



DRAFT Words into Action

Implementation Guide for Addressing Water-Related Disasters and Transboundary Cooperation

Integrating disaster risk management with water management and climate change adaptation

Summary and proposed action by the Task Force on Water and Climate

The Sendai framework for disaster risk reduction was adopted at the third United Nations World Conference on Disaster Risk Reduction (WCDRR) in Sendai, Japan, in March 2015 and subsequently endorsed by the United Nations General Assembly. During the consultations and negotiations that led to its finalization, strong calls were made to develop practical guidance to support implementation, ensure engagement and ownership of action by all stakeholders, and strengthen accountability in disaster risk reduction.

In order to support the process, a number of targeted Sendai Framework implementation guides are being developed generating evidence-based and practical guidance for implementation in close collaboration with States, and through mobilization of experts; reinforcing a culture of prevention in relevant stakeholders.

Under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) serviced by the United Nations Economic Commission for Europe (UNECE), the Task Force on Water and Climate has worked since its creation in 2006 on promoting transboundary cooperation in climate change adaptation and disaster risk reduction, including in the framework of global processes on climate and disasters.

As suggested by the United Nations Office for Disaster Risk Reduction (UNISDR), an implementation guide on “Addressing Water-Related Disasters and Transboundary Cooperation” is therefore being developed under the Water Convention, in cooperation with UNISDR during the period from 2016 to 2018. At its twelfth meeting, the Convention’s Working Group on Integrated Water Resources Management (IWRM) endorsed the development of such guide and entrusted the Task Force on Water and Climate and, more specifically a drafting group led by the Netherlands to prepare the first draft of the guide for review at its next meeting, to be held on 29 to 30 May 2018 in Geneva.

In 2017, a drafting group was set up with experts from around the world under the leadership of the Netherlands. The drafting group met once in person and held several phone conferences. The drafting group prepared the draft guide contained in this document. It still requires revision and editing.

The Task Force on Water and Climate is invited to review the draft guide, to provide comments at the 9th meeting and in writing until 15 January 2018 and entrust the drafting group to address the comments received and submit a revised edited version to the thirteenth meeting of the Working Group on IWRM (Geneva, 29-30 May 2018) for consideration.

At the same time, since the guide is a joint document with UNISDR, it will also undergo a number of steps in the quality control process foreseen for words into action guides, namely a peer review by UNISDR and an open online consultation.

It is envisaged to finalize the guide in time for endorsement at the eighth session of the Meeting of the Parties of the Water Convention (Astana, Kazakhstan, 10-12 October 2018).

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1. Key messages

1.1. Overview of the key messages from the guide

Water is central to many different sectors that directly depend on water being available and of high quality. Therefore, water management can limit or enhance disaster risks of water-related sectors. Climate change's impacts on water are expected to have cascading effects on human health and on many parts of the economy.

Transboundary cooperation is both necessary and beneficial in disaster risk management. It is necessary throughout the entire process of developing and implementing a strategy. International basins constitute about half of the Earth's land surface. The fact that many water bodies cross boundaries means that risks and challenges are shared and that solutions therefore need to be coordinated.

Disaster risk management measures need to be flexible. This is required by the uncertainties which exist about the direction and nature of change the climate is causing in hydrological systems. Interventions chosen should be flexible enough to deliver maximum benefits under a range of conditions instead of being designed for what are thought to be the "most likely" future conditions. If conditions change or if the changes prove different from those expected today, the measures taken should be capable of changing in step.

Effective disaster risk management requires a cross-sectoral approach including at the transboundary level, in order to prevent possible conflicts between different sectors and to consider trade-offs and synergies between different measures. Uncoordinated sectoral responses can be ineffective or even counterproductive, because a response in one sector can increase the vulnerability of another sector and/or reduce the effectiveness of its disaster risk responses.

It is increasingly acknowledged that degraded ecosystems such as wetlands complicate the disaster risk context. Degraded systems are often a contributing factor to the development of hazards while at the same time people derive less goods and services from such systems reducing their overall resilience. Such eco-effects can propagate through water related systems and may cross borders. Hence implementing the Sendai Framework in a transboundary context should include ecosystem management and restoration and the use of ecosystems as green infrastructure to mitigate disaster risk effect.

Uncertainty should never be a reason for inaction. What we know about climate change is qualified by a level of uncertainty. All the same, we can identify trends that allow us to act. A twin-track approach, combining immediate action and further research, is therefore recommended. Water management and water-related policies and measures need to be adapted now to climate change on the basis of what we know already. At the same time, we need to do more research into the effects of climate change to deepen our knowledge.

Implementing national legislation and international commitments supports disaster risk management. A number of international agreements include provisions and have developed tools that can support the development of disaster risk strategies. Countries should take into account and build on such provisions to maximize results and ensure the coherence of the policies and measures they adopt.

