. A similar approach is applied within the IPCC working groups when drawing expert-based conclusions on risk, for instance for identifying key risks (Zommers et al., 2020). The criteria for the risk assessment could be similar to the ones described above for the magnitude of adverse consequences. Or they could already be oriented towards criteria that are applied during the risk evaluation such as classification into acceptable tolerable and intolerable risks.

3.8.3 Comparing risks across systems and sectors

A common risk classification scheme (e.g. from negligible to high) allows comparison of risks within one system (e.g. a social sector), across timescales (e.g. risk for the current situation versus risk for potential future situations), across sectors and across regions (if a risk assessment is performed in a spatially explicit manner). This is helpful if risks and risk reduction demand has to be prioritized.

Zooming out: analysing risks across sectors and systems

In a complex climate risk assessment, a large number of risks to different human or ecological sectors are often addressed. In such a context, the final step of the risk analysis could be to assess the interrelationships among single risks across sectors. Risk complexes that are all related to specific parts of impact chains can frequently be identified. For instance, climate impacts on water availability have wide consequences for agriculture, energy production, health, industry and even transport. Identifying such risk clusters is helpful in ascertaining efficient risk reduction measures that tackle the risk early in a cascading risk cascade and reduce the risk for more than one system or sector. Warren et al. (2016) and Buth et al. (2017) give good examples of national climate risk studies in which meta-analysis and risk clustering are used as a final step of the risk analysis.

3.8.4 Risk evaluation

Risk evaluation is the final step of a risk assessment. According to ISO 31000 (ISO, 2018), the purpose of risk evaluation is to support decisions. Risk evaluation involves comparing the results of the risk analysis with the risk criteria established in the scoping phase to determine where additional action is required. This can lead to the following decisions:

- Do nothing further
- Consider risk treatment options
- Undertake further analysis to better understand the risk
- Maintain existing controls
- Reconsider objectives

The concept of risk evaluation is underdeveloped in climate risk assessments. There are only a few examples of national climate risk assessments that explicitly address this step and that distinguish it from risk analysis. In the United Kingdom's climate change risk assessment and New Zealand's national climate risk assessment (Stationery Office, 2017; Ministry for the Environment, 2019), a final evaluation of all risks into an "urgency for action" class is performed (more action needed, research priority, sustain current actions and watching brief). Mechler and Schinko (2016) propose classifying climate risks according to their tolerability (intolerable, tolerable or acceptable) and to link this evaluation to the demand for action, or the necessity of gaining international support.

3.9 ADDRESSING UNCERTAINTY AND VALIDATING RESULTS

KEY MESSAGES

Risk assessments in the context of climate change are subject to a high degree of uncertainty due to the complexity and the systemic character of risks and the uncertainties of future scenarios. Qualitative assessment of sources of uncertainty and the confidence of main statements is recommended.

Climate risk assessments are subject to a high degree of uncertainty. In particular, when addressing future risks, uncertainty in climate risk assessments is very high. There is uncertainty in data, in understanding processes to ascertain the right proxy indicators, in all methods for weighting and so forth.

However, there is a growing agreement among experts that an accurate prediction of climate is not an impediment to adaptation decision-making. A risk assessment is not just about an improved prediction of likelihood or consequence. Moreover, reducing uncertainties is only one means by which progress towards adaptation occurs (Dessai et al., 2001).

It is nonetheless important to address uncertainties, at least in a qualitative way, by making the sources of uncertainty transparent for each key statement. For instance, statements on risks related to direct impacts of increasing temperature are less uncertain than risks related to impacts of heavy rain events. An assessment of complex risks with long and cascading chains is more uncertain than that of less-complex risks.

For complex statements for which uncertainty cannot be estimated in quantitative terms, IPCC uses the term “confidence” instead of “uncertainty” as a mixed concept when referring to the agreement of information and the amount of information available. Understanding the level of uncertainty and/or confidence of a statement is also important to avoid maladaptation. Regarding future risks, quantitative measures should not be overinterpreted and should be taken more as indications of what can happen. In general, measures with a more generic effect leading to more resilience are better suited to respond to uncertainty than measures that require precise technical information on the potential impact.

Validation is another important concept to address and reduce uncertainties and to increase confidence. Validation can be performed on all levels:

- Quantitative approaches such as climate models; impact models can be validated quantitatively for past periods based on comparison with observations (i.e. measured data)
- Any qualitative or conceptual approach such as expert estimates; impact chains can be validated by a group of independent experts
- The final result such as the final risk report; key findings should be reviewed by an adequate number of independent experts

As important as validation is the creation of consensus and commitment regarding the results of the risk assessments from risk managers and stakeholders representing the affected systems including vulnerable groups. If these stakeholders do not agree on the results of the assessment, they will not be committed or not accept the measures for risk reduction.

3.10 PRESENTING RISK ASSESSMENT RESULTS

KEY MESSAGES

Results can be presented in a comprehensive risk report that addresses the risks from different hazard types as well to different human and ecological systems. The report, as well as other dissemination activities, should be co-designed with the stakeholders that operate the systems and sectors for which the risk assessment has been implemented, together with vulnerable groups that are at risk. Presentation of results could include impact chains showing the interdependencies for particular risks or sectors, as well as maps representing where in the region assessed, the risk and its component hazards, exposure and vulnerability are most pronounced in order to inform stakeholders which geographic regions should be prioritized for action.

The design of a CRA should also be reflected in the structure of the final assessment report. While disaster risk assessment reports usually follow a structure by hazard type, a CRA report, if the risk assessment addresses more than one sector or system, could be structured by sectors and systems, from physical impacts to natural environment to human systems. The presentation of the results of the risk assessment could be structured in the following order:

- Impacts on the physical environment, often triggering secondary hazards such as environmental hazards and geohazards (e.g. water cycle, cryosphere and terrain stability)
- Impacts on and risks to biodiversity, ecosystems and ecosystem services
- Impacts on and risks to physical assets (e.g. settlements and critical infrastructure)
- Impacts on and risks to humans and their livelihoods (e.g. health and injury and direct livelihoods)
- Impacts on and risks to social services (e.g. access to nutrition, education, health services and care)
- Impacts on and risks to the primary sector and essential services related to the management of natural resources (e.g. agriculture, forestry, fishery and water management)
- Impacts on and risks to other essential sectors and services (e.g. energy, transport or information and communications technology)
- Impacts on and risks to other societal sectors (e.g. tourism, industry or trade)

The risk assessment report will contain graphics such as impact chains. These allow the interconnectedness of factors making up a specific risk under consideration or a sector in one picture to be viewed. The report should also contain tables listing the key factors that contribute to each risk component and how each factor was measured, using indicators if quantitative data were available or indications of how the factor was measured using a qualitative method. To understand where in a region or country the overall risk, its components and factors are most pronounced and hence where specific actions have to be taken and how urgently they need to be undertaken, visualizing the information in maps is recommended. Maps can be part of the report and they can be made available online for decision makers and citizens to consult.

A COMPREHENSIVE APPROACH FOR INTEGRATING RISK ASSESSMENT RESULTS AND RISK INFORMATION INTO DECISION-MAKING AND PLANNING PROCESSES

This chapter focuses on risk-informed decision-making and planning processes to support countries' efforts in managing risks in a comprehensive manner. It briefly describes why integrating risks is needed, followed by common challenges for risk-informed development and how some of these can be overcome by adopting a comprehensive approach, presenting good practices and recommendations.

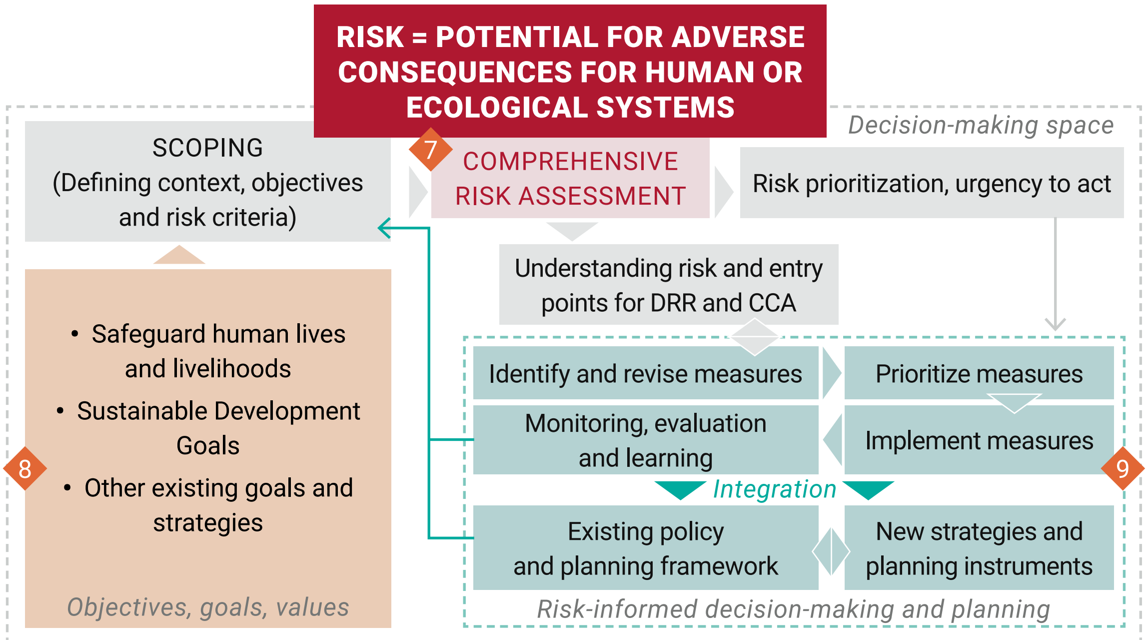
4.1 RATIONALE FOR A COMPREHENSIVE APPROACH TO INTEGRATING RISKS INTO PLANNING PROCESSES

Risks related to climate change and disasters are complex. They affect entire systems and communities, and lead to a variety of interconnected adverse consequences for ecological and human systems. At the same time, other underlying risk drivers such as poverty, demographic development and/or land degradation are aggravating exposure and vulnerability to hazards. Owing to this complexity, assessing and managing risks in the context of climate change require elaborate and transformative approaches that take into consideration further factors and a wide set of stakeholders – sometimes even challenging existing norms.

A critical step in managing risks for resilient and sustainable societies is the integration or mainstreaming of risk assessment results into decision-making and planning processes. This step gives decision makers and planners the opportunity to take the assessed risks into consideration in choosing and prioritizing actions towards reducing and managing risks.

It typically involves identification, evaluation and selection of measures to manage current and reduce future risks in the context of climate change. Necessary adjustments may need to be made to the design of policies, plans, programmes and financial instruments to implement them at various scales (IRGC, 2017). It also lays the foundation for monitoring, evaluation and learning (MEL) systems of the measures and related outcomes. Figure 19 shows different components or steps for integrating risks into decision-making and planning processes. However, in reality, these are not necessarily undertaken in a sequential manner, and the comprehensive approach presented here is built on an iterative process, allowing for dealing with dynamic situations and different starting points given the user context.

Figure 19. Extract of a CRA and planning framework



Note: Typical planning steps or components involve: defining the need for and type of risk assessment based on a review of the existing policy and planning framework; risks are assessed against defined objectives, goals and values; risk reduction and risk management measures are identified, co-designed and selected based on risk assessment results; they are integrated in existing and/or new policies and plans; and implemented within the context of climate-related risk-informed decision-making and planning.

4.2 CHALLENGES IN INTEGRATING RISK ASSESSMENT RESULTS INTO PLANNING

Decision makers, practitioners and communities have increased their knowledge on the urgency of the climate crisis over the years. However, translating this knowledge to redirect resources, change behaviour and make hard decisions is yet to happen on a wide scale (Overland and Sovacool, 2020). Limited resources, capacities, time and political will are posing significant challenges to decision-making and planning processes in any field, including for the uptake of risk assessment results. Other common challenges can be grouped into three main categories: (a) distinct assessment and planning stages, (b) working in silos linked to institutional settings and (c) dealing with different spatial and temporal scales. These are explained in further detail in this section. The following section 4.3 then presents recommendations and good practices on how to overcome some of these challenges.

4.2.1 Distinct assessment and planning stages

A disconnect between the assessment (understanding the risks) and planning steps (deciding on how to deal with the situation) has been observed in practice. While unintentional, long-standing practices among groups conducting climate risk assessments and those leading the planning processes have contributed to widening this disconnect.

Climate or disaster risk assessments have tended to focus on (single) hazards, such as hydrometeorological ones, excluding other factors that are also contributing to vulnerabilities of communities and systems. However, understanding risks to human and ecological systems demands an analysis of exposure and vulnerability components of risks. While focusing on (single) hazards may be appropriate in some instances (e.g. direct flood control measures), policies and plans usually define ways to reduce vulnerability and/or strengthen adaptive capacities (e.g. EWSs, vegetation/green buffers along rivers and income diversification). This is even more relevant and difficult when dealing with complex and systemic climate-related risks with long time frames. Additionally, slow-onset processes, which are harder to assess, also tend to be less clearly perceived as risks demanding action in the decision-making and policy space.

Unfortunately, approaches and terminology used by climate scientists are different from those used by planners and decision makers. The latter need to consider factors that expose communities and governments to a risk, like non-hydrometeorological or biological hazards, and ensure their limited number of resources are adequately used to address varying priorities and needs (most of which are urgent). Different terminology used by communities of practice (DRR and CCA) also present significant challenges in better working together across the assessment and planning stages and within each stage. In most instances, climate/disaster risk assessments and planning processes happen in isolation, and with different timings for each. This further contributes to a disconnect between them, making it challenging to build a culture of systemic risk-informed planning.

4.2.2 Working in silos – distinct planning processes

Most countries have long-established institutionalized planning mechanisms based on their national circumstances, including those linked with international targets and commitments. The various institutions have specific mandates, budgets and plans and are mostly meant to work independently. Common to these institutional settings is the presence of distinct and sometimes even parallel and multilevel planning processes led by different government agencies at the national and subnational levels. While this set-up is working well to ensure continued government operations and accountability lines, unfortunately, this is also reinforcing siloed working arrangements, including in managing complex and evolving risks.

An essential component of planning is inclusivity and building on an interdisciplinary, whole-of-society and multisectoral approach. This is challenging in most countries due to parallel institutional arrangements and the presence of ad hoc dialogue mechanisms among key stakeholders. Generally, it is the ministry of interior or defence, the civil protection agency or the national DRM authority that are responsible for DRM at the country level, with decentralized implementation responsibilities at the subnational level. The environment ministry and sometimes the water and meteorological agency are responsible for coordinating climate change actions (OECD, 2020). This is accentuated when dealing with different planning processes wherein a wide range of stakeholders across sectors and government levels take part.

Moreover, the real and/or perceived power asymmetries among the various institutions involved, and the lack of capacities, institutional mandates and incentives, make it challenging to overcome working in silos. Rapid changes in political leadership and the high turnover of technical staff/civil servants are additional challenges to effective collaboration and long-term planning (UNFCCC, 2017).

4.2.3 Dealing with different spatial and temporal scales

There are multiple challenges in dealing with different spatial and temporal scales owing to the need to consider present and future risks in the context of climate change as well as impacts across levels with implications for the planning phase. There are uncertainties linked to climate projections, slow-onset processes and forecasting specific hazard occurrences. There are also uncertainties in the interactions between climate-related hazards and non-climate-related hazards, including socioeconomic factors and different development pathways that can be undertaken.