Ensuring that data and information are readily available is crucial for making climate projections and identifying vulnerable groups and regions. So sharing information, including that from early warning systems, between countries and sectors is essential for effective and efficient disaster risk management.

2. Introduction

2.1. Context and rationale

A large part of disasters risks are directly or indirectly linked to water (e.g. flood, drought, typhoons/cyclones, flashflood, landslides and water quality emergency). Since 1992 floods, droughts and storms have affected 4.2 billion people (95% of all people affected by disasters) and US\$1.3 trillion of economic losses (WCDRR 2014). The number of people affected and estimated damages from water-related disasters continue to increase. This increase can be partially explained by better reporting and documenting of such disasters and its consequences such as through the Emergency Events Database (EM-DAT¹). However, another explanation lies in the fact that the occurrence and magnitude of natural hazards like floods and droughts have increased due to higher weather variability and due to changed land and water practices and land use. Additionally, the increase of people being affected is caused by higher population densities and resulting from people having moved to marginal lands known to be exposed to such disasters. Fortunately, the higher number of people being affected is not accompanied by a similar trend in lethal casualties. The reduction in fatalities probably has to do with the fact timely warnings are provided and increasingly also heeded (Lumbroso et al. 2017). This suggests that some parts of disaster risk management is working. Nevertheless, the financial losses because of natural disasters have increased, resulting from the increasing number of assets and wealth currently present in disaster-stricken areas. Disaster impact statistics, to conclude, show a global trend: more disasters occur; larger populations are affected but fewer people die; and economic losses are increasing (IFRC 2000). The negative impacts of disasters may nevertheless exacerbate inequalities and are disproportionately borne by poor and vulnerable communities. Developing robust solutions to manage escalating disaster risks due to rapid global changes will call for new strategies and a stronger capacity to absorb expected changes (WCDRR 2014). For instance, receding glaciers catchments can change drastically due to climate change, like the receding Kaskawulsh glacier in 2016 causing the Slim river to be pirated by a second river. The water now flows to the gulf of Alaska instead of the Bering Sea ².

At least 276 rivers and even more groundwater bodies cross borders, risks and challenges are shared between countries and solutions as a consequence need to be coordinated. Countries in river basins may encounter inland disaster risk issues that are also experienced in nearby countries as their context may be relatively similar. In some cases, countries face similar disaster risks as they have the same regional driver, like a “simultaneous” increase in floods in various European countries resulting from an increased regional-level precipitation intensity (e.g. Blöschl et al. 2017). Similarly, droughts occur in several countries in Africa because of regionally reduced precipitation. Additionally, hazards or causes for hazards can propagate through a river basin connecting upstream and downstream countries into a disaster risk management context. Unilateral adaptation and disaster risk reduction measures can have negative effects on other riparian countries. Cooperation on adaptation, at the same time, can help to find better and more cost-effective solutions, by considering a larger geographical area in planning measures, by broadening the information base, by exchanging data and by combining efforts and pooling resources. This guide will therefore put disaster risk reduction (DRR) in water management into the context of transboundary cooperation.

As stated, water related disasters affect a large number of people yearly and this is expected to increase as a result of climate change. The vulnerability of people to flood hazards and droughts has increased and will continue to do so through population growth, poverty, land shortages, urbanization and the poor condition of flood protection and drainage infrastructure, especially in developing countries. Moreover, droughts, as slowly developing disasters, may lead to the collapse of social structures and to refugees that may cause disruptions in social structures of adjacent regions. At the same time, many of the water-related disasters occur in transboundary basins. Approximately 40% of the world population live in rivers and lake basins that comprise two or more countries. It is even more significant that over 90% of the world’s population lives in countries that share basins. The existing 276 transboundary lake and river basins cover nearly one half of the Earth’s land surface and account for an estimated 60 per cent of global freshwater flow. A total of 145 States include territory within such basins, and 30 countries lie entirely within them. In addition, about

¹ <http://emdat.be>

² <https://www.theguardian.com/science/2017/apr/17/receding-glacier-causes-immense-canadian-river-to-vanish-in-four-days-climate-change>

2 billion people worldwide depend on groundwater, which includes approximately 300 transboundary aquifer systems (UN Water, 2008, *Transboundary Waters: Sharing Benefits, sharing responsibilities*). And transboundary cooperation is an essential element as disasters tend to strike harder in transboundary basins (Bakker 2006; 2009). Water is the central medium through which climate change will affect communities. Therefore water management is central in climate change adaptation. And as so many waters are shared between countries, transboundary water management is imperative.