Moreover, the short-term political cycles and development practices underpinning planning processes make it challenging to deal with the future dimension of climate-related risks (e.g. taking into account future generations). It is also challenging to deal with the high levels of uncertainty for decision-making today (e.g. investing in preventive measures to reduce potential damage that may or may not happen, best exemplified by most funding being directed to post-disaster recovery rather than prevention) (Tanner et al., 2015; IFRC, 2020). Additionally, impacts cross multiple scales, such as political boundaries, and demand multilevel and sometimes transboundary governance, thus challenging existing norms (Schweizer and Renn, 2019).

4.3 GOOD PRACTICES FOR COMPREHENSIVE INTEGRATION OF ASSESSED RISKS INTO PLANNING

To address the above challenges, this section explores how comprehensive approaches can be applied in existing planning processes, with the aim to better manage climate-related risks. As emphasized in earlier chapters, current needs are changing and evolving, and require a transformation in the way risks are identified, assessed and addressed.

Using the principles presented in earlier sections (see Box 3), examples are presented to show how existing good practices and models are already breaking barriers and allowing governments and communities to consider these complexities and work beyond existing systems. Most of these principles are applicable across all the "usual" planning steps, while others might be more relevant for specific ones. For ease of reading, the following subsections are presented in a sequence informing a "usual" planning process. However, since neither these principles nor the usual planning necessarily happen in a sequential manner in reality, the comprehensive approach presented in this guidance is meant to be flexible and usable in a variety of policy and planning contexts and at whatever stage the user finds themself in.

BOX 3. TEN KEY PRINCIPLES FOR A COMPREHENSIVE APPROACH FOR RISK ASSESSMENT AND PLANNING IN THE CONTEXT OF CLIMATE CHANGE

1. PUTTING RISK TO HUMAN AND ECOLOGICAL SYSTEMS AT THE CENTRE BY CONSIDERING:

- The dynamic interaction among hazards, vulnerability, exposure and underlying risk drivers when assessing risk and seeking solutions (risk reduction and adaptation)
- CRA as a foundation and integral part of the overall risk management process
- A common understanding of the broad risk perspective and of the value added of bringing closer together DRR and CCA communities of practices, including a mind shift towards prevention and preparedness
- Risk as a value-based concept

2. FULLY ACCOUNTING FOR THE CONTEXT OF CLIMATE CHANGE BY CONSIDERING:

- Climate change as an underlying risk driver that modifies climate-related hazards, and also vulnerability and exposure, today and in the future
- The full spectrum of climate-related hazards (extreme events and slow-onset processes and trends), as well as their interaction with and implications on non-climatic hazards
- Current climate risk as well as future climate risk, insofar as they are relevant to their respective sectors and systems and the decision-making and planning process to ensure adaptive planning and dealing with different timescales

3. RECOGNIZING THE COMPLEX AND SYSTEMIC NATURE OF RISKS BY CONSIDERING:

- Effects of multiple hazards, compound events, cascading hazards, impacts and risks, as well as linkages among risks across sectors, with the objective of understanding how these cascades could be interrupted by risk reduction measures
- Risks to a wide range of interrelated human and ecological subsystems (including ecosystems and other natural systems, physical assets, humans and livelihoods, and societal sectors)
- The "non-quantifiability" and high uncertainty in understanding important parts of complex risks, which require the application of hybrid, qualitative and participative methods for risk assessment and flexible approaches for risk management towards more resilient systems

4. APPLYING INCLUSIVE RISK GOVERNANCE BY:

- Engaging and partnering with multiple stakeholders, adopting a whole-of-government and whole-of-society approach (public, private, communities, knowledge centres, media, etc.), and strengthening the involvement of decision makers and populations at risk in order to increase buy-in and facilitate implementation

5. USING MULTIDISCIPLINARY APPROACHES TO IDENTIFY AND SELECT MEASURES BY CONSIDERING:

- A wide portfolio and combination of risk reduction and risk management measures (DRR, CCA, etc.), engaging various sectors and systems, to address multiple and context-specific risks
- Diverse information and knowledge sources by including at risk population

6. USING THE CONCEPT OF RISK TOLERANCE TO:

- Evaluate risks according to their tolerability to spur action
- Inform the identification and selection of appropriate risk reduction and risk management measures

7. ADDRESSING, MINIMIZING AND AVERTING RISKS THROUGH NBSS BY CONSIDERING:

- The role of ecosystems and their services: as part of the risk (climate impacts on ecosystem and their services cause risks for human systems, degradation of ecosystem services increases vulnerability to climate risks)
- The approach to be adaptable to different spatial scales, including transboundary as part of the solution

8. INTEGRATING RISK ACROSS SECTORS AND LEVELS BY CONSIDERING:

- Synergies and trade-offs across multiple levels, linking local realities with national and international processes
- A wide range of planning instruments, "game-changers" such as financial instruments and their timing

9. STRENGTHENING RISK COMMUNICATION, INFORMATION AND KNOWLEDGE SOURCES BY CONSIDERING:

- A combination of diverse information sources, methods and knowledge to include scientific, traditional, local and indigenous knowledge, facilitating knowledge co-creation processes and designing measures
- Gaps in and needs for climate information and services (CISs) and strengthening them
- To keep the end users in mind throughout the assessment and integration process, tailoring risk information
- The potential of behaviour change and individual responsibility

10. USING ITERATIVE AND FLEXIBLE PROCESSES BY CONSIDERING:

- Adaptive management and planning based on robust MEL frameworks, feeding into an iterative and dynamic process to allow adjustments to planning and implementation
- The value added of the overall process itself as a way to help fill capacity gaps, improve information sharing and coordination mechanisms

4.3.1 Putting risks to human and ecological systems at the centre

KEY MESSAGES

It is recommended to use a broad approach to risk, centred around risks to human and ecological systems. This has four major implications in making planning processes more comprehensive by:

- Creating a shift in mindsets from response and recovery towards prevention and preparedness to comprehensively and effectively reduce risks and address residual ones.
- Ensuring the policy and planning objectives define the need, purpose and scope of the risk assessment. Policymakers and planners are the ones to frame and guide what is needed from a CRA, at the start of a planning process.
- Identifying solutions that take into account interactions, trade-offs and co-benefits across sectors and at different scales if they are to deal with complex and interlinked risks.
- Inviting a widening of responsibility for action across all of society, helping to break long-standing silos.

The proposed comprehensive risk framework focuses on the risk to social and ecological systems as most actions will be planned on that level rather than the more usual "risk from hazard" perspective. Priority 2 of the Sendai Framework (United Nations, 2015) and GAR2019 (UNDRR, 2019b) push for a comprehensive understanding of risks to support risk-informed planning. A broader approach to risk has four major implications in making planning processes more comprehensive:

1. While there is growing convergence around a broader approach to risk, shared by the DRR and CCA communities, most interventions, development aid and investments are still geared towards disaster response and recovery. A shift to more attention on prevention and preparedness, including pre-emptive, anticipatory and adaptation options, is still needed to comprehensively encompass the DRM cycle. It is less costly to invest in prevention than in response, given that disasters erode development gains. Prevention also reduces losses and saves lives, as well as providing opportunities to increase economic potential and generate development co-benefits, referred to as the "triple dividend of resilience" (Tanner et al., 2015).

2. A comprehensive approach to risk management strongly brings together the understanding and assessment components with their integration into decision-making and planning processes. The assessment is seen as a foundation and integral part of the overall risk management process and should be calibrated and designed based on the policy and planning objectives. The information gathered and questions asked will help planners and policymakers identify actions to manage the spectrum of risks they face. Therefore, it is the policy and planning objectives, framed by the overall societal goals, that define the need for, the purpose and the scope of the risk assessment in the context of climate change, generally associated with the "scoping step" (box 4). This helps to overcome some of the challenges linked to a disconnect between the assessment and the planning processes.

3. A CRA in the context of climate change provides the necessary base to identify risk reduction, risk management and adaptation measures, aiming to reduce vulnerability and strengthen human and ecological systems' resilience. The assessment analyses the dynamic interaction among hazards, vulnerability, exposure and underlying risk drivers. This provides direct entry points to identify risk reduction measures. As such, "Solutions must similarly be more integrated and robust, taking into account interactions, trade-offs and co-benefits across sectors and at different scales — and therefore across traditional jurisdictions of government agencies — under a range of scenarios" (Phillips et al., 2020).

4. A broader approach motivates widening the responsibility for action across all of society, encompassing conventional institutions such as civil protection agencies or environmental agencies, and all sectors, governmental organizations, non-governmental organizations, civil society, research, media and the private sector (box 5). Wider responsibilities with clear roles and related mandates provide incentives to collaboratively work together and extensively integrate climate-related risks into planning processes. This collective responsibility will help break long-standing vertical and horizontal silos in planning processes.

BOX 4. GUIDING QUESTIONS FOR SCOPING

Guiding questions of particular relevance for the scoping step when reviewing or screening the policy, strategy, plan, programme or project (hereafter referred to as the policy or planning instrument) for risk-informed evidence-based include:

- Does the policy or planning instrument consider how its objectives are affected by climate risks (including interlinkages between climate-related and non-climate-related hazards)?
- Do the planned strategies and activities of the planning instrument consider whether they could increase vulnerability factors identified (e.g. in the impact chains), thereby increasing overall risks of disasters?
- Does the policy or strategy take advantage of the opportunities to address structural causes of vulnerabilities to climate risks?
- Is all the needed information available (stocktaking and building an understanding of the context, including available climate information)? What else is needed that the risk assessment could focus on?

Source: IRGC (2013)

BOX 5. GOOD PRACTICE: UNDERSTANDING AND LINKING THE DECISION-MAKING PROCESS WITH THE RISK ASSESSMENT

The NASA Earth Applied Sciences Disasters Program and Columbia University's International Research Institute for Climate and Society are applying new approaches to use Earth science data for decision-making by a variety of users. For example, the programme helps assess landslide risk in Rohingya refugee camps in Bangladesh. Scientists collaborate with United Nations agencies, government officials and humanitarian end users to understand how decisions are taken and by whom, which data and type are most needed, before generating needed risk information and co-developing tailored products that address specific needs. "Working in teams that bridge traditional professional and disciplinary boundaries gives data and climate scientists the opportunity to learn more about decision making in specialized contexts" (NASA, 2019).

4.3.2 Applying inclusive risk governance

KEY MESSAGES

"Inclusivity" is a key ingredient for comprehensively integrating risks into planning processes. A useful starting point can be to gain an understanding of the existing (risk) governance system in the country or region of focus, to help identify potential bottlenecks and opportunities for enhanced coordination. Institutional arrangements with clear roles and responsibilities are needed to enable collaboration among a broad range of stakeholders, including marginalized and at-risk populations. Ensuring their effective participation in the risk governance space and seeing them as agents for change facilitates identification of risk reduction measures better aligned to their needs and capacities. It also entails relying on and incentivizing political will and leadership.

Providing space for key stakeholders, especially those most at risk, to contribute and be heard will help ensure their needs are recognized and addressed. Obtaining views from different agency leads is also important, as this will help ensure all factors/challenges/risks are taken into consideration. Bringing everyone in the risk governance space, various communities and stakeholders together to become part of the thinking and decision-making processes (and not just spectators or recipients of help) is empowering and part of good governance.

Governance systems and decision-making processes provide the mandate and enabling environment for risk-informed decision-making and planning (Forino et al., 2015).3 Given the systemic nature of risk and the compounding impacts of disasters, countries and communities are experiencing hazards that are more frequent, more intense and more unpredictable (UNDRR, 2020b). A whole-of-society and whole-of-government approach towards planning is needed to ensure all fronts are considered in the prioritization of strategies, resources and actions (box 6).

3 Governance systems are the decision-making processes (means of interactions and networks of actors and the instruments) chosen to help people solve societal problems (Forino et al., 2015).

In practice, this means (UNDRR, 2019c):

- Broadening the scope of involved actors and bringing in various stakeholders (national and subnational governments, communities, civil society, knowledge centres, media, the private sector, etc.).
- Ensuring consistent and wide use of gender-sensitive processes, policies and plans that recognize the different roles, responsibilities, capacities and contributions of men, women, youth and older persons.
- Having institutional arrangements with clear roles and responsibilities enabling the engagement of and better coordination among all involved actors, such as DRR, CCA, social protection and other development stakeholders.
- Institutionalizing mechanisms that enable information-sharing, coordination and collaboration among sectors and across administrative levels, including decision makers throughout the risk management process.
- Ensuring effective participation of at-risk members of the population in the planning process.
- Promoting a sense of strong commitment, leadership and political will.
- Putting in place monitoring, evaluation and reporting systems, with clear lines of accountability, from start to finish.

Investing time to gain an understanding of the existing governance system in the country or region of focus can help to identify potential bottlenecks and opportunities for enhanced coordination. One entry point for improved coordination is sharing and strengthening data and information management systems, including climate and disaster information services, as well as social protection registries.

BOX 6. GUIDING QUESTIONS ON INCLUSIVE RISK GOVERNANCE

- Are there mechanisms in place to consult stakeholder groups, including at-risk populations, during the development, review, planning, budgeting and implementation of the policy, strategy or plan, and do they facilitate uptake of their inputs?
- Are roles and responsibilities clearly defined in these coordination and institutional mechanisms (who leads, who participates, etc.)?
- Do the policies and plans recognize the different roles, responsibilities, capacities and contributions of women, men, youth and older persons? Is a gender-sensitive approach used throughout the planning process?
- What are the capacity needs and gaps for engaging relevant stakeholders in the planning process at the national and subnational levels?
- Does the revision or development process of the strategy or plan contemplate strengthening the needed capacities?
- Are there dedicated financial resources to the development and implementation of policies, strategies and measures?
- Are institutions responsible and accountable for implementation of the policy (at national, regional and local levels) clearly defined?

Institutional arrangements or decision-making processes – formal or informal – should define clear roles and responsibilities in supporting the overall planning process as well as information-sharing. In particular, this entails defining modalities to interact with the risk assessment teams during the planning process to better integrate risks as needed along the process. It is recommended to establish clear roles and responsibilities for National Meteorological and Hydrological Services (NMHSs) and knowledge brokers to facilitate access to and sharing of tailored risk information, helping to overcome some of the data and information gaps as well as difficulties in using them (OECD, 2020; UNDRR, 2020c).

Inclusivity in the sense of effective participation of vulnerable and marginalized populations, women and indigenous groups, who can also be important agents for change is key, as climate change affects people differently given their adaptive capacities. Knowledge co-creation and co-design of risk reduction measures supported by flexible and participatory decision-support tools should be considered for effective participation. These measures and tools should be capable of responding to the needs and realities of different population groups, including those most at risk (Turnbull et al., 2013)

This requires that the risk assessment takes into consideration how differentiated levels of vulnerabilities (Phillips et al., 2020), poverty and inequality interact with gender, race, class, age, access to social protection schemes and so forth, and evolve throughout a person's life cycle. This enables identifying solutions that can target or be sequenced as needed across age and population type. At the local level, when revising or designing new projects or plans, it would mean including public and private entities (e.g. local governments and industry/interest groups associations) and ensuring that the different population groups including minorities are also represented and can effectively take part in the planning process.

At the national level, it is also important to work with sectors and with representative groups (associations, civil society organizations, etc.) that can represent the interests of different population groups and regions. Moreover, the effectiveness of coordination mechanisms often depends on the enabling environment, including existing policies and regulatory frameworks, existing capacities and information management systems (see the principle on iterative and flexible processes in using the process itself to strengthen capacities during the planning process).

Multi-stakeholder, multisectoral and multilevel approaches contribute to the comprehensiveness of the undertaking. This means that instead of discrete policy instruments in separate sectors, synergies among policy objectives are pursued to maximize resources, reduce duplication and avoid undermining one area over another by identifying trade-offs (Turnbull et al., 2013; UNFCCC, 2017; IPCC, 2019b; Sandholz et al., 2020). Decentralized governance and decision-making processes enable wider participation and facilitate working in collaboration across sectors and fields and can also facilitate adaptive planning. Identifying synergies and trade-offs among policy objectives and planning instruments will provide clarity in planning processes with the end in view of addressing risks across vertical and horizontal lines.

Political will and leadership are key to steering any planning process and its implementation. CCA and DRR planning processes (e.g. NAPs and DRR strategies) are usually led by the ministry of environment or civil protection agency. A way to steer political engagement has been to widen the actors involved and ensure effective participation, including that of the finance and planning ministries or equivalent, in the revision or strategy development processes. Involving them in the respective steering committees or working groups, for example, has been found in practice to help overcome existing power asymmetries, facilitate buy-in and raise awareness across sectors.

Institutional arrangements should also allow for some degree of flexibility to respond to changes in leadership and political context (e.g. turnover), and to be capable of supporting iterative risk management/adaptive planning. This could involve reviewing strategies, plans and programmes as risk factors change (Dazé et al., 2016) (see the principle on flexible and iterative processes).

4.3.3 Fully accounting for the context of climate change

KEY MESSAGES

Risks are context specific. Planning across multiple time and spatial scales is important to comprehensively manage risks. This will help identify actions in the short, medium and long terms to account for present and future climate-related risks. To do so, it is recommended for the planning process to be flexible enough to deal with these different time horizons and spatial scales. Having the planning instrument's objective define the needed timescale for the climate information is a step in that direction. Other steps include adopting adaptive planning approaches so that the process, policies or plans are flexible enough to changing conditions. This could entail improving:

- The availability of climate forecast and projection data
- The capacity to use and act based on forecasts
- The enabling policy environment
- Closer working relationship among scientists, planning officers, and other disciplines and stakeholders to ensure all elements are considered across time and scale

Decision-making and planning processes need to account for present and future climate risks, generally implicating longer time horizons and affecting a broader range of human and ecological systems than other sources of risks (Jones et al., 2014).

On one hand, this means revising existing policy and planning instruments to ensure objectives can still be reached given present climate-related risks. On the other hand, it means evaluating and making the necessary adjustments to existing measures or new ones given future climate-related risks and uncertainties. It also includes considering the outcomes of proposed policies and measures as well as potential changes in policy direction (development pathways or trends) (IPCC, 2007; Hurlbert et al., 2019). When taking development decisions with long-term outcomes (longer than political cycles, but typically shorter than climate change projection timescales used in the CCA field), such as infrastructure or land-use plans, climate change needs to be taken into account to plan for climate-resilient investments. Moreover, policies, strategies, plans, programmes and projects may all have different timescales and spatial units that need to be considered for comprehensive and effective planning, thus adding complexity.

Therefore, a degree of flexibility to deal with different time horizons and spatial scales can be retained by having the objective of the planning instrument define the needed timescale for the climate information. This is most likely to be defined in the scoping step. For example, infrastructures such as dams, roads or hospital buildings are planned to operate for several decades if not hundreds of years with appropriate maintenance, whereby climate change projections for the medium term are useful. In contrast, finance or agricultural sectors operate over much shorter time frames, whereby seasonal climate forecasts are more useful. Sectoral policies tend to span over 10 years, strategies are usually planned over 5 years or less and plans on a 1- or 2-year time-horizon.

Additionally, it is recommended that the process and policies or plans are flexible enough to changing conditions, facilitated by using adaptive planning approaches. Flexibility in using various planning timelines depends significantly on: (a) the availability of climate forecast and projection data, (b) the capacity to use and act based on forecasts, (c) a strong enabling policy environment and (d) close working relationships among scientists, planning officers, and other disciplines and stakeholders to ensure all elements are considered across time.

Some decision-support tools such as participatory scenario planning, gaming tools, storytelling and other tools involving experts' and stakeholders' experiences can be used under various degrees of uncertainty and multiple scenarios . In particular, these can help simulate possible futures combining climate and development scenarios (analysis of the consequences of climate-related risks on proposed policies and measures and what would happen under different climate and development scenarios).

Finally, another way to overcome some of the challenges at the planning phase is to combine and layer measures, considering no- or low-regret options such as NbSs (favouring positive outcomes no matter the "actualized" risk or whether a risk can be specifically attributed to climate change or another cause) and those likely to stop cascading impacts (see the principles on systemic nature of climate risks, NbSs and multidisciplinary approach). A comprehensive approach also implies drawing expertise and knowledge from multiple sources of information (e.g. combining local or traditional knowledge with scientific data), involving a broad range of stakeholders and pulling from a wide portfolio of risk management measures (DRR, CCA, social protection, ecosystem-based adaptation, etc.), which can help deal with data gaps and unavoidable uncertainties.

4.3.4 Strengthening risk information and communication

KEY MESSAGES

Understanding the information from risk assessments, communicating them and translating them into plans and actions to address/reduce risks are crucial steps in comprehensively managing risks. They will help facilitate dialogues and enhance collaboration needed for risk-informed planning (Natoli, 2019; Leitner et al., 2020). To do so, tailoring risk assessment results and communicating "actionable" risk information for each user at the right time is needed. On the one hand, combining and using diverse information and knowledge sources can facilitate identifying and designing solutions better aligned with user needs and priorities. On the other hand, strengthening risk communication approaches throughout a policy and planning process is needed, and can entail:

- Having the policy or planning objective define the type of risk assessment outputs and risk information needed, for whom and in which format at the scoping stage
- Setting up the modalities to share and communicate risk information at the beginning of the planning process
- Tailoring results formats depending on the target audience such as visual or numerical evidence
- Identifying and co-producing tailored climate information services with NMHSs and other users
- Developing or strengthening needed capacities to understand and use risk information

Combining and using diverse information and knowledge sources

A first consideration is how to blend various sources of information. There is a diversity of risk knowledge sources and experiences that can include those from scientific data, various disciplines, indigenous peoples and local communities. Bringing them together will enhance linkages among understanding differentiated levels/types of risks (from the assessment part) and identifying actions and priorities to adequately address them based on local contexts, existing practices, resources and needs (Hurlbert et al., 2019). Gathering inputs from a wide group of stakeholders can collectively identify a rigorous set of actions that are co-designed with those most at risk. This will empower them to become agents of change. This is particularly relevant for local-level planning and will help ensure co-ownership of efforts.

Strengthening risk communication

An important part of the cross-learning exercise is the opportunity for different stakeholders to openly share their perspectives on risk information and experiences. Risks in the context of climate change can be complex, multiple and systemic, differently affecting distinct population groups with varying adaptive capacities. Sometimes, they are also too abstract, too probabilistic and too forward looking to be taken into consideration, especially by communities and governments with limited existing resources. For example, scientists may be concerned about a 2 mm increase in rainfall, but local communities, especially farmers and those living in the areas affected, will not feel the gravity of the information unless it is translated into practical and real-life contexts.

In the same manner, with decision makers or policymakers having planning timelines according to their number of years in office or constrained with short-term resourcing cycles, understanding the science and the impact on communities will allow them to see a fuller picture across different timescales. Unless this gap in the differences of understanding is broken, which goes beyond translating the information into national and local languages, the identification of actions to address and/or reduce these risks will not reach consensus. In addition, more work on targeted communication will also support closing data gaps and related uncertainties. This is particularly relevant during the risk evaluation stage (societal valuation of tolerable and intolerable risks), ensuring the appropriateness of strategies or designed measures and facilitating ownership of the decision-making process buy-in from stakeholders.

Deliberate and thought-through risk communication approaches are key for the uptake of risk assessment results in decision-making and planning, as well as for behavioural change. Taking cognizance of the end users' needs and capacities, including how best the risk information can be appreciated and understood, is at the heart of CRM. For example, in the scoping stage, the policy and planning objectives can already guide the type of outputs and risk information needed, for whom and in which format. This enables tailoring risk assessment results and communicating "actionable" risk information for each user at the right time. For example, climate resilience scores, multi-hazard maps and seasonal calendars are some of the more effective visual tools that help prompt dialogue with decision makers, while still acknowledging the assumptions and eventual uncertainties behind these simplified representations.

Deciding and setting up the modalities to share and communicate risk information at the beginning of the planning process (i.e. how the risk information generated will be communicated, to whom and via which (institutional) mechanisms) should be thoroughly considered and discussed. Several options in practice can help overcome some of the data- and information-sharing challenges and facilitate stakeholders' buy-in during and beyond the planning processes. These include identifying and promoting better data- and information-sharing policies, identifying, using and improving risk communication channels such as science–society partnerships, CISs, using citizen science, and developing capacities to interpret and use that information, strengthening and relying on knowledge brokers (key informants). NMHSs, which typically create, store and analyse climate data, can play a critical role in producing or co-producing CISs adapted to users' need by working together with different line ministries or institutions requiring climate information. The growing application of impact-based forecasting by national meteorological offices can also help strengthen risk communication, by providing forecasts on the possible impact of weather disturbances, instead of forecasting only about extreme weather events.

4.3.5 Recognizing the complex and systemic nature of risks

KEY MESSAGES

Risks can be systemic and lead to cascading crises as exemplified by the COVID-19 health pandemic and accompanying socioeconomic crisis. Adopting systemic risk management options by governments requires a better holistic understanding of the interconnected, complexity and non-linear cause–effect within the system's elements to identify appropriate responses. Based on systemic risk properties, it is recommended to:

- Review and analyse how past disasters unfolded to inform future planning exercises
- Shift approaches from hazard-plus-hazard perspectives to multi-hazard and system perspectives
- Use the impact chains from the risk assessments to build awareness and identify how direct impacts can cascade through those chains to counter them
- Identify possible risk management options based on a combination of multidisciplinary, inclusive and transboundary approaches, among others

The COVID-19 pandemic is a health crisis and a socioeconomic crisis that continues to threaten the welfare of hundreds of millions of people. It is resulting in direct loss of life and also negatively affecting employment, industrial production and supply chains, financial markets and savings, human mobility, agriculture and food security, mental health and access to health care, among others. In addition, on top of the health pandemic, other hazardous events continue to happen as evidenced by Tropical Cyclone *Harold* (UNDRR, 2020d), creating compound risks that further exacerbate impacts.

This situation clearly demonstrates what UNDRR outlined in GAR2019 (UNDRR, 2019a): **risk is systemic, and crises are cascading.** Existing policies and systems (e.g. health, financing, education and social protection), decisions and priorities all contribute to either making communities more vulnerable or more resilient. With more stresses and shocks bound to occur, understanding the interrelationship of these factors will allow better mitigation of risks and recovery from impacts in the future. Systemic risks are emergent and not necessarily obvious using contemporary hazard-plus-hazard approaches until the disaster occurs. They become obvious only in retrospect, as a result of a series of events that cross human-imposed boundaries, whether institutional, geographic, disciplinary, conceptual or administrative (UNDRR, 2019a).

As explained in earlier chapters, the interplay among hazards and various underlying sources of vulnerability results in impacts, which, if unchecked, will result in rippling and cascading effects. Climate change exacerbates risks, which greatly (and negatively) affect the interrelated elements and functions of a system – from physical impacts through to the economy, development and society (Ramani, 2020; EPFL, 2021). This demands new forms of analysis, methods and tools to understand, assess, identify and prioritize appropriate response measures for disasters that produce cascading effects (UNISDR, 2017a).

Various issues need to be considered when applying this in decision-making and planning processes. One is to look at the "big picture" and the existing policy and planning framework and budget allocation, ensuring they provide sufficient room to adopt changes that enable plans and actions, including budgets, to be responsive in managing and reducing risks. This includes updating or formulating new policies, governance and management of disaster impacts across individual and interlinked sectors (Shimizu and Clark, 2015).

In addressing systemic risks, planning processes should consider reviewing and analysing: (a) how past disasters unfolded, (b) how each hazard interacted with another and (c) which and how various vulnerability factors led to the disasters and their impacts. Doing so can provide a clear picture of the bottlenecks, lapses and even areas where cascading risks were averted and arrested. Reviewed alongside forecast and climate projections and other vulnerability and risk data, this can provide a good understanding of the complexity of risks the country faces at the national and subnational levels. Countries with strongly interconnected communities, industries and critical infrastructure would benefit significantly from this kind of planning review. Adopting systemic risk management options by governments requires a better holistic understanding of the interconnected, complex and non-linear cause–effect within a system's elements. This will then allow for identification of possible risk management options based on a combination of multidisciplinary approaches. These will help prevent, reduce and transfer risks, or even transform the situation altogether or address remaining residual risks.

Various authors and case studies have offered ways to unpack the systemic nature of risks and how best to improve understanding and analysis of their effect and develop strategies to stop their rippling and cascading effects. Table 6 characterizes systemic risks with six properties in the first column that require relevant considerations to plan appropriate risk management options described in the second column (Schweizer and Renn, 2019).

Table 6. Addressing and managing systemic nature of risks

PROPERTIES OF SYSTEMIC RISKS	CONSIDERATIONS TO ADDRESS SYSTEMIC RISKS
Highly complex	Characterize the systemic interdependencies among natural hazards and other types of hazards in a built environment for the identification of appropriate risk management measures (Schweizer and Renn, 2019). Adopt a combination of natural, technical, social science and humanities (interdisciplinary) and practice and science (transdisciplinary) approaches to assess, manage and govern natural hazards (Schweizer and Renn, 2019).

Many are transboundary	Adopt transboundary cooperation and collaboration approaches. Many if not all of the systemic risks are beyond political boundaries and need multilevel governance and international cooperation (e.g. global warming). While challenging, history has shown that during a large-scale disaster, international cooperation has worked (IRGC, 2013). The ongoing intergovernmental cooperation and collaboration on climate change, SDGs and the Sendai Framework can help further promote needed collaboration.
Characterized by the stochastic relationship between trigger and effects: interconnected, complex and non-linear in their cause–effect relationship and the linkages among risks across sectors	Use tools such as scenario planning to understand which parts of the system a climate hazard will affect and how the ripple effects will affect and lead to failures in the system (Schweizer and Renn, 2019). The findings from scenario planning and vulnerability assessments can be integrated into existing strategies or into emergency planning (e.g. scenario planning for flood emergency preparation).
Systemic developments are non-linear and include tipping points	Identify which actions are most likely to end up dangerously close to a critical threshold/transition and enable policies that avoid such actions. Rank actions according to the likelihood of such risk (IRGC, 2013) to help prioritize appropriate risk management approaches.
Often underestimated in public policy due to high uncertainties in occurrence points, the extent of damage and general complexity	Evidence-based decision-making needs factual analysis (IRGC, 2013). Natural hazard management tends to address direct impacts only. Use the impact chains from the risk assessments to build awareness and bring governments' attention to the systemic nature of risks and in particular, how direct impacts can cascade through those chains to design effective risk management approaches. Innovative risk communication approaches to unpack these relationships in simpler ways can help provide a clear picture that informs public risk perceptions.
Influenced by interlinkages among the social, ecological, technical and urban environments	Adopt a multi-hazard approach that aims to identify the interaction and interrelationship between natural and human-made hazards. For example, identify and rank elements of a system according to their importance to sustain the system's core functions.

Source: Adapted from Schweizer and Renn (2019)

4.3.6 Using multidisciplinary approaches to identify and select measures

KEY MESSAGES

A multidisciplinary approach is needed to better understand risks and be better equipped to comprehensively manage and reduce those risks. This is particularly relevant when identifying and prioritizing measures that can avert, minimize and address cascading risks as early as possible in the impact chains. It helps to ensure adequacy of measures from a wider portfolio of good practices and even using blended approaches. These can include tried-and-tested strategies from the fields of DRR, adaptation planning, ecosystem management and social protection, which are already increasingly being used. Additionally, it is important to decide on appropriate selection criteria with key stakeholders and document the process. A range of decision-support tools can help prioritize measures, given varying degrees of available information and uncertainties.