Proper Integrated Water Resources Management (IWRM) at the basin level is, as a consequence, highly important to reduce this increasing disaster risk, taking into account climate change. It can help to reduce disaster risks caused by flooding and droughts. For instance, measures and infrastructure to retain surplus water can help to reduce flooding from heavy precipitation or droughts when stored for dry periods. As human use is already over 50% of all renewable and “accessible” freshwater flows, including in-stream dilution of human and industrial wastes (Postel et al. 1996), water demand management is an important means to reduce the impacts of droughts. Moreover, ecosystems have a pivotal role to play in both flood and drought risk reduction and should play an important role in water management. Disaster risk can be reduced significantly through appropriate water management including having effective measures, involving right stakeholders and addressing the risks at appropriate scales. Also the role of appropriate communication at all scales and to all (early warning enabling early action) cannot be underestimated. The most effective and efficient scale for risk reduction to most of water-related disasters is creating understanding and developing measures at basin level. In order to achieve the targets of the Sendai Framework proper consideration of measures to address water-related disasters and associated transboundary cooperation should be given priority.

There are, however, some obstacles that inhibit the consideration of transboundary cooperation. Among many reasons are the fears of losing national sovereignty, misperception about cost and benefits of transboundary cooperation and a lack of political will. In many situations, technical cooperation is ahead of institutional and political cooperation. At the technical and expert levels, it is often easier to start cooperation and address the problems, thereby starting to build trust. And even when countries are ready to promote transboundary cooperation, they may still have insufficient capacity to assess transboundary disaster risks, developing and implement transboundary disaster risk management plans.

This Words into Action Guide is prepared to support the implementation of Sendai Framework. It aims at raising awareness on the importance of river basin management and transboundary cooperation in DRR taking into account climate change adaptation. It provides information on steps that countries can take to harness the values of river basin management and transboundary cooperation together with good practices and lessons learned in this field.

2.1.1. Implementation of the Sendai framework

The goal of the Sendai Framework for Disaster Risk Reduction is to prevent new and reduce existing disaster risks. The framework encourages countries to implement integrated and inclusive measures that prevent and reduce hazard exposure and vulnerability to disaster, and increase preparedness for response and recovery thus strengthening resilience.

Floods, droughts and storms are the most frequently occurring natural disaster events and account for almost 90% of the 1,000 most disastrous events since 1990 (WCDDRR 2014). Moreover, damages from water-related disasters can in economic terms be up to 15% of annual GDP for certain countries (UNISDR 2015). The Sendai framework in relation to water therefore stresses (UNISDR 2015):

- To support, as appropriate, the efforts of relevant United Nations entities to strengthen and implement global mechanisms on hydro-meteorological issues in order to raise awareness and improve understanding of water-related disaster risks and their impact on society, and advance strategies for disaster risk reduction upon the request of States (34(e)).

The framework also stresses the importance of transboundary cooperation:

- International, regional, sub regional and transboundary cooperation remains pivotal in supporting the efforts of States, their national and local authorities, as well as communities and businesses, to reduce disaster risk (8);
- Each State has the primary responsibility to prevent and reduce disaster risk, including through international, regional, sub regional, transboundary and bilateral cooperation (19(a));
- To guide action at the regional level through agreed regional and sub regional strategies and mechanisms for cooperation for disaster risk reduction, as appropriate, in the light of the present

Framework, in order to foster more efficient planning, create common information systems and exchange good practices and programmes for cooperation and capacity development, in particular to address common and transboundary disaster risks (28(a));

- To promote transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches with regard to shared resources, such as within river basins and along coastlines, to build resilience and reduce disaster risk, including epidemic and displacement risk (28(d)).

The framework takes an explicit holistic approach where the interconnectedness of various types of biophysical systems and the relation between social and biophysical systems are addressed. Such an holistic approach has been similarly fundamental in water resources management (both in national and transboundary contexts):

- To attain the expected outcome, the following goal must be pursued: Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience (17)
- The development, strengthening and implementation of relevant policies, plans, practices and mechanisms need to aim at coherence, as appropriate, across sustainable development and growth, food security, health and safety, climate change and variability, environmental management and disaster risk reduction agendas. Disaster risk reduction is essential to achieve sustainable development (19(h)):
- Foster collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as for climate change, biodiversity, sustainable development, poverty eradication, environment (28(b)):
- Promote the mainstreaming of disaster risk assessment, mapping and management into rural development planning and management of, inter alia, mountains, rivers, coastal floodplain areas, drylands, wetlands and all other areas prone to droughts and flooding, including through the identification of areas that are safe for human settlement and at the same time preserving ecosystem functions that help reduce risks (30(g));
- Strengthen the sustainable use and management of ecosystems and implement integrated environmental and natural resource management approaches that incorporate disaster risk reduction (30(n));