It is essential to consider various disciplines in decision-making and planning processes to ensure risks are managed comprehensively, based on the nature of the risk and its potential impacts described in Chapters 2 and 3 (e.g. systemic, interconnectedness, cascading and transboundary). This is particularly relevant when identifying and prioritizing risk reduction and risk management measures or when revising existing ones (box 7).

BOX 7. KEY CONSIDERATIONS WHEN IDENTIFYING AND SELECTING MEASURES

- How and with whom will measure identification and selection be done? For example, adopting a multidisciplinary and inclusive approach involves a broad set of stakeholders (including physically and mentally impaired or other marginalized populations) to co-design context-specific measures.
- What types of selection criteria are relevant and which supporting tools can help evaluate the different risk reduction and risk management options?
- Which combinations of measures are needed? Either simultaneously and/or at different times (e.g. prevention, preparedness, response and recovery).
- Who are the measures for? Vulnerability varies across population type and age depending on interlinked factors such as inequality, poverty, gender, race and so forth. Therefore, risk reduction and adaptation measures need to be tailored to address this differentiated vulnerability.

Governments and communities face vulnerabilities that have various underlying causes. Addressing these effectively requires a combination of disciplines to analyse risks at all levels, draw up plans and implement activities to reduce risks and strengthen resilience. Sometimes, this requires linking of development, DRR, CCA, humanitarian perspectives and other disciplines like social protection, health, environmental care and ecosystem services. Through CRAs, government planners and decision makers will have a clear picture of the cascading risks and compounding impacts on communities. Therefore, they should also identify and plan actions together with other sectoral specialists.

Using a multidisciplinary approach in planning enhances collaboration among different agencies/groups. They bring different perspectives from a wide portfolio of risk management measures and discuss priorities of action given the limited number of resources. This collaborative planning process also takes into consideration different national, regional and global commitments, standards and frameworks, and will allow for strategic alignment of efforts and resources.

Impact chains can help identify different measures to address, minimize and reduce existing and future risks, targeting weak spots in the visualized system (which can trigger system failures), reduce vulnerability factors and increase resilience sources. A wide portfolio of measures can encompass (UNFCCC, 2017, 2019):

- Structural or hard measures: for example, dikes to reduce impacts from floods, improved irrigation and water collection systems in drought-prone areas and improved access to energy via renewables.
- Non-structural or soft measures: for example, capacity-building, integration into the formal and informal education sector, changing social behaviour, land-use planning laws and building codes.
- Ecosystem-based adaptation and ecosystem-based DRR: for example, mangrove reforestation to reduce flood intensity or soil conservation and agroforestry practices to reduce pests, increase diversity and better filter water.
- Other sustainable natural resource management practices: for example, climate-smart agriculture.
- Social protection and economic measures: for example, cash transfers, cash for work, social insurance, adaptive social protection, climate and disaster financial risk transfer and insurance instruments.
- Transformational measures: for example, diversification of livelihoods, human resettlement and circular economy approaches aiming to change the fundamental attributes of a given system.

EWSs are critical instruments to reduce risks, protect lives and assets, and facilitate continuous risk monitoring (Hurlbert et al., 2019). A multi-hazard EWS can issue warnings for one or more hazards and/or impacts in contexts where hazardous events may occur alone, simultaneously or cumulatively over time (compound events) and take into account the potential interrelated impacts. Improved climate and disaster information services are also key in supporting EWSs and ensuring the information reaches the last mile.

Additionally, when various disciplines come together, the planning discussions become more extensive. Each person involved brings in distinct perspectives and expertise also in prioritizing appropriate measures and other important elements to help prevent and/or stop cascading hazards, impacts and/or risks, contributing to decide on the most-appropriate selection criteria. For example, low-regret measures, such as NbSs, have the potential to stop such cascading impacts, address transboundary risks and provide multiple co-benefits for the present, as well as lay the foundation for addressing projected changes.

Irrespective of the chosen set of criteria, it is important to consider their relative weight and degrees of importance, given a specific context. Deciding on the selection criteria and weight should be clearly documented to be understandable by other actors and inform later iterations. It should involve the whole multisectoral planning team, as well as inputs from the targeted population depending on the policy and planning instrument.

Additionally, a variety of decision-support tools exist to help evaluate and prioritize the best measures given the user's specific context, degree of uncertainty, available information and type of decision-making processes, using quantitative and/or qualitative methods. These include, for example, cost–benefit analysis, cost-effectiveness analysis, multi-criteria analysis, robust approaches, and adaptation pathways and participatory scenario planning. Other decision-support tools combine assessments and planning stages, adopting flexible approaches and functioning under different levels of available information such as the Caribbean Climate Online Risk and Adaptation tooL (CCORAL), the Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) (a project planning tool that helps users design activities that support climate adaptation (i.e. adaptation to climate variability and change) at the community level) and its suite, and the Flood Resilience Measurement for Communities (FRMC) tool. These and other tools support users to design measures and revise existing strategies, plans or measures to account for current and future risks given climate change.

Finally, deploying and implementing risk management measures effectively might require implementation at different stages of planning, response and recovery. This requires a wide set of knowledge, skills, techniques and approaches familiar with relevant stages, as well as insights on emerging trends in social, economic, political, technological and environmental domains. This broader range of knowledge and experiences (i.e. a multidisciplinary approach) is needed to better understand risks and how to manage and reduce those risks (IRGC, 2018).

4.3.7 Using the concept of risk tolerance to identify and select measures

KEY MESSAGES

"Risk tolerance" is a relatively new concept, so little guidance on how to operationalize it exists. Nevertheless, as risk is a value-based concept, evaluating risk tolerance could facilitate identification of appropriate and legitimate risk management measures and help deal with unquantifiable risks and non-monetary values. Therefore, it is vital to involve at-risk populations when deciding on risk levels and to which degree these are tolerable or intolerable.

Risks can be categorized and/or classified based on severity, spatial and temporal extents, and societies' valuation for tolerable and intolerable risks, using the results from risk evaluation. This allows prioritization of risks that will be the objects of risk management strategies and plans.

Since the concept of risk tolerance is still underdeveloped, recommendations here are based on two frameworks that have been proposed: one by Mechler et al. (2014) and the PCL framework put forward by Nassef (2020). The latter proposes a systemic optimization of action across three main response clusters, namely, pre-emptive action by pre-emptive adaptation or risk reduction; contingent arrangements; and actual loss acceptance, without a given hierarchy of risk management strategies. Both frameworks propose to rely on economic valuation of measures and to also consider societal valuation of risk and loss tolerance, which enhances political and public buy-in and facilitates dealing with unquantifiable risks and non-monetary values.

Key in both frameworks is the importance of involving at-risk populations (marginalized people or critical ecosystems on which livelihoods depend) in deciding on acceptable risk levels since not everyone has the same risk tolerance capacity (Opitz-Stapleton et al., 2019). While involving scientific, technological, ethical, economic cost–benefit analysis and political considerations is important, how the community values the risk, and its acceptance are the most important considerations. This remains a subjective and context-specific exercise. Acknowledging this is a fundamental part of the process, alongside selecting and applying prioritization criteria for risk reduction measures. Both processes should be recorded to increase transparency, accountability and replicability, as well as acknowledge limitations. Such processes are recommended to the extent that they can inform risk management decisions.

4.3.8 Addressing, minimizing and averting risks through nature-based solutions

KEY MESSAGES

The potential of NbSs to simultaneously contribute to address climate change, DRR and conservation objectives, thereby contributing to overall sustainable development, has been widely recognized. NbSs represent clear examples of how to apply integrated risk management (IRM) approaches on the ground, operationalizing policy coherence among DRR, CCA and other fields. They can help address systemic, multi-scale and transboundary risks, overcoming some of the common challenges in integrating risks into planning for risk-informed development. NbSs should thus be an integral part of the broad portfolio of available risk reduction and risk management options.

In developing plans and actions to comprehensively manage risks, NbSs are among the commonly preferred options at the national and subnational levels. While many policy instruments and risk reduction measures exist, this subsection specifically focuses on NbSs, which are increasingly being viewed as "win–win" solutions to global challenges. NbSs focus on the restoration and sustainable management of ecosystems and their services, for example, ecosystem-based adaptation and ecosystem-based DRR approaches. These help reduce and regulate natural hazards, reduce exposure and vulnerability and adapt to the consequences of climate change, thereby providing multiple social and ecosystems benefits, and increasing resilience to multiple shocks and slow-onset processes (IUCN, 2016; Whelchel and Beck, 2016; UNDRR, 2020e).

The potential of NbSs to contribute simultaneously to climate change, DRR and conservation objectives, and thereby contribute to overall sustainable development, has been widely recognized. For example, mangrove restoration helps stabilize slopes and prevent landslides, serves as a habitat for species, regulates water flow to prevent or minimize the intensity of floods, protects coastal communities and sequesters carbon (Cohen-Shacham et al., 2016).

By contributing to address the interconnected global challenges framed in the 2015 multilateral agreements such as the Sendai Framework, the Paris Agreement and the 2030 Agenda (SDGs), but also other conventions such as the Convention on Biological Diversity, the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat and the United Nations Convention to Combat Desertification, NbSs are fostering coherence among these policy objectives and represent clear examples of how to apply IRM approaches on the ground. Therefore, a comprehensive approach to planning should consider NbSs as part of the broad portfolio of available risk reduction and risk management options and be integrated into planning processes for risk-informed development. In fact, many countries and initiatives have started to integrate NbSs across national, sectoral and local DRR, CCA and development strategies and plans. Specific guidance (e.g. UNDRR, 2020f) and best practices have increased in the last few years.

Approaches to implement NbSs are comprehensive by nature and require a comprehensive approach to planning framed by all 10 key principles in this guidance. They can facilitate collaboration between CCA and DRR fields as their design and implementation require strong collaboration and multi-stakeholder engagement across sectors and disciplines, combining technological, organizational, societal, cultural and behavioural innovation, including traditional and scientific knowledge, with community-based or co-management forms at the local level (EEA, 2017; Natoli, 2019). Additionally, they are usually based on landscape approaches such as watersheds, river basins or marine and coastal ecosystems, which can transcend administrative divisions and are thus more apt to reduce transboundary risks. This further helps to deal with different spatial scales, fosters vertical and horizontal integration and has the potential to stop cascading hazards, impacts or risks early on in the impact chains (contributing to "operationalize" principles such as systemic risks and integration across multiple levels). Moreover, by usually being "no- or low-regret options", NbSs can be implemented and still hold multiple co-benefits despite varying degrees of uncertainties linked to climate- and non-climate-related hazards.

4.3.9 Integrating risks across sectors and levels

KEY MESSAGES

To comprehensively manage risks, they need to be coherently integrated throughout policy and planning cycles. This is necessary to adjust or design policy and/or planning instruments in such a way that they can reach their objectives without creating new risks, but on the contrary, increasing overall resilience to multiple climate-related risks. This includes:

- Integrating risks into a wide variety of national policies, sectoral or subnational strategies, plans, financial systems, programmes, projects and other planning instruments
- Analysing synergies and trade-offs among policy objectives
- Combining bottom-up and top-down approaches
- Adopting multidisciplinary and inclusive approaches

Many initiatives are already fostering horizontal and vertical integration, better linking local realities with national and international processes.

Systemic risks can be observed, assessed and addressed by understanding and capturing the multilevel and multidimensional underlying drivers. This will prevent the many non-destructive yet non-linear and constantly growing risks from becoming disasters that cross boundaries and affect entire systems.

To address these risks, coherently mainstreaming assessed risks and addressing them by integrating actions across sectors (horizontal) and at multiple levels (vertical) should be done, rather than stand-alone processes. This can be conducted in a wide variety of national and subnational policies, strategies and plans, including at the sectoral level, and in financial systems, programmes and projects (hereby referred to as policy and planning instruments).

Ideally, risk assessment findings (depending on the set objectives) and risk information should be integrated throughout the policy and planning cycle. This will help adjust (existing) or design (new) policies and/or plans to ensure they can reach their objectives without creating new risks or increasing vulnerabilities, thereby strengthening overall resilience to multiple climate-related risks.

Moreover, integrating risks into development plans and planning processes (e.g. national development visions or sectoral plans, such as in the infrastructure, agriculture, education, water, energy or tourism sectors and social protection schemes) is increasingly recognized as an effective and comprehensive planning approach and helps facilitate synergies and trade-offs among various policy objectives. This is echoed by the policy coherence agenda at the international level to reach targets and commitments made under the 2030 Agenda, the Sendai Framework and the Paris Agreement (UNFCCC, 2017; UNDRR, 2019c). Pursuing policy coherence among DRR, CCA and development planning at the national level can provide a strong enabling environment for integrated implementation at the local level, resulting in stronger synergies and reducing trade-offs. Potential trade-offs could entail having to choose between detailed and resource-intensive regional or local risk assessments, for example, to inform local land-use plans versus less-detailed but covering larger spatial scales for national processes such as the NAP and/or national DRR strategies (key informants). An additional and usual trade-off also happens when climate and disaster risks are treated separately in planning processes, instead of addressing them jointly.

The involvement of a wide set of actors, including planning and decision-making authorities across sectors and at-risk populations, following an inclusive governance system, helps overcome some of these barriers (box 8).

BOX 8. GUIDE QUESTIONS FOR MULTISECTORAL AND MULTILEVEL INTEGRATION

- How can subnational perspectives be best integrated into national policy or strategy design (e.g. the NAP process)?
- How can local-level risks be addressed and/or considered in national-level risk assessments, and vice versa?
- How can national orientations be best integrated in subnational and local plans?
- Are transboundary risks taken into account and embedded in planning?
- How could the policy or planning instruments interact with others operating at multiple levels (are they contributing to achieving other objectives or undermining, and in what ways)?

Horizontal integration

Adaptation and disaster risk planning is critical to enable stakeholders to prepare for and respond to the impacts of climate change. The main strategy and planning instruments in climate change and DRR include NAPs,[4] national adaptation programmes of action (NAPAs) and national DRR. They address risks associated with climate change (NAP, NAPA and DRR strategies) and non-climate-related hazards (DRR strategies) and their declination at the subnational and local levels for implementation.

4 Note that NAP planning is an iterative and flexible process. In some contexts, the planning process might start at the national level through the development of sectoral adaptation plans feeding into a national one, which provide a framework for subnational planning. In others, subnational adaptation plans are developed first and fed into the design of a national plan. Moreover, others pursue a mix of these two approaches, undertaking national and subnational planning processes simultaneously (Dazé et al., 2016).

NAPs and NAPAs focus on adaptation interventions by sectors. They give a road map for the country and all sectors, regarding the main direction and needs to increase societies' resilience to climate-related risks. In fact, a recent assessment of adaptation progress at the global level shows that 72% of countries already "have at least one national-level planning instrument in place that addresses adaptation" and a further 9% are developing one, with most developing countries preparing NAPs (UNEP, 2021). Such strategies and plans are also meant to inform sectoral planning and are sometimes developed as an aggregation of regional and/or sectoral adaptation plans as in the case of some NAPs.

Likewise, climate risks – derived from the risk assessment – could be integrated into existing development (e.g. mid- and long-term development plans and vision) and sectoral planning processes (e.g. land-use plans, education, agriculture, water and energy). By using the same risk assessment information as in NAPs and/or NAPAs, strategies and plans can be aligned and reduce changes creating new risks. For example, the infrastructure sector represents an important entry point, as investments in the sector are particularly long lasting (e.g. roads and education and medical infrastructure), and often derived at least partly from public funds framed by regulations and plans.