The Sendai framework encourages shared, evidence-based assessments of (disaster) risks and strong stakeholder engagement, both elements which are strongly promoted in transboundary water management:

- Promote real-time access to reliable data, make use of space and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data (24(f));
- Promote and improve dialogue and cooperation among scientific and technological communities, other relevant stakeholders and policymakers in order to facilitate a science-policy interface for effective decision-making in disaster risk management; (24(h));
- Enhance the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems (25(a));
- Promote and enhance, through international cooperation, including technology transfer, access to and the sharing and use of non-sensitive data, information, as appropriate, communications and geospatial and space-based technologies and related services. Maintain and strengthen in situ and remotely-sensed earth and climate observations.....(25(c));
- Enhance the scientific and technical work on disaster risk reduction and its mobilization through the coordination of existing networks and scientific research institutions at all levels and all regions with the support of the UNISDR Scientific and Technical Advisory Group in order to: strengthen the evidence-base in support of the implementation of this framework; promote scientific research of disaster risk patterns, causes and effects; disseminate risk information with the best use of geospatial information technology (25(g)).

2.1.2. Mainstreaming of DRM measures in (transboundary) basins

DRR planning as much as Climate Change Adaptation (CCA) should be integrated into existing policy development, in planning, programmes and budgeting, across a broad range of economic sectors – a process generally called “mainstreaming”. This process is using or creating mechanisms that allow decision-makers to integrate future climate risks into all relevant ongoing policy interventions, planning, and management (Luers and Moser 2006). It includes assessing the implications of disasters and climate change on any planned development action in all thematic practice areas and sectors at all levels, including the transboundary level, as an integral dimension of the design, implementation, and monitoring and evaluation of policies and programmes. Moreover, inclusion of transboundary impacts and opportunities of DRR in national strategies will support extending the decision-space. Mainstreaming of DRR and CCA into international, national and regional sectoral policies is important to reduce, in the long-term, the vulnerability of sectors such as: agriculture, forests, biodiversity and protection of ecosystems (including water), fisheries, energy, transport, drinking water and sanitation, and health. Mainstreaming must be carefully prepared and be based on solid scientific and economic analysis. For each policy area, there should be a review of how policies could be refocused or amended to facilitate adaptation (UNECE 2009a; 2009b).

Box: Mainstreaming climate change in the forest and biodiversity sector in Kyrgyzstan

Climate change adaptation programme and action plan for 2015-2017 for the Forest and biodiversity sector in the Kyrgyz Republic ³ serves as a sectoral policy document aimed at strengthening the resilience of the sector to the adverse effects of climate change on natural ecosystems and communities. The goals of the programme are: i) to incorporate the climate change impacts into protected areas and forest enterprises management plans and practices and involve forest communities into activities to strengthen the resilience of ecosystems and communities ; ii) to promote the conservation and restoration of damaged natural ecosystems to strengthen their resilience to climate change; and iii) to increase the capacity and awareness of stakeholders of the Forest and Biodiversity sector on adaptation to climate change (SAEPF, 2015).

DRR and CCA mainstreaming encounters barriers and challenges including, among others, bureaucratic organizational processes, lack of capacity and knowledge, high staff turnover, ineffective procedures for retaining organizational memory and a culture of working in ‘silos’. At a practical level, there are also disparate issues such as unclarity of roles and responsibilities and time constraint when it comes to DRR and CCA mainstreaming. The lack of funding for cross-cutting initiatives is another hurdle (IFRC 2013).

Mainstreaming DRR and CCA includes considering and addressing risks associated with disasters and climate change in all processes of policy-making, planning, budgeting, implementation, and monitoring. This entails an analysis of how potential risks and vulnerability could affect the implementation of policies, programmes and projects. Concurrently, it also analyses how these, in turn, could have an impact on vulnerability to hazards. This analysis should lead on to the adoption of appropriate measures to reduce potential risks and vulnerability, where necessary, treating risk reduction and adaptation as an integral part of all programme management processes rather than as an end in itself (IFRC 2013).

The cost of adapting water management to disaster risks and climate change will likely add to the already substantial financing gap for water systems. Adaptation and risk management costs for water could be substantial, especially for flood protection. Nevertheless, many of the investments needed could take place within normal investment replacement cycles or could be added on top of planned investments. Moreover, the benefits of investing in DRM outweigh the costs of doing so on average and this can be by about four times the cost in terms of avoided and reduced losses (Mechler 2016). It is difficult and often not practical

³ Available from <http://naturalresources-centralasia.org/flermoneca/index.php?id=56>

to attempt to separate out the marginal additional costs related to adaptation from those due to a broader range of pressures on water systems resulting from a wide range of drivers (UNECE 2015).

2.2. Aims and scope

The general objective of this guide is to support implementation of the Sendai framework in (transboundary) basins. This includes ensuring that IWRM issues are considered at all levels including the international level and that the role of water and basins is taken into account. This will take into account the framework of various international commitments including the Paris Agreement and the Sustainable Development Goals (SDGs).

2.3. Target audience

The main target groups are practitioners in DRR and water management, more specifically, water managers and institutions responsible for water management, and authorities and institutions responsible for DRR, at local, regional, national and international level. As water management cannot be separated from water users and often water users' behavior and decisions result in man-made hazards, the guide will also be relevant for, but not specifically target water users, a.o. from the industry, agriculture and energy sectors. Furthermore, the guide will be brought to the attention of the humanitarian sector and development aid.

2.4. Structure of the guide

Disaster Risk Management (DRM) is the implementation of DRR. DRM describes and implements actions that aim to achieve the objectives of reducing risk. Many different structures exist to describe the steps in DRM. In this guide we will use the Disaster Risk Management Cycle, that distinguishes three steps (Figure 1):

1. Disaster risk assessment. This step entails to assess what potential disaster risks can be identified and how much impact such a disaster would have.
2. Develop a strategy to reduce the risk. Based on the risk assessment, per (type of) risk, a strategy is designed to mitigate the effects of the disaster, thus reducing the risk.
3. Create programmes to put these strategies into effects. For each strategy, programmes need to be developed to implement the strategy.



Figure 1- Disaster Risk Management Cycle

Additionally, two activities need to be taken into account while implementing the three steps:

1. Consultation. Ultimately, each measure needs to be taken on the ground. This implies that stakeholders need to be involved in the whole process from assessing the risks up to the implementation of programmes to assure implementability of the measure in the local situation as well as support for the actual implementation.
2. Monitoring and evaluation. Each step in the risk management cycle is based on the information available. Nevertheless, as the process to come to implementation of measures can be lengthy, new

information may come available over time. Next to this, implementation of measures will influence the risks. Moreover, information is needed on the effects of each measure after implementation. Therefore, monitoring and evaluation is a continuous process during and after performing the risk management steps. Repeating the steps on a regular basis ensures that measures are taken based on the most recent information while new information may induce reassessment of the risks.

The whole DRM cycle is embedded in an enabling environment, addressing the political, legal and institutional frameworks that may need to be assessed and adjusted to allow for DRM.

3. Governance, roles and responsibilities

3.1. International commitments

While the Sendai Framework is the most relevant international commitment towards disaster risk reduction, a number of additional recent international frameworks are addressing disaster risks as well. For example, the Sustainable Development Goals (SDGs) and the UNFCCC's Paris Agreement include DRR as an integral part of sustainable development and address the intricate relations between climate change mitigation and adaptation and DRR.

International frameworks underpinning transboundary cooperation are the UNECE Water Convention and the UN Watercourses Convention. They were finalised when DRR concepts were still under development. But while they do not include disaster risk management as much as the SDGs and the Paris Agreement, they do contain provisions on emergency situations and hazardous substances. Next to this, the Ramsar Convention recently adopted a resolution on wetlands and disaster risk reduction. More detailed descriptions on how SDG's, the Paris Agreement, the Water conventions and the Ramsar Convention relate to disaster risk management are given in the sections below

3.1.1. Sustainable Development Goals

On 25 September 2015, the 194 countries of the UN General Assembly adopted the 2030 Development Agenda titled 'Transforming our world: the 2030 Agenda for Sustainable Development', popularly known as the Sustainable Development Goals⁴. This international framework contains 17 goals and 169 targets aimed at achieving Inclusive Social Development, Environmental Sustainability, Inclusive Economic Development, and Peace and Security. The most relevant for this guide include:

- Target 6.3 aims to minimize the release of hazardous chemicals and materials.
- Target 6.5 aimed at implementing integrated water resources management at all levels including through transboundary cooperation links well with the Sendai Framework articles that promote transboundary cooperation. Although the Sendai Framework does not explicitly mentions IWRM as a means to address transboundary disaster risks, many of its provisions do contain elements, strategies and methodologies that are very common to IWRM (see section 2.1.1).
- Target 6.6 to protect and restore water-related ecosystems including mountains, forests, wetlands, rivers, aquifers and lakes is supporting the field of providing nature-based solutions to disaster risks management and links well with IWRM practices.
- All the targets of Goal 13 on Climate action can be linked to the Sendai Framework, especially target 13.1 that calls for strengthening resilience and adaptive capacity to disasters.
- Goal 15 aims to aims to protect, restore and promote sustainable use of terrestrial ecosystems. The goal reinforces the need to protect the ecosystem services which includes vital hazard regulating services and aims to reverse land degradation seen as a key driver for disasters.