Risk information generated by the assessment would help to assess what adjustments need to be made in the existing strategy as well as protocols such as building codes and budget allocation mechanisms to ensure infrastructure set-up today will continue to serve its purpose in the future, given climate change. Another important entry point with the potential to be a game-changer or catalyse changes in other policy fields has been the education sector, including civil servant training programmes, developing needed capacities and aiming to support sustainable changes. The social protection field is another potential game-changer, by focusing on reducing vulnerability, especially that of the most-vulnerable population groups, to a range of shocks including those exacerbated by climate-related risks. In fact, 58% of countries "have also increasingly established sectoral planning instruments to support adaptation progress and '21 per cent' at the subnational level" (UNEP, 2021).

At the national level, it is key that all sectors, public and private entities, academia and civil society organizations are represented and participate in the process, following an inclusive approach. This can take the form of national and subnational consultations, reporting to an institutional mechanism in place to design or revise the policy or plan with clearly defined roles and responsibilities. Attention should be paid at how evidence and voices of different population groups are being included in the planning process, via for example representative organizations, building from local and regional consultations and on multilevel coordination mechanisms. The assessment team could take part in these consultations or there should at least be a mechanism set up for the risk assessment results to be discussed and to inform the identification and selection of appropriate risk management measures, among other sources of information.

At the local level, one comprehensive climate risk assessment could be used to inform several planning processes sharing the same spatial and temporal scales. Moreover, a comprehensive approach to integrating risks into local planning processes should also be multi-stakeholder and multisectoral and allow for integrating national-level considerations (e.g. in policies and strategies). Proximity may facilitate coordination across sectors and institutions as well as involving at-risk populations, especially in deciding which risk management measures are needed, thereby increasing accountability and ownership of the overall process. However, human and financial resources may be more limited and may demand particular attention, incentivizing capacity development in the planning processes themselves.

Vertical integration

National and sectoral strategies provide the overall direction of a country and a road map defining how to collectively move towards its targets and vision. These are usually developed by the national development planning office (for the development plan) and the national climate change or DRR offices (for the NAP, NAPA and DRR strategies). However, at the subnational level, local government units lead the planning processes. These local government units fall under the supervision of the ministry/department of interior and local government. This long-standing disconnect at the country level provides an additional challenge in integrating risk assessments into plans and in ensuring alignment across these vertical planning processes. Instituting ways to: (a) recognize local/subnational risks; (b) monitor and report progress at the subnational/local to the national levels; (c) identify roles, responsibilities and accountabilities; (d) sustain financial, human and technological resources; and (e) ensure mutual reinforcement of these plans, should be carefully studied and operationalized.

Linking local realities with national and international processes, combining bottom-up and top-down approaches can support vertical integration. Bottom-up approaches such as ecosystem-based approaches that cross administrative borders and bring together a variety of actors can be used to showcase good practices, which can be fed into regional and national processes, integrating risk considerations into financial or budgetary systems.

Mainstreaming risk into financial or budgetary systems represents another important entry point for comprehensive risk-informed planning. If embedded in public financial systems that are “systematically” resourced and applied, this could have important multiplier effects for risk-informed investments (e.g. public annual budget allocations that factor in climate-related risks before approving projects). A specific example is the protocols in place for the approval of public infrastructure projects that need to deliver services such as hospital buildings in the face of current and future climate- and non-climate-related hazards (GIZ, 2019; Ahmed et al., 2021).

Another example of integrating risks into financial systems can be found in the Caribbean region, where CCORAL has been used to support institutionalizing risk integration processes.

Other ways of applying risks in financing mechanisms focus on pre-identified actions and funding allocations at the national, regional and subnational levels (see the case study on the Philippines in Annex 1). There is now a wide range of policy and financial instruments including subsidies, taxes, grants, bonds, border adjustments (e.g. tariffs) and targeted microfinance that have been used to help integrate risks into planning. Moreover, the private sector and public–private partnerships, such as in the insurance field, tend to already conduct risk assessments as part of their business-as-usual activities and monitor multiple risks, facilitating the integration of risk information in financial instruments. For example, the InsuResilience Global Partnership advocates for strong collaboration with the (re) insurance industry to incorporate expertise on risk analytics for developing countries for the scale-up of climate and disaster risk finance and insurance. The Insurance Development Forum – a member of the partnership – and its Risk Modelling Steering Group aim to accelerate the spread of risk understanding. This entails easy access to risk tools and models to promote local engagement and the integration of local data and knowledge in the modelling process.

Two additional elements could be considered to help comprehensively integrate risks into financial instruments in the context of climate change. First, expenditure or budget tagging exercises can help track public national and subnational spending to improve transparency and help identify opportunities for integration of CCA and DRR planning and implementation as well as track progress in reducing risks. Second, looking at whether funds can be disbursed at the right time to initiate pre-emptive actions that lead to reduced level of impact, and in which combinations or layering of financial instruments, can be as important as whether there are sufficient funds being allocated (IFRC, 2020).

The application of anticipatory financing, like forecast-based financing (FbF) – a mechanism to trigger early action based on early warnings – will allow timelier and risk-based actions. To build an FbF system, the first investment needed is to develop early action protocols, which delineate triggers, roles and responsibilities for quick action. Second, investments are needed in funding mechanisms to make resources available at the time of the trigger.

A critical component of CRM is the ability of governments to act on extremes using information over shorter timescales. This can be realized when integrated into plans and/or strategies that enable the release and use of resources, based on peaks in risks and thresholds. Furthermore, this can be facilitated by using existing targeting and payout mechanisms and channels such as those used by social protection systems. When linkages to EWSs and FbF are in place, this enables prompt payouts to those in need, given the existence of social registries with disaggregated and geo-targeted data. Additionally, insurance payouts, contingency budget lines and other instruments can provide quick funds for response and recovery, if these have been put in place before disasters occur. This reduces the need for governments to reallocate scarce resources or for borrowing under unfavourable financial terms directly after a disaster.

4.3.10 Using iterative and flexible processes

KEY MESSAGES

Given the dynamic nature of risk, adaptive management and planning based on strong MEL frameworks, feeding back into an iterative integration process, are needed to flexibly adjust implementation, inform future decisions and resource allocations. This helps ensure plans remain responsive to needs and provide the enabling environment for timely and appropriate actions that reduce vulnerabilities of communities and systems. The integration process can be used to help fill identified capacity gaps and improve information-sharing and coordination mechanisms.

Risk is context specific, meaning risk reduction measures and management strategies are also highly dependent on local realities and considerations. Thus, they need to be tailored, discussed and decided upon with relevant stakeholders, including at-risk populations for gender-responsive and inclusive planning, based on assessed differentiated vulnerabilities. Therefore, there is no one-size-fits-all method (UNDRR, 2019c). Plans should be flexible enough to allow the inclusion of multiple perspectives, timescales and new inputs, the use of different methods as appropriate to the specific context and for continuous adjustment throughout the process. This will increase the plan's responsiveness to the evolving needs and capacities of communities and institutions.

Adaptive management and planning based on iterative processes

Monitoring and evaluation (M&E) frameworks help appraise whether a risk reduction or management measure is justified and whether it is bringing about the intended benefits, including contributing to building overall resilience (IFRC, 2013). M&E can inform learning (referred to together as MEL frameworks) from successes and failures, feeding this back across the risk assessment and planning stages enabled by an iterative process.[5]

A comprehensive approach to planning requires robust MEL frameworks, established before implementation of risk reduction measures supporting adaptive management and planning (IDRC, 2009; USAID, 2018). Adjustments throughout the overall process are important to better operate in variable degrees of uncertainty given the dynamic nature of risk (e.g. uncertainty in risk estimates). Such adjustments to programming, based on continuous monitoring including the identified risks (of extreme and slow-onset processes), can reveal the need for new information (e.g. updated risk assessments), revise ongoing activities and strategies, inform future risk management decisions and resource allocations as well as help identify best practices and support information-sharing across communities of practice. Some approaches in the field have started to test assumptions in their theories of change after an extreme weather event such as flooding has happened, based on setting up monitoring systems facilitating revisions. In fact, failing to revisit a risk decision in light of new knowledge based on M&E is an important challenge to implementation (IRGC, 2017).

Policy and planning instruments could be reviewed in terms of their "adaptability" (i.e. the capacity to respond to anticipated and non-anticipated changes and enhance resilience sources). Several tools exist to help assess the adaptability of policies or programmes in the context of climate as an underlying risk driver such as the Adaptive Design and Policy Assessment Tool (ADAPTool)[6] or the Food Security Indicator & Policy Analysis Tool (FIPAT).[7]

For a comprehensive approach, an M&E framework should be designed by the same core stakeholders involved in revising or developing risk reduction measures and other plans. It should include the institutions responsible for implementation.

Using the integration process itself

Additionally, the integration process can be used to help fill capacity gaps and improve information-sharing and coordination mechanisms of existing or designed institutional arrangements (see the principle on inclusive governance), thereby strengthening the overall enabling environment for risk-informed decision-making and planning.

To improve information-sharing and evidence-based planning, dialogues and peer-to-peer exchanges on M&E of CCA and DRR policies can help identify opportunities to harmonize DRR and CCA policies and plans contributing to dealing with multiple risks in the context of climate change spanning a wide range of policy and planning instruments. The data and information from MEL frameworks and reporting mechanisms, which record the state of knowledge and progress for example of adaptation and risk reduction efforts, can support making information more widely accessible for the benefit of DRR, CCA and sustainable development fields (IISD, 2012). Mandatory reporting mechanisms for DRR and CCA at the international and national levels could further support monitoring efforts and data sharing among these different communities of practice.

Using the integration process itself can also entail strengthening key stakeholders' (human) capacities at all levels, including technical and "soft skills", such as using collaborative tools and

5 Iterative risk management is an ongoing process of assessment, action, reassessment and response (Hurlbert et al., 2019).

6 ADAPTool was developed by the International Institute for Sustainable Development and partners to assess the adaptability of policies or programmes in relation to any defined stressor or external change, such as climate.

7 FIPAT, with its guidebook, is an analytical tool to help governments identify required resilience actions, monitor food system resilience over time, and assess the extent to which current policies strengthen food system resilience. It was developed by the International Institute for Sustainable Development and partners.

facilitation techniques, adaptive management and M&E. Capacity development strategies for relevant actors have been integrated within the process of designing NAPs, and DRR strategies whereby both entail an assessment of existing and needed capacities (Dazé et al., 2016; UNDRR, 2019c). Some capacity development measures can hold several co-benefits by enabling other sectors (other than those directly targeted) to better address climate and disaster risks. Conversely, the process can help raise awareness about the adjusted/developed policies, strategies and plans. Finally, the risk integration process can be used to help showcase the value added of DRR and CCA communities of practice working together to reduce existing vulnerabilities and increase resilience to present and future climate-related risks. This can be facilitated by showcasing best practices from the local or regional levels, thereby building evidence for risk-informed planning.

CHALLENGES FOR COMPREHENSIVE RISK APPROACHES AND WAYS FORWARD

KEY MESSAGES

Risk approaches promoted by science and policy (e.g. by IPCC and UNDRR) are becoming more comprehensive. However, for practical applications, some bottlenecks and challenges need to be tackled, and further research and development is needed. There is a need for:

- Pragmatic approaches for addressing the complexity and the systemic character of risks in the context of climate change
- Proper consideration of current risks and the dynamic nature of risk drivers including climate change, as well as future risks
- Improvement in the availability and accessibility of data on hazards and impacts, and also on vulnerability and exposure factors
- Consistent concepts on how to assess and manage risks related to slow-onset processes
- Reflection on the appropriateness and relevance of some risk metrics such as the concept of likelihood in the context of slow-onset processes and future scenarios
- Better scenario concepts including storylines for future reduction of exposure and vulnerability

The need for a comprehensive risk approach that integrates DRR and CCA perspectives has been discussed for almost a decade. Coherence among DRR and CCA approaches, and SDGs has been pursued at the policy level. However, practical implementations of comprehensive approaches on the ground are still in their infancy due to several conceptual, methodological and practical challenges. The following sections propose and list some key conclusions on challenges and areas demanding further research for a comprehensive risk approach.

5.1 DEALING WITH MULTIPLE RISKS IN COMPLEX SYSTEMS

In reality, risks are the result of complicated interactions in complex systems. This complexity can never be fully addressed. And even a simplified conceptualization of a system (e.g. with impact chains) cannot be fully operationalized. Hence, there is always a trade-off between complexity and operationalization. The more complex the conceptualization gets, the more non-quantitative elements (e.g. expert assessment, participative elements and narratives) need to be added to a risk analysis (IRGC, 2018).

While there are attempts to model even complex systems with approaches such as system dynamics or agent-based models, the large effort and the lack of understanding of complex processes, as well as the difficulty to adapt such approaches to the highly diverse context of real-world risks, are preventing operationalization beyond the academic context.

There are still significant gaps in the understanding of many of the complex processes and interactions between natural and physical factors and socioeconomic risk factors. Social vulnerability and transboundary effects are two important fields where understanding is missing. More evidence describing impacts, L&D related to the combination of multiple hazards, exposure and vulnerability factors and underlying risk drivers is needed.

Another limitation is risk analysis across risks and sectors. It is still common to analyse and address mainly single risks. Linkages and co-effects of multiple risks or specific exposure and vulnerability dynamics that are relevant for more than one risk are often not addressed. A major limitation for conducting multiple-risk analysis comes from distinct planning processes, due to existing institutional set-ups being less conducive to collaboration in the risk assessment or planning phases. More innovation from system theory and concepts on managing systemic risks need to be introduced into DRR and CCA.

5.2 CONSIDERING RELEVANT TIME PERIODS

DRR and CCA approaches often have different time horizons. While DRR often does not focus on potential future developments, CCA assessments often do not focus enough on the current situation. For a comprehensive approach, it is recommended to start with a thorough analysis of the current situation.

Every DRR assessment could be at least expanded towards an outlook on potential future developments, where relevant and with a suitable time-horizon (e.g. 5 years for agriculture, 20 years for small infrastructure, 50 years for large infrastructure or 100 years for forestry).

Equally, every CCA assessment could include a thorough analysis of the current situation, with methods and information adapted from the DRR context.

5.3 LACK OF AVAILABILITY OF AND/OR ACCESS TO DATA

A sound risk assessment is based on the best evidence and knowledge available, which implies working with data-driven approaches wherever possible. This could include data on current and past hazards and their impacts (e.g. from event databases), data on exposure (e.g. population data) and data on vulnerability factors. However, for many aspects, data are available but are not openly accessible. Either data have to be purchased (e.g. meteorological data) or they are simply not freely available. A free and open data policy to global and national databases is key for a comprehensive risk approach.

Furthermore, data do not exist for many aspects of risk. It is important to not let data availability drive a risk assessment. If a hazard, an impact or a risk has been identified as relevant for a country, a social sector or a social group, this risk has to be considered in risk assessment, decision-making and planning, independently of whether data are available or not. Qualitative methods such as expert-based assessment and participative approaches are a good choice to complement or substitute quantitative data-based methods.

5.4 UNDERSTANDING CAPACITIES

Analysis of existing institutional, organizational and individual capacities to respond or adapt to the analysed risks is key to designing appropriate risk reduction and adaptation strategies and measures. Reviewing the effectiveness of past plans and measures (e.g. how they have functioned in the aftermath of disasters) is important to inform future decisions.

5.5 SLOW-ONSET PROCESSES

The consideration of slow-onset processes in risk assessment and decision-making and planning is still challenging, as most risk concepts are focused on hazardous events with concepts such as return periods for the risk assessment. This guidance has discussed and proposed methods on how to treat slow-onset processes as hazards and how to consider the effect of slow-onset processes on hazardous events. For the risk management side, a long-term perspective is important, starting from monitoring slow-onset processes to having long-term strategies on how to cope with and adapt to related impacts. This should include thinking beyond the limits of adaptation in the risk evaluation and addressing transformational approaches in decision-making and planning.

5.6 CONCEPT OF LIKELIHOOD IN THE CONTEXT OF CLIMATE CHANGE

There is no appropriate concept of if and how likelihood can be applied for slow-onset events and for future climate impacts and risk. In reality, the concept of risk as applied in a pre-Sendai Framework DRR approach (risk = impact of an event × probability of impact) can often not be applied for several reasons. Climate impacts are frequently not related to a single event, but rather to complex processes, which have no return period or frequency, and potential future developments are related to different climate scenarios that have per se no likelihood. Concepts on how to deal with this challenge and if likelihood should be replaced by alternative concepts have yet to be developed.

5.7 FUTURE DEVELOPMENTS FOR EXPOSURE AND VULNERABILITY

For potential climate futures, standard approaches exist with climate scenarios and model ensembles, as well as downscaling techniques to the subnational and local scales. However, there are almost no examples of scenarios for exposure and vulnerability. Such scenarios are important because the dynamics of exposure and vulnerability often contribute as much or even more to a risk than the climate-related hazards.

Furthermore, exposure and vulnerability factors frequently have a higher spatial heterogeneity than climate hazard patterns and are the key entry point for DRR and CCA. There are some attempts to use IPCC SSPs, which are linked to specific RCPs, but for national to subnational risk assessments, these scenarios are generic and have a set of variables that are too reduced to allow an outlook of a specific country or region with its specific context. Progress has been made, especially at the local and subnational levels, with some decision-support tools and approaches supporting the elaboration of participatory development scenarios and foresight techniques.

5.8 VALUE-BASED PART OF RISK ASSESSMENT AND IMPLICATIONS FOR RISK MANAGEMENT

A core element of a risk assessment is a value-based assignment of risk levels (e.g. from low to high) and a risk evaluation (e.g. from acceptable to intolerable). However, the context-specific criteria-building for this important step is often not transparent and explicit. It is absolutely necessary to make this step explicit and address it in the scoping phase of a risk assessment. A link to SDGs as a seed for discussion and decision-making on objectives and how the risk evaluation would inform risk management is recommended.

5.9 MAKING RISK ASSESSMENTS SPATIALLY EXPLICIT ENOUGH TO SUPPORT DECISION-MAKING AND PLANNING

Risks are often local. While a lot of effort is made to downscale climate scenarios, exposure and vulnerability factors are often the factors requiring high-resolution data because they vary from one place to another and are characterized by local and specific factors or combinations of factors (e.g. highly erodible soils, steep slopes and in-migration of people). Risk assessments on national or subnational scales often do not address the spatial component of risk in this detailed manner. An alternative for high-resolution spatial approaches would be to address specific zones with similar, homogeneous attributes (e.g. urban areas, coastal zones, mountains and arable lands in the plains).

These can benefit planning efforts as landscape or ecosystem-based approaches and NbSs are already being applied, recognizing that risks often cross administrative and political boundaries. Additionally, planning processes tend to have clear spatial reference units (e.g. municipality or city-level plans). Aligning the risk assessment to the spatial units of the planning process would improve the usefulness and likelihood of risk integration into planning processes. However, challenges remain as the spatial scales of certain hazards might not match those of planning needs, nor are data always available or accessible in the right format, at the appropriate scale.

5.10 RISK ASSESSMENT AND IDENTIFICATION OF RISK REDUCTION MEASURES

One of the main objectives of a risk assessment should be to support the identification of risk reduction measures. This requires a deep understanding of the context of a specific system and factors that are often related to historical or ongoing trends (e.g. land ownership or vulnerable groups) and might include local phenomena (e.g. missing maintenance of irrigation channels in a specific area).

5.11 EXISTING CONTEXT OF RISK REDUCTION AND CLIMATE CHANGE ADAPTATION

The current state of risk management practices and existing DRR and CCA strategies are often not considered enough in a risk assessment. It is recommended to fully build on the existing context in DRR and CCA by including a systematic review of existing measures, regulations, plans, strategies and risk governance systems, as well as institutional coordination mechanisms and the enabling environment, into the risk assessment. This will help identify opportunities for approaches that are more coherent, tailor the needed risk assessment, and situate where and how it will inform risk integration across and among governance levels. It could also inform how the assessment process and revision, or design of policies and strategies can be used to strengthen the needed capacities and improve the risk governance system towards a systemic inclusion of risks. It could help identify opportunities for financial mechanisms to foster collaboration between CCA, DRR and development processes, as well as harmonize actions and funding streams of development cooperation organizations.

Finally, based on better understanding of existing contexts, deliberate choices could be made to support governance systems capable of addressing multilevel and transboundary risks, the engagement of all actors, and a shift in mindsets and incentives rewarding strong leadership, political commitment and foresight. This will allow rethinking socioeconomic and political systems, so they address the root causes of vulnerability, leave no one behind, and overcome institutional, political and economic challenges for risk-informed resilient societies.

ANNEX 1. CASE STUDIES

It is clear that comprehensive approaches to risk assessment and planning in the context of climate change support integration of risks into all sectors and plans, including considering how risks may affect action across sectors and scales. However, practical examples and guidance on how to do so are still in their infancy. This guidance showcases some initiatives and early practices to demonstrate how comprehensive approaches to integrating risks in planning processes have been operationalized at different scales, and how they are overcoming some of the common institutional and practical challenges for risk-informed planning. The case studies also serve as an inspiration on how risk assessments can be implemented in specific contests, for instance how a final risk matrix can be designed (see the Viet Nam example), how impact chains can be utilized (see the Madagascar study) and how risk assessment results can be made available and tailored to a wide range of stakeholders on an interactive online mapping platform (see the Nepal case).

Most cases can be related to all or several of the key principles presented in this guidance, highlighting the importance of partnerships and their role as knowledge brokers as well as that of inclusive governance through setting up and using effective participatory processes. Most of the approaches strive to bring various perspectives and skills needed to help tackle systemic risks. They use a variety of decision-support tools such as participatory scenarios and quantitative and qualitative methods, combining traditional and scientific knowledge sources. These make it possible to work with uncertainties and identify possible synergies and trade-offs in pursuing more coherence among different policy agendas.

CHILE

Assessing climate change impacts on relevant social, economic and ecological systems

Francisco Meza, René Garreaud, Andrés Pica and Susana Bustos

Context

Chile faces numerous challenges with regards to climate change. There is an urgent need to achieve carbon neutrality. At the same time, characterizing and reducing the vulnerability of socioeconomic sectors and natural systems to future climate impacts is of utmost importance. In this context, the Climate Risk Atlas of Chile (ARClim) is the first multisectoral assessment of climate risks under a coherent set of climate scenarios and a common methodological framework. ARClim is a project of the Environment Ministry of the Chilean Government, funded by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, with the aim to communicate the potential impacts of climate change on several critical sectors to facilitate the development of adaptation measures.

The project was led by the Research Centre for Climate and Resilience and the Centre for Global Change of the Universidad Católica de Chile and involved 27 other national and international research organizations. Results are displayed on a specifically design web-based platform (https://arclim.mma.gob.cl/index/) that allows user-defined visualization of results and access to all the data used in the project. ARClim was developed during part of 2019 and 2020 and released for use on 3 December 2020.

Approach

Climate-related risk is usually understood as the potential magnitude of damage that could materialize as a consequence of changes in climatic conditions. The project followed a risk framework methodology developed in the context of the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report assessment process, which combines concepts of climate hazards, exposure (a metric gauging the "size" of a system) and vulnerability (a metric that considers non-climatic factors that modulate the impact of climate) to define climate risk. While most human, natural and economic sectors will be negatively affected by climate change, ARClim also reveals some opportunities, mostly in the expansion of some agricultural species and new investments in the energy sector.

Based on downscaled, bias-removed climate information, the project team identified 45 climate hazard indicators most relevant for Chile (all of them available in ARClim), covering extreme weather events and slow-onset processes. Then, 12 broad sectors (including human and natural systems, as well as economic sectors) potentially affected by climate change were identified, from where 55 impact chains were identified (i.e. a plausible narrative that connected hazards, exposure and vulnerability). By focusing on specific impact chains rather than on the hazard itself, further cascading risks, such as parasites and algae blooms that have negative impacts on aquaculture, were also identified.

Depending on the available information and the specific knowledge of the responses of the system under climate change, ARClim developed a quantitative or semi-quantitative approach. Climate change is assessed by comparing past (1980–2010) and future (2035–2065) climate conditions under the representative concentration pathway (RCP) 8.5 emission scenario. With few exceptions, exposure is kept constant to actual values, and vulnerability does not include adaptation measures. Thus, ARClim displays a rather pessimistic scenario of climate change risk, which can help to orient adaptation strategies. For instance, this information is being used in a related project to assess the economic costs of no action.

ARClim was built from publicly available information. To minimize model bias, the use of gap-filling data and/or interpolation was avoided as much as possible, and existing information was relied upon instead. In most cases, risk (and its basic elements) was assessed at a commune level, the basic administrative division in Chile, and across the whole country (346 communes in total). Nonetheless, in some cases, such as the forestry and agriculture sectors, data are presented as a spatial continuum, whereas in others, point results are presented, such as in the case of ports and towns.

Considering the diverse nature of the systems under analysis, the simple combination of different indices does not yield a comparable metric. For this reason, results were rescaled and expressed in five categories, which represent the degree of relative risk for each impact across Chile. Thus, ARClim results can be directly used by sector-specific, nationwide institutions (e.g. the Ministry of Energy). However, further work is needed to combine indicators with other sources of information, to assess local and regional risks from a multisectoral perspective.

Challenges

The project faced a number of major challenges. Sectoral models have different climate data requirements, in terms of specific variables as well as formatting. A task group for metadata was set up to facilitate data exchange and accessibility across research teams. This group was also responsible for integration and the data display providing specific recommendations and guidance.

A second major challenge was related to implementation of the risk framework in sectors that have different system responses, data requirements and model results. Although seemingly intuitive, the IPCC fifth assessment report risk framework is different from previous frameworks, thus causing some confusion in the definition of exposure and vulnerability. Furthermore, the project's working groups tended to identify an ample set of relevant impact chains, some of which could not be quantified because of a lack of reliable exposure/vulnerability data and/or a weak relationship with climate factors. Therefore, the project's central team maintained a permanent dialogue and set up specific meetings for coordination and discussion until the ideas were assimilated and a common narrative was established.

There is still a pending and major challenge with regards to integration across sectors. Within the limited time and resources of ARClim, it was not possible to develop a regional multivariate risk assessment. All elements have been developed, but a consistent methodology for combination needs to be identified and tested. The key question is how to weight the changing risk from different activities and sectors that coexist in a unit of territory. Furthermore, sector-specific risks are expressed either on a relative scale or with their own units, calling for a common metric yet to be developed.

Finally, a major challenge for ARClim was the communication of results. Several workshops were organized to present partial results and receive feedback on relevance, clarity and realism. Users from the public sector (unfortunately, the opportunity to present early results to the private sector was not possible due to the tight schedule) were always enthusiastic supporters of the initiative, but normally developed high expectations about the potential use and eventual results that can be obtained. For instance, they suggested additional impact chains, some of them plausible but others beyond the scope of this project. These meetings allowed the central team to present the limitations of the project and share a fundamental concept for these types of studies: "we can only obtain results for cases in which we have the knowledge, data, and tools at hand". Meetings were also useful to document research needs and data gaps that have to be filled to expand the capabilities of ARClim.

Enabling factors and lessons learned

Some of the key enabling factors and lessons learned include:

- A core, directive group is essential, given the multiple working groups, multiple requirements from the public and private sectors, and eventual misinterpretation of the methodological framework.
- Working groups need to be experts in their specific sectors. These groups usually comprise academics, bringing all their expertise in research, but they also need to be in close contact with external groups (in the public and private sectors) to validate the proposed impact chains (including internal metrics) and propose new ones.
- In addition to the sectoral working groups, two others are essential: the one in charge of providing climate indices and the other for developing the web platform.
- The web platform must be designed and implemented to allow simple, intuitive navigation, yet allow sophisticated analysis and accesses to all data/metadata used in the project. This will enable users to conduct further analysis.
- ARClim provides sector-specific, high-resolution, nationwide risk assessments, which are of immediate help for developing sectoral adaptation plans at a country level. Furthermore, ARClim offers the foundation to assess regional risks from a multisectoral perspective. However, this requires further research and work on integrative assessment.
- Building trust in the platform and methodology is essential for further development and refinement. ARClim has been presented as a dynamic and cooperative tool that can be updated when new information is incorporated and system understanding, and risk modelling capabilities improve.

INDIA

A subnational climate risk assessment

K. S. Kavi Kumar and Chandra Sekhar Bahinipati

Context

GIZ conducted a subnational climate risk assessment in the Indian State of Tamil Nadu, together with local and international stakeholders. The Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage (L&D)) developed and piloted the methodology. The programme's objective is to develop and pilot innovative concepts and tools for assessing and managing climate risks. As one of the countries most vulnerable to climate change impacts, India has an interest in methods and concepts for the development of measures to reduce climate-related L&D.

Approach

A rapid L&D assessment was conducted in Tamil Nadu in 2014–2015. The assessment followed an impact-based approach. The approach combined data on past events collected from secondary sources and from focus group discussions of various stakeholders and household surveys at the community level. The study focused on the climate hazards of cyclones and salinization, representing sudden and slow-onset climate events, respectively. The aim was to identify avoided, unavoided and unavoidable, economic and non-economic, and direct and indirect L&D.

For selected climate events, impact chains were created to display cause–effect relationships and to provide a basis for further analysis. Based on the documented damage, event-specific damage functions were developed for assessing future impacts. With the help of projected impacts, qualitative analysis of field-level observation and potential adaptation scenarios, state-wide L&D characterization was conducted.

For the analysis of future impacts, available damage functions were used, as well as qualitative analysis conducted to derive L&D. Adaptation scenarios were developed in some cases.

The underlying six-step methodology, developed by the GIZ Global Programme on L&D, is a customized approach that can be utilized to assess and develop various measures at national, regional and local levels. It can deal with severe climate risks, including residual risks that could contribute to potential L&D. The overarching objective is to derive assessment results that help identify an effective and sustainable combination of instruments and tools considering environmental, social, economic and cultural aspects as a foundation for an effective climate risk management approach.

Lessons learned

The assessment approach was found to be beneficial as it allowed quantification of unavoidable L&D at state and community levels. It also made the non-economic losses visible. The main lessons learned were on the need to continuously improve the database as well as modelling approaches, including verification. In particular, the study identified that data on past impacts (economic and non-economic) at state level were missing.

This was particularly true in the case of impacts due to gradual changes such as salinization. Farmers in the coastal areas of Tamil Nadu are being severely affected by salinization. However, in contrast to sudden-onset events such as cyclones, the government does not provide assistance for the losses incurred due to salinization. Analysis of factors contributing to salinization in Tamil Nadu suggested that poor and unplanned developmental activities is one of the main reasons. In addition to measurement issues, quantification of the extent of salinization in the state faces challenges due to a lack of proper baseline data. As the government does not fully recognize salinization as a potential cause of L&D, necessary mechanisms for data collection and impact assessment are absent in Tamil Nadu. Insight from a study based on farmers' assessment of damage incurred due to salinization has provided useful inputs for recognizing the severity of the issue. This could help facilitate formulation of appropriate disaster management plans together with relevant short- and long-term adaptation strategies.

Having the data as evidence to raise awareness within the government departments is a key challenge, especially for slow/gradual-onset events such as salinization. As recognized by the study, equally critical is the need to acknowledge and plan for transformation changes by the government.