3.1.2. Paris Agreement

UNFCCC's Paris Agreement for Climate Change⁵ is the successor of the Kyoto Protocol. The Paris Agreement is legally binding and was adopted in December 2015 and signed in April 2016. It contains targets for restricting global warming up to 1.5 to 2° C, as well as long-term goals to achieve climate resilience via adaptive measures. The Agreement also has provisions that address loss compensation.

As climate change is known to develop new kinds of disaster risks and/or intensify current disaster risks, mitigation is an ultimate but long-term disaster risk measure. But even under strong reductions of greenhouse gases the global climate will change. Therefore, DRM and CCA under a changing climate will remain necessary.

The Paris Agreement acknowledges the Sendai framework in its preamble. Articles 7 and 8 frame climate

⁴ <https://sustainabledevelopment.un.org/>

⁵ <https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf>

change risk in such a way that it relates well to Sendai framework concepts and principles. These articles also contain many provisions that are considered essential within IWRM and transboundary water resources management like:

- strengthening of the knowledge base
- sharing of information, knowledge and experiences
- monitoring and evaluation of plans and policies
- developing of both socioeconomic and ecological resilience

While, the Paris agreement mentions the importance of regional cooperation in adaptation, the original UN Framework Convention on Climate Change did not specifically aim at enabling transboundary climate change adaptation. Nor is the Climate Change Convention intended to prevent and peacefully settle the types of disputes that may arise between watercourse states and which may increase to arise under climate change. To enable this, other Conventions as described in the next section are essential.

3.1.3. Water Conventions and the Ramsar Convention

UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes⁶ (Water Convention) serviced by the United Nations Economic Commission for Europe (UNECE) strengthens transboundary water cooperation and measures for the ecologically-sound management and protection of transboundary surface waters and groundwaters. The Convention fosters the implementation of integrated water resources management, in particular the basin approach. It was adopted in 1992 and entered into force in 1996. The Water Convention started as a regional convention but was opened up to countries outside the UNECE region in 2016. Most UNECE countries having transboundary basins are Party to the Convention.

Article 2 contains the general provisions:

- The Parties shall take all appropriate measures to prevent, control and reduce any transboundary impact (1)
- The Parties shall, in particular, take all appropriate measures (2)
 - To prevent, control and reduce pollution of waters causing or likely to cause transboundary impact (a);
 - To ensure that transboundary waters are used with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection (b);
 - To ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact (c);
 - To ensure conservation and, where necessary, restoration of ecosystems (d).
- Measures for the prevention, control and reduction of water pollution shall be taken, where possible, at source (3).
- These measures shall not directly or indirectly result in a transfer of pollution to other parts of the environment (4).

Although not framed in the typical DRR language as used e.g. in the Sendai framework it does address transboundary pollution which is a water-related disaster risk. In article 11 on joint monitoring and assessment also flood risks are briefly mentioned. Under the Water Convention, a series of useful tools have been developed to improve transboundary disaster risk management. These include, among others, Guidelines on Sustainable Flood Prevention⁷, Model Provisions on Transboundary Flood Management⁸, Strategies for monitoring and assessment of transboundary rivers, lakes and groundwaters⁹, Guidance on Water and Adaptation to Climate Change¹⁰, Guidance on Water Supply and Sanitation in Extreme Weather

⁶ <https://www.unece.org/env/water/text/text.html>

⁷ <https://www.unece.org/index.php?id=12617>

⁸ https://www.unece.org/fileadmin/DAM/env/documents/2006/wat/ece.mp.wat.19_ADD_1_E.pdf

⁹ <https://www.unece.org/index.php?id=11683>

¹⁰ <https://www.unece.org/index.php?id=11658>

Events¹¹ and Model Provisions on Transboundary Groundwaters¹². Moreover, a Policy Guidance Note on the Benefits of Transboundary Water Cooperation: Identification, Assessment and Communication¹³ was developed to underpin what benefits cooperation can bring about.

The Global network of basins working on climate change adaptation, established by UNECE in cooperation with the International Network of River Basins (INBO) in 2013, promotes experience and knowledge exchange in the fields of disaster risk reduction and climate change adaptation, especially in transboundary basins. Currently the Global network includes 15 member basins, including from outside the UNECE region, such as Chu-Talas, Dniester, Neman, Rhine, Mekong, Niger, Sava, Congo, and Senegal. The network members work together to develop solutions for water management that would reduce risks of natural disasters, among other benefits.

A series of participatory basin-level assessments of intersectoral links, trade-offs and benefits in the water-food-energy-ecosystems nexus¹⁴ demonstrates the value of transboundary cooperation to control risks. One study shows, for instance, that coordinated flow regulation in the Drina Basin is not only crucial for minimizing damages from flooding but also benefits electricity generation from hydropower plants. In the Alazani/Ganykh Basin, coordinating jointly investments into flood protection and energy infrastructure would have the greatest effects; and improving access to modern energy sources with appropriate policy and measures would reduce exposure to flood damage by limiting deforestation.

UN Convention on the Law of the Non-Navigational Uses of International Watercourses

The UN Convention on the Law of the Non-Navigational Uses of International Watercourses (Watercourses Convention) is a global treaty, adopted in 1997 and entered into force in 2016. It is a framework convention governing international watercourses. Similar to the UNECE Water Convention, it was developed before current DRR concepts matured. However, it does contain articles that relate to disaster risk management:

- Article 1 states that Watercourse states shall exchange information and consult each other and, if necessary, negotiate on the possible effects of planned measures on the condition of an international watercourse. This does include informing each other on measures that can cause downstream disaster risks like building of dams increasing the low flow and drought probabilities downstream.
- Article 27 states that Watercourse states shall, individually and, where appropriate, jointly, take all appropriate measures to prevent or mitigate conditions related to an international watercourse that may be harmful to other watercourse states, whether resulting from natural causes or human conduct, such as flood or ice conditions, water-borne diseases, siltation, erosion, salt-water intrusion, drought or desertification.
- Article 28 deals with emergency situations and states that ‘emergency’ means a situation that causes or poses an imminent threat of causing, serious harm to watercourse states or other states and that results suddenly from natural causes, such as floods, the breaking up of ice, landslides or earthquakes, or from human conduct, such as industrial accidents.

Ramsar Convention Resolution on Wetlands and disaster risks reduction

The Convention on Wetlands, called the Ramsar Convention, is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The Convention was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975.

Wetlands provide a wide range of ecosystem services that contribute to human well-being, such as fish and fibre, water supply, maintenance of water quality, climate regulation, flood regulation, coastal protection, and recreation and tourism opportunities. Wetlands are also critical for the conservation of biological diversity. In particular, wetlands are vitally important for providing the regulating and supporting ecosystem services that underpin water resources management, and can thus be considered as essential

¹¹ <https://www.unece.org/index.php?id=29338>

¹² <https://www.unece.org/index.php?id=35126>

¹³ <https://www.unece.org/index.php?id=41340>

¹⁴ Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems nexus (UNECE, 2015) and technical reports on the Drina and Alazani/Ganykh River Basins. Available from <http://www.unece.org/env/water/publications/pub.html>

components of overall water infrastructure. However, this importance was not always adequately reflected in water resources planning and management in the past. In summary, to improve the integration of wetlands into river basin management, attention needs to focus on three major areas of activity:

- A supportive policy, legislative and institutional environment that promotes cooperation between sectors and sectoral institutions and amongst stakeholder groups;
- Communication, education, participation and awareness (CEPA) programmes to support communication of policy and operational needs and objectives across different sectors, primarily the water and wetlands sectors, and amongst different stakeholder groups;
- Sequencing and synchronization of planning and management activities in different sectors responsible for land use, water resources and wetlands (Ramsar Convention Secretariat 2010).

At the 12th Meeting of the COP to the Ramsar Convention in 2015, Resolution XII.13¹⁵ on Wetlands and disaster risk reduction was adopted. The resolution acknowledges “the vital role of wetland ecosystems, most especially healthy and well-managed wetlands, in reducing disaster risk, by acting as natural buffers or protective barriers” and recognizes “that fully functioning wetland ecosystems enhance local resilience against disasters by providing fresh water and important products and by sustaining the lives and livelihoods of local populations and biodiversity.”. The resolution bridges the international frameworks that focus on DRR / CCA and the ones dealing with IWRM and transboundary water management and bring nature-based solutions to the fore.

This resolution reiterates that “the Sendai Framework for Disaster Risk Reduction 2015-2030 acknowledges declining ecosystems as an underlying disaster risk driver, and recognizes the importance of strengthened sustainable use and management of ecosystems and the implementation of integrated environmental and natural resource management approaches that incorporate disaster risk reduction” (article 9);

It also relates disaster risk reduction to the concept of ecosystem services (goods and services people may benefit from nature). Disaster risk reduction type of ecosystem services are provided through wetlands “by acting as natural buffers or protective barriers, for instance through mitigating land erosion, the impact from dust and sandstorms, floods, tidal surges, tsunamis and landslides, and by storing large volumes of water, thereby reducing peak flood flow during the wet season, while maximizing water storage during the dry season” (article 6).

The resolution asks parties to include DRR intervention in wetland management plans and to include wetlands as ecosystem-based solution to landscape wise DRR-plans. This introduces the concept of ecosystem-based solutions that try to mitigate disaster risk impacts not by means of engineered or hard infrastructure interventions such as dams and dikes, but by smartly using landscape entities such as the forested water towers or hinterlands, wetlands, river floodplains and coastal mangroves.

3.1.4. Required national and transboundary EIA/SEA

Most countries have adopted and apply the Environmental Impact Assessment (EIA) and Strategic Environmental assessment (SEA) policy instrument to help to steer large scale land use and water allocation planning and to assess impacts of large scale infrastructural interventions. While the EIA is a formal process used to predict the environmental consequences of a project or an event, SEA is a systematic process for evaluating the environmental consequences of policies, plans, programmes or proposals and ensure that the environment is explicitly factored in decision making process, and next to economic and social arguments.

Both EIA and SEA are well established environmental decision-making tools and have been applied regularly within the field of IWRM and River Basin Planning. The tools can be expanded relatively simply be expanded to include assessing potential disaster risks of plans, policies and proposals. This allows for expanding EIAs and SEAs to inclusion of ex ante disaster risk assessments and the definition of mitigative measures to avoid disaster risks from policies and plans allows the crucial mainstreaming of DRR into conventional land and water use planning and management. Despite the conceptual logic for such an integration only few countries have adapted their EIA/SEA policies. A clear example of such adapted

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http://www.ramsar.org/sites/default/files/documents/library/cop12_dr13_disaster_risk_reduction_e.pdf

guidelines are developed by the Department of Environment and Natural Resource in the Philippines (2011). Environmental Impact Assessment Technical Guidelines, as revised to integrate Disaster Risk Reduction and Climate Change Adaptation approaches and concepts.

At the transboundary level, the UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)¹⁶ lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries. The Espoo Convention was complemented by the Protocol on Strategic Environmental Assessment to ensure that individual Parties integrate environmental assessment into their plans and programmes at the earliest stages.

3.2. Responsible institutions

3.2.1. Different institutions

Disaster risk management involves a variety of disciplines, institutions and stakeholders which are active at different levels in time (sequential interventions) but also at different scales (transboundary actors like basin wide institutions, national actors like ministries and water boards, local actors like alarm and rescue services). Moreover, Institutions dealing with disaster risk reduction generally have few connections with the institutions dealing with water management. Table ... shows examples of the different institutions dealing with DRR and water management for different categories. A comprehensive mapping of these actors and layers is needed to understand who has which mandate.

Category	DRR	Water management
Institution/s with primary responsibility	Ministry of Interior, National Disaster Management Authority, Federal Emergency Management Agency, or Ministry of Disaster Management and Relief	Ministry of Water Management, Environment, Agriculture and/or Natural resources
Fully dedicated institutions with specific responsibilities	Meteorological Services, Civil Defense, seismic research centers, search and rescue teams, fire departments, the National Red Cross/Crescent Societies	River Basin Organisations (RBOs), meteorological services, hydrological research centers and services, water boards
Sectoral ministries and local governments which have a role in integrating DRR and/or water management into development planning	Agriculture, environment, education, urban development, water, transport, gender/women's affairs/social affairs. Municipalities. In some countries, almost all governmental ministries may have an existing or potential role in DRR.	Agriculture, industry, environment, education, urban development, transport, gender/women's affairs/social affairs. Municipalities. In some countries, several governmental ministries may have an existing or potential role in water management.
Private sector and civil society organizations (CSOs)	Insurance companies, business associations, and including international NGOs, community-based organisations and women's organisations.	Water Users Associations (WUAs), insurance companies, business associations, and including international NGOs, community-based organisations and women's organisations.

Table ... Organisations typically involved in DRR and water management respectively (based on GFDRR 2017)

¹⁶ More detailed information see <http://www.unece.org/env/eia/welcome.html>

To be able to implement a DRM strategy in a transboundary IWRM context, understanding is needed of the enabling environment, i.e., the existing policy, legal and institutional framework. This entails an analysis to evaluate if the water-related policies, legal setting and the institutions will enable implementing the strategy. If gaps or barriers are identified, actions should be developed to overcome these gaps and barriers. often, different institutions are involved in DRR and water management (see Table...) which complicates finding the proper institution to address. Next to this, stakeholder engagement is needed for reducing the risks associated with water-related disasters within the context of the (transboundary) basin. Overall the analysis includes an assessment of the policies and legal arrangements, the institutions and stakeholders and their instruments (basin plan, national disaster plan, climate initiative, standing legislation, etc.) in place to map the landscape and identify the entry points for mainstreaming DRR.

Assessing the enabling environment in the Lower Mekong Basin

In 2015-2016, the Mekong