After completion of the assessment, it was recommended that future assessments should investigate non-climatic drivers of impacts further at the local level, which would then allow development of appropriate adaptation measures. Moreover, risk tolerances need to be determined for L&D impacts. The study strongly recommended the need to conduct qualitative analysis to identify the non-economic L&D, which may otherwise be neglected at the policy formulation levels (Kavi Kumar et al., 2018).

MADAGASCAR

Mainstreaming climate risk assessment results in several planning processes

Vanessa Vaessen, Maminiaina Rolland Randrianarivelo and Alicia Natalia Zamudio

Context

In the national adaptation plan (NAP) process of Madagascar, several climate risk assessments were conducted, supported by various partners and projects. Three regional climate risk and vulnerability assessments (CRVAs) using the vulnerability sourcebook methodology were conducted as part of a climate change adaptation (CCA) project, led by GIZ. CRVA results informed various policy processes such as the NAP, 35 local municipal land-use planning schemes resulting in 35 adaptation projects in each municipality and the Climate Change National Policy, as well as sectoral strategies such as the National Policy on Infrastructure and Equipment, the National Education Curricula, the National Plan on Health and the National Strategy for Wood Energy. All relevant indicators were integrated into the National Monitoring and Evaluation System led by the Ministry of Economy and Budget.

Approach

An inclusive approach was adopted including all relevant stakeholders at the national and regional levels, applying a gender-sensitive approach, given that the main objective was to inform the NAP. The National Coordination Office for Climate Change under the Ministry of Environment led regional consultation on the NAP process. Various training sessions (NAP training modules, SNAP Tool, CLiFIT) were held for boosting and dynamizing the NAP steering committee. Training of journalists was held for awareness-raising.

The approach used qualitative and quantitative methods and combined socioeconomic data and trends with climate data and climate scenarios from all relevant sectors (forest and biodiversity, water and sanitation, public health, costal zones and fisheries, agriculture and livestock).

Challenges

Given the different institutional mandates and rapid changes in leadership and high-level civil servants, coordination among the different agencies and government levels needed for an inclusive approach was challenging. Institutions responsible for disaster risk reduction (DRR) and for CCA lack incentives to work across institutional silos, even though Madagascar has a designated National Office for Disaster Risk Management. Other challenges included the perceived and real power asymmetries between this office and the Ministry of Environment, as well as a lack of coherent approaches by development partners and donors supporting risk assessments and planning processes in the context of the NAP. Additionally, trade-offs were identified and undertaken. These included the most-appropriate risk assessment scales given the policy and planning objectives among less-detailed risk assessments to inform national processes, detailed regional ones applicable for a few regions or detailed local level assessments to inform local land-use plans.

Enabling factors for integration into planning processes

The process was flexible enough to include capacity development of relevant stakeholders, favouring a continuous learning process, which helped build collaboration and buy-in for the overall planning process. Integration of climate risk management into the National Education Curricula and into a training programme also helped to strengthen capacities and contribute to a sustainable approach.

The objectives to inform various policy processes, including the NAP, were decided on before starting the assessments (and included in the Terms of References for recruiting an assessment team). This allowed the assessment methodology to be shaped and the assessment stage to be better linked with the planning one. Additionally, including the identification and prioritization of adaptation options directly in the Terms of Reference as part of the assessment process facilitated the continued involvement of key stakeholders (e.g. in regional NAP consultations) in the assessment and planning phases. At the local level, the results of the CRVA informed the 35 different municipal land-use plans, which developed and implemented 35 adaptation projects based on the assessments.

The management of climate risks was a cross-cutting theme in the CRVA and in the NAP. When designing the scope and working group leading the assessments, a practical solution was to ensure CCA and DRR stakeholders and relevant sectors (e.g. institutions) were involved and that such groups had clear roles and responsibilities to collect and share data and information generated across sectors and stakeholders. These were captured in a communication and dissemination strategy of assessment results. The strategy facilitated identifying multiple end users and their needs, subsequently tailoring the risk information depending on the various end users. It was supported by engagement of the National Meteorology Agency. For example, using index maps and impact chains in discussing adaptation options with decision makers helped summarize assessment results and conveyed them in a more usable and appealing format.

Risk information also supported broader awareness-raising and advocacy purposes during the NAP process. Other factors were instrumental in helping to overcome some of the institutional barriers. For example, investing time in understanding or setting up and strengthening coordination mechanisms with clear roles and responsibilities to lead the NAP process and the CRVA process, including how the information would be managed and shared. This also involved the setting up of a national database system on climate change activities and actions such as risk assessments and ongoing activities in the country.

NEPAL

Harmonizing disaster risk reduction and climate change adaptation for local resilience – a risk information web platform

Pradip Khatiwada, Reena Bajracharya and Janak Pathak

Context

In Nepal, deployment of DRR and CCA governance systems and institutional set-ups does not seem to be deliberately planned in administrative silos. Nepal has revised some policies and regulations based on the Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework). The local disaster management plan guideline of 2011 was revised to the local disaster and climate-resilient plan (LDCRP) guideline of 2017. It guides local governments in developing their local disaster and climate-resilient committees (LDCRCs) and mainstreaming DRR and CCA into their local development planning processes. It is a bottom-up, inclusive and decentralized DRR and CCA planning process. Based on the local context and climate profile, it acknowledges the needs of local people and builds on current and future vulnerabilities. The planning process promotes effective investment for resilience through risk analysis, adaptation capacity and development of local institutional mechanisms.

Approach

The LDCRP guideline seeks to aid coordination of all the local bodies from district to ward level to work with local representatives to form an LDCRC. The LDCRC nominates disaster and climate change experts to form a local disaster and climate-resilient planning subcommittee. An integrated disaster and climate risk profile based on vulnerability and capacity assessment includes analysis of the five livelihood capitals (social, human, natural, physical and financial) and daily livelihood to develop the LDCRP. All local governments are required to follow the guideline to develop and implement their plans.

Challenges

The 2017 guideline is intended to replace the local disaster management plan guideline of 2011 and focus more on disaster risk than climate change. It is not clear how the local adaptation plans for action (LAPA) framework will be incorporated into the LDCRP, and the current process set out in the LDCRP seems incompatible with the LAPA framework. DRR and CCA must be part of the development priorities and agenda, and part of the local and provincial government's planning and budgeting process to achieve integration and mainstreaming (Regmi et al., 2019). Merging the local disaster risk reduction management plan (LDRRMP) and LAPA into the LDCRP may raise a few questions in terms of harmonization, especially when it comes to allocating funds for CCA. In the absence of a national act on CCA at the local level, local authorities do not prioritize this work.

Enabling factors and lessons learned

Most municipal budgets prioritize disaster response and emergency relief. Identifying commonalities and areas of convergence between DRR and CCA can provide a strong rationale for funding risk reduction measures and preparedness.

This also applies to development investments. Most municipal infrastructure projects have co-benefits to mitigate disaster risk and adaptation to climate change, yet they are not fully realized by local governments (Mercy Corps, 2019). The public favours infrastructure developments that provide direct benefits and promote livelihoods, such as building roads, irrigation embankments and culverts. DRR and CCA investments are lower priority, mainly because payback takes longer and is not directly visible unless there is an extreme event. DRR and CCA must be fully integrated into the local development planning process, to ensure these projects are risk informed and climate resilient.

Visualization of integrated risk information

The Government of Nepal has developed an online web portal to meet the needs of Sendai Framework Priority 1 on understanding disaster risks. Moreover, the Building Information Platform Against Disaster portal is strongly based on Nepal's national Disaster Risk Management Act 2017 and national policy plan. The new interactive web mapping tool brings all the disconnected information regarding risks including climate risks, vulnerabilities, hazard events and near real-time response information from government and non-government stakeholders together. For instance, vulnerability data are currently shown at district level, whereas landslide susceptibility is available to interrogate at ward level. There is now an obligation to make all information or analysis part of this portal. Every municipality can link its own information and run its analysis. The portal is a good example of how to set up and present risk data in an integrative way. The technology is open source and could thus be replicated by any country or region.

PERU

Zurich Flood Resilience Alliance programme and application in Peru by Practical Action

Colin McQuistan, Orlando Chuquisengo Vásquez, Miguel Arestegui and Miluska Ordoñez

Context

The Zurich Flood Resilience Alliance (ZFRA) is a multisectoral and multi-actor partnership launched in 2013 focused on strengthening the resilience of communities to flood risk. It consists of humanitarian, non-governmental organization, research and private sector partners forming a science–society partnership for more evidence-informed and effective disaster (flood) risk management. ZFRA has applied and tested a resilience framework and tools working with more than 110 communities in nine countries. The overall objective is to achieve climate-smart risk-informed development, using a resilience concept to help operate within the development, DRR and CCA nexus, bringing together humanitarian practitioners, development partners, private sector, community members and decision makers.

Approach

ZFRA uses an adaptive management cycle to foster resilience in what is referred to as the "shared resilience learning dialogue". The approach is flexible and emphasizes continuous learning and innovation among stakeholders. For almost each step, there is a variety of decision-support tools, often co-created, starting with the assessment step, and followed by identification and prioritization of risk management interventions drawing from the CCA and DRR field, and integrating these interventions in projects or plans. These are then implemented, monitored and evaluated. After a flood event has occurred, assumptions are re-evaluated to ensure they hold true and risk management strategies are appropriate. These insights are fed back into each step. One of the decision-support tools presented as part of the toolbox, which can be tailored depending on the specific user's context, is the Flood Resilience Measurement for Communities (FRMC) tool.

Application of the Flood Resilience Measurement for Communities tool in Peru in two river basins systems

The FRMC tool and overall resilience-based approach was applied in two river basins in Peru: the Rimac and Pirua River basins. Participatory vulnerability and (adaptive) capacity assessments,[8] based on the Sustainable Livelihoods Framework, were also conducted as part of the FRMC application to gain insights into current hazards, perceived risks and capacities. The FRMC tool facilitated communities to measure their own flood resilience (across resilience sources) and track it over time.

This decision-support tool helped integrate risk information into local community-owned planning processes, for example through illustrating grades and scores resulting from its application, helping to visualize the perceived risks from floods. Moreover, the process helped to identify and select measures with and by the communities involved having gained an understanding of the differentiated vulnerabilities by population groups and their enabling environment, geared to increase resilience sources. Additionally, to facilitate navigating the complexity of each decision-making context, a Flood Resilience System Framework and Model (FLORES) was developed. As a result, early warning systems led by the National Weather Service considering citizen information, including participatory monitoring systems combined with data from climatic stations, are being implemented, among other initiatives.

Challenges

One main challenge highlighted has been to deal with institutional barriers and siloed approaches, between DRR, CCA and development institutions as well as communities of practice, including among international cooperation organizations using different methodologies. Additionally, taking into account the future dimension of climate change (e.g. how underlying slow-onset processes are and can change risk patterns) remains challenging, as many tools focus on past and present risk information.

Enabling factors and lessons learned

The adaptive planning approach helps to overcome institutional barriers by accommodating various perspectives, as it is inclusive and community led, as well as being based on multidisciplinary teams. Additionally, ZFRA applications could draw from multiple perspectives and from well-established working relationships with community organizations, facilitating participatory processes. Tailoring the risk information to different audiences (e.g. by generating visual statistical evidence such as climate resilience scores from the FRMC tool) helps to attract the attention and engagement of decision makers.

The overall assessment and planning process is used to raise awareness and strengthen capacities geared towards self-empowerment. Moreover, using a combination of tools, including scenario planning tools, bringing together climate change scenarios with development plans, helps to simulate different courses of action and prioritize appropriate solutions. By focusing on managing risks, meaning integrating flood risk into planning and investment decisions including in planning for response and recovery to avoid losing assets and development gains, rather than removing all risks from the equation, the FRMC tool and more generally, adaptive planning approaches such as this one, help to operate under existing uncertainties.

8 Such assessments aim to support communities to identify key vulnerabilities, understand perceived and actual risks, analyse the resources and capacities available to reduce said risks and develop action plans to address identified vulnerabilities and risks.

PHILIPPINES

Bottom-up approaches for cross-sectoral and multilevel risk integration

Donna Mitzi Lagdameo and Mareike Bentfeld

Context

The Philippines is often cited as a best-practice example of policy coherence and practical integration of DRR and CCA fields across national, regional and subnational/local scales. This case study highlights some ongoing or recent initiatives and key enabling factors that have been identified and/or commonly cited. One such initiative is the global alliance called Partners for Resilience (PfR). PfR member organizations combine their expertise to strengthen resilience and livelihoods of vulnerable communities with risks of natural and human-induced hazards, impacts of climate change, and impacts of damaged or overused ecosystems by adopting an integrated risk management (IRM) approach. Another example is the Global Initiative on Disaster Risk Management (GIDRM), supporting selected international and national, governmental and non-governmental, stakeholders in their efforts to increase coherence regarding planning, implementation and reporting on disaster risk.

Approach

The PfR IRM approach brings together DRR, CCA, and environmental management and restoration interventions to manage current and future risks (across timescales) happening at the community scale and beyond, adopting a landscape approach (enabling operation across administrative and political boundaries).

Local participatory risk assessments are conducted by combining scientific and traditional knowledge using a variety of tools such as games and storylines to provide the information needed to mainstream risks within various local plans. These include local climate change adaptation plans (LCCAPs) and local LDRRMPs. PfR used the same risk assessment tools and outcomes to inform the LCCAP and LDRRMP. These were then integrated into the two key planning documents, mandated by the Department of Interior and Local Government: the local comprehensive land-use plan and the comprehensive development plans. Through the PfR initiative, a manual of tools for conducting participatory risk assessments in communities and a checklist of "minimum standards for local climate smart DRR" programming were developed. LDRRMPs and LCCAPs were annexed to the comprehensive development plans, which in turn were linked to the annual investment plans to receive budgetary allocation from the local government unit.

In an effort to allow for greater synergies among different local planning processes with a more coherent consideration of risk aspects, GIDRM supported the Department of the Interior and Local Government in harmonizing climate and disaster risk assessment methodologies used at the local level. By analysing the risk assessment requirements from different national ministries for specific local planning processes, a common set of methodologies has been identified that can build the basis for more coherent and risk-informed local planning processes.

Additionally, to support risk-informed decision-making, the suitability model methodology was developed and tested in Leyte and Cebu in the Philippines. This methodology allows private and public sector actors to use scientific data related to climate change and disaster risks in decision-making processes such as land-use planning. The methodology helps to integrate the climate and disasters by developing multi-hazard maps indicating different probabilities of hazard occurrence and potential for damage to certain development options (e.g. buildings or crops). These are expressed as a percentage of expected annual economic costs, using a variety of information sources and tools such as geographic information systems in participatory processes.

At the national level, the Philippines has a supporting legislative framework with integrated financial instruments. In 2010, the country enacted into law the National Disaster Risk Reduction and Management Act or Republic Act 10121 (RA10121). This superseded the Presidential Decree 1566, the Disaster Management Act of 1978. RA10121 transformed the then National and Local Calamity Funds, used primarily for response operations, to the National/Local Disaster Risk Reduction and Management Fund (N/LDRRMF). Due to the enhancement, the N/LDRRMF was mandated to allocate 30% for the Quick Response Fund for relief and response operations, while 70% is for broader risk reduction efforts.

All local government units automatically set aside at least 5% of their internal revenue allocation for the LDRRMF, the use of which is guided by the LDRRMP. As there is no institutional budgetary allocation for adaptation-related projects, it is important for LDRRMPs to also address climate-related risks to be able to use the LDRRMF in addressing climate-related and disaster risks. In that regard, the GIDRM project, implemented by GIZ, worked on integrating the LDRRMP and LCCAP to allow local government units to use a single plan for successful application for funds. Moreover, under RA10121, all line agencies are mandated to allocate at least 5% of their annual budgets under the General Appropriations Act, which will also have the same 30:70 formula for allocation/use.

Challenges

While much progress has been made, especially at the local level, difficulties in adopting a coherent approach at the local and national levels remain. At the national level, an additional challenge comes from the many acts, laws and sectoral plans, which may lead to duplication and siloed approaches (Sandholz et al., 2020). Moreover, donors and partners supporting similar processes often use different approaches, tools and methods.

Enabling factors and lessons learned

To overcome some of these challenges, relying on the existing legislative mandate has facilitated working across scales. Instead of prescribing one methodology to follow, key principles, minimum standards and flexible methodologies were developed to allow each organization and community to focus on particular needs and context at the assessment and planning levels. Moreover, policymakers and government officials at the local level were involved from the start of the process, including the same stakeholders that took part in the risk assessment and also in the risk management part. This helped build buy-in and ensure risk information was tailored to users, for example via multi-hazard maps presenting visual and quantitative information of possible economic losses to local government officials (GIDRM initiative).

The PfR initiative implementation lasted for 10 years, longer than usual development project time frames. This allowed a first focus on building strong relationships with stakeholders and a common understanding of key terminology and underlying risk concepts, which facilitated the overall planning processes. Both relied on bottom-up approaches to help mainstream risks across different planning processes (e.g. sharing lessons learned to feed the ongoing NAP process or relying on mayors to talk to governors).

VIET NAM

Climate-informed decisions for resilient infrastructure for sustainable development

Nguyen Thi Minh Ngoc

Context

Viet Nam, and especially its Mekong Delta, is prone to extreme weather events and slow-onset processes such as sea-level rise. In collaboration with GIZ, a climate risk assessment was conducted with the aim to ensure the resilience of existing and new infrastructure. The International Climate Initiative global project Enhance Climate Services for Infrastructure Investments, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and implemented by GIZ with a case study of the Cai Lon–Cai Be sluice system in the Mekong Delta, is a good example of a comprehensive risk assessment focusing on one particular aspect: infrastructure.

With the overarching aim of sustainable development, this assessment looked at the comprehensive and systemic management of the planning stage of infrastructure investment projects. The climate risk-based recommendations have been considered by the infrastructure project owner in adjusting detail design and construction of the sluice infrastructure accordingly in 2020–2021. The assessment is also in line with planning law, which specifies all investments in the future need to consider climate risks.

Approach

The basis of the approach was the Engineering Protocol for Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate (Public Infrastructure Engineering Vulnerability Committee) and its step-by-step methodology of climate risk assessment for infrastructure. The hazards considered included slow-onset processes because they are important for infrastructure. Also, coincidences of climatic hazards with non-climatic hazards were analysed. Which hazard will have which impact on different parts of the infrastructure was analysed in detail. Based on the resulting potential impacts, engineering solutions were developed to mitigate those risks.

The risk assessment approach combined qualitative and quantitative methods. In a mixed quantitative–qualitative assessment, individual risk severities and probabilities were classified from 0 to 7 (0 means no negative consequence and 7 means failure of the infrastructure) for each infrastructure component and for the present and future. Subsequently, the risk scores were categorized into low, medium and high risks according to the Public Infrastructure Engineering Vulnerability Committee guidelines. High risks require a considerable response in the detailed design phase, while a low risk level needs no immediate actions. Results were visualized in a combined risk matrix for current and future conditions, for climate and non-climate hazards (Nguyen et al., 2019).

Lessons learned

The climate service for infrastructure project was a pilot, trying to understand whether the method described above can be recommended for long-term infrastructures projects. The threshold setting for the final risk scores was a challenge. Thresholds were set by experts from different institutions engaging in discussions. In this case study, present and future risks were both assessed. A risk score was specified for different components of the planned infrastructure. Measures for climate proofing of single components of the infrastructure could then be developed. Risk scores were a result of: (a) quantitative analysis of climatic variables and phenomena and their interactions with the infrastructure, (b) the calculated probability of occurrence and (c) expert-based judgment of the severity of the consequence, which led to identification of vulnerabilities. Limitations regarded data availability for data on storm surges, waves, water temperature and sediment transport. It is recommended to increase monitoring and observation activities, to derive impact data of extreme climate events on infrastructure. Further research is needed on the impacts of climate change and the response of infrastructure components to specific impacts.

ANNEX 2. TECHNICAL RESOURCES AND GUIDELINES

Over the years, various organizations have developed and proposed comprehensive risk management (CRM) frameworks in the context of climate change; some of them are already being used. They share similar characteristics, which have informed the comprehensive risk assessment and CRM approach proposed in this guidance. This annex provides a list of CRM frameworks, including various guidance documents that can be used when assessing climate and disaster risks and integrating them into planning processes. It is an indicative list of technical resources for further reading and is not intended to be exhaustive.

RISK MANAGEMENT FRAMEWORKS	
Adaptive management cycle	Developed by the Zurich Flood Resilience Alliance (ZFRA), this approach focuses on identifying and strengthening resilience sources and how these help communities to function well and even thrive despite hazards and stresses.
Climate risk management framework	An approach developed by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH to manage risks from short-term extreme events and long-term gradual changes. It focuses on ways to avert, minimize and address loss and damage associated with climate change (GIZ, 2019).
Comprehensive risk management approach	Developed under the Platform for Climate Adaptation and Risk Reduction (PLACARD) project, this approach brings together the climate change adaptation (CCA) and disaster risk management (DRM) cycles using a four-step sequential approach, namely CRM monitoring, climate risk framing, climate risk analysis, CRM options and CRM implementation (Leitner et al., 2020).
Integrated climate risk management	Developed by GIZ and the Munich Climate Insurance Initiative, this approach focuses on the five phases of climate risk management and their relationships with a typical DRM cycle, including risk analysis, risk reduction, emergency management, relief, disaster risk financing and building back better.
PCL framework	Developed by Youssef Nassef, this framework focuses on pre-emptive action, contingent arrangements and actual loss acceptance. It proposes classifying climate risks according to their tolerability and linking this evaluation to the demand for action (Nassef, 2020).

DISASTER RISK ASSESSMENT GUIDELINES	
IEC 31010 Risk management – Risk assessment techniques	This standard provides guidance on the selection and application of techniques used for risk assessment that is applicable in various situations. It is used to support decision-making and risk management processes, especially when uncertainty is strong (ISO, 2019).
INFORM Index for Risk Management: Concept and Methodology	Developed by the Disaster Risk Management Knowledge Centre of the European Commission, this model/methodology uses a composite risk index and includes data on hazards, exposure, vulnerability and coping capacity to understand and analyse the level of risk across regions or countries (Marin-Ferrer et al., 2017).
National Disaster Risk Assessment	Published by the United Nations Office for Disaster Risk Reduction (UNDRR), these Words into Action guidelines focus on Priority 1 of the Sendai Framework for Disaster Risk Reduction 2015–2030. They aim to motivate and guide countries in establishing a national system for understanding risks and implement holistic assessments to cover the wide array of dimensions of disaster risks (UNISDR, 2017b).
CLIMATE RISK ASSESSMENT GUIDELINES	
Assessment of Climate-related Risks: A 6-step Methodology	Developed by GIZ (Global Programme on Risk Assessment and Management for Adaptation to Climate Change (Loss and Damage), this methodology is part of a climate risk management framework that focuses on assessment across the full spectrum of risks and on specific data needed in each step. It also proposes fit-for-purpose measures for implementation of actions (GIZ, 2021).
IVAVIA Guideline: Impact and Vulnerability Analysis of Vital Infrastructures and Built-up Areas	Developed under the RESIN (climate-resilient cities and infrastructure) initiative of the European Union H2020, this guideline on risk assessments aims to unpack impacts related to climate change in urban areas and infrastructure (Rome et al., 2018).
The Vulnerability Sourcebook: Concept and Guidelines for Standardised Vulnerability Assessments	Developed by GIZ together with other institutions, this sourcebook offers a wide array of tools – from a conceptual framework to standardized vulnerability assessments to monitoring and evaluation of adaptation actions (Fritzsche et al., 2014).

TOOLS FOR RISK SCREENING AND INTEGRATION INTO PLANNING	
Capacity for Disaster Reduction Initiative (CADRI) tool	Developed by CADRI, a global partnership composed of 20 organizations working towards the achievement of the Sustainable Development Goals, this capacity assessment and planning tool helps facilitate multidisciplinary approaches and increases coherence across United Nations programmes to prioritize risk reduction actions at national and subnational levels; https://www.cadri.net/cadri-tool
Caribbean Climate Online Risk and Adaptation TooL (CCORAL)	Developed by the Caribbean Community Climate Centre, this Caribbean-focused tool aims to help decision makers understand and identify actions that minimize climate-related losses and develop strategies for climate-resilient development; http://ccoral.caribbeanclimate.bz/
Climate & Disaster Risk Screening Tools - Agriculture Projects	Developed by the World Bank, this tool presents a systematic way to identify potential risks for agriculture-based projects and how extreme temperature, precipitation and other related hazards can affect production, other related risks and economic losses; https://climatescreeningtools.worldbank.org/agr/agriculture-welcome
Climate, Environment and Disaster Risk Reduction Integration Guidance (CEDRIG)	Developed by the Swiss Agency for Development and Cooperation, this practical and user-friendly tool was developed to systematically integrate climate, environment and disaster risk reduction (DRR) into development cooperation and humanitarian aid, and follows an integrated approach to assess risks; www.cedrig.org
Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL)	Developed by the International Institute for Sustainable Development, International Union for Conservation of Nature, Helvetas Swiss Intercooperation and Stockholm Environment Institute, this project planning tool seeks to systematically assess impacts of climate change on local communities and livelihoods. It is also a context-specific decision-making framework centred on livelihoods and gender-sensitive approaches (IISD, 2012); https://www.iisd.org/cristaltool/
Food Security Indicator & Policy Analysis Tool (FIPAT)	Developed through the Climate Resilience and Food Security in Central America project and in partnership with various organizations, this policy analysis tool helps governments identify required resilience actions, monitor food system resilience over time and assess the extent to which current policies strengthen food system resilience (Echeverría and Keller 2014); https://www.iisd.org/publications/fipat-guidebook-food-security-indicator-policy-analysis-tool

Zurich Flood Resilience Measurement for Communities (FRMC)	Developed by ZFRA, this framework combines 44 indicators of resilience and systems thinking to help users understand and develop actions that will help them withstand and respond to shocks; https://floodresilience.net/frmc/
GUIDELINES FOR INTEGRATING CLIMATE RISKS AND DISASTER RISKS	
Addressing Climate Change within Disaster Risk Management: A Practical Guide for IDB Project Preparation	Developed by the Inter-American Development Bank, this project preparation technical note aims to provide climate risk management options and develop considerations to track progress on the ground. It helps users identify effective solutions in strengthening resilience (Herron et al., 2015).
A Guide to Mainstreaming Guiding Principles Disaster Risk Reduction and Climate Change Adaptation	Developed by the International Federation of Red Cross and Red Crescent Societies, this guide aims to help national societies and their staff to systematically integrated climate and DRR measures in humanitarian work (IFRC, 2013).
Bonding CCA and DRR: Recommendations for Strengthening Institutional Coordination and Capacities	Developed under the PLACARD initiative, this "bonding" tool showcases innovative approaches to improve cooperation, collaboration, capacity sharing and coherence between DRR and CCA communities (Leitner et al., 2020).
Integrated Risk Management Law and Policy Checklist	Developed under the global initiative on Partners for Resilience, this checklist identifies entry points to improve current laws, policies and implementation plans, and to integrate DRR, CCA and ecosystem management and restoration approaches across scales (PfR, 2019).
Integrating Disaster Risk Management into Climate Change Adaptation	Developed by the Asian Disaster Preparedness Center, this practitioners' guide focuses on integrating DRM approaches into adaptation actions and decision-making. It draws on practical experiences from Asia and the Pacific in implementing risk-centred CCA actions (ADPC, 2013).
Minimum Standards for Local Climate-smart Disaster Risk Reduction	Developed by the Red Cross Red Crescent Climate Centre, this checklist identifies practical and simple steps to integrate climate information in DRR actions, at national and community levels (Red Cross Red Crescent Climate Centre, 2013).

Toward Resilience: A Guide to Disaster Risk Reduction and Climate Change Adaptation	Developed through years of collaboration and lesson sharing among project agencies/organizations working with populations most at risk from climate change and disasters, this guide highlights the replicable elements from good practices in integrating rights-based approach to DRR and CCA integration (Turnbull et al., 2013).
REPORTS ON ENHANCING COHERENCE BETWEEN CCA AND DRR	
Climate Change Adaptation and Disaster Risk Reduction in Europe: Enhancing Coherence of the Knowledge Base, Policies and Practices	Developed by the European Environment Agency, this technical report aims to better inform national and subnational strategies, plans and actions towards more coherent implementation of DRR and CCA. It also explores the application of domain-specific methods and tools to drive mutually beneficial learning and capacity-building (EEA, 2017).
Common Ground Between the Paris Agreement and the Sendai Framework: Climate Change Adaptation and Disaster Risk Reduction	Developed by the Organisation for Economic Co-operation and Development, and informed by country approaches in Ghana, Peru and the Philippines, this report examines the potential for increased coherence in the approach used for CCA and DRR, structured around: policy and governance; data and information; implementation; financing; and monitoring, evaluation and learning (OECD, 2020).
Disaster Risk Reduction and Climate Change Adaptation: Pathways for Policy Coherence in Sub-Saharan Africa	Developed by the UNDRR Regional Office in Africa, this report proposes pathways for policy coherence across the integration spectrum and uses them to assess the level of integration between DRR and CCA policies. It was developed based on the analysis of DRR and CCA strategies from 32 countries in the region (UNDRR, 2020c).
GUIDELINES FOR INTEGRATING CLIMATE AND/OR DISASTER RISKS INTO DEVELOPMENT PLANNING	
Coherence Cookbook: Building Resilience in an Integrated Way	Developed by the Global Network of Civil Society Organizations for DRR, this cookbook presents recipes for building coherence and highlights the important role civil society organizations play in this process. The various case studies present success factors in enhancing coherence between DRR and CCA, including resilience at the local level (GNDR, 2019).

Developing National Disaster Risk Reduction Strategies	Developed by UNDRR, these Words into Action guidelines seek to help national governments develop their national DRR strategies, contributing to the achievement of Target (e) of the Sendai Framework. The guidelines contain a 10-step approach to the development or revision of an inclusive national DRR strategy, which can be customized based on national circumstances (UNDRR, 2019c).
Disaster Risk Management and Country Partnership Strategies: A Practical Guide	Published by the Asian Development Bank, this practical guide presents actions to strengthen disaster resilience, including the integration of DRR into development plans and presentation of actions for consideration in the development and implementation of country partnership strategies in developing countries (Asian Development Bank, 2017).
Integrating Disaster Risk Reduction and Climate Change Adaptation in the UN Sustainable Development Cooperation Framework	Developed by UNDRR for United Nations Resident Coordinator Offices and Country Teams, this guidance note suggests steps for risk-informed actions for each phase in the United Nations Sustainable Development Cooperation Framework life cycle with the end in view of formulating and implementing cooperation frameworks that support countries, communities and people in using climate and DRM approaches to build disaster resilience (UNDRR, 2020g).
Mainstreaming Disaster Risk Reduction for Sustainable Development: A Guidebook for the Asia-Pacific	Developed by the United Nations Economic and Social Commission for Asia and the Pacific, this guidebook presents practical steps in mainstreaming DRR into policies, plans and programmes across key sectors. It discusses strategic approaches towards risk resilient development in the region (ESCAP, 2017).

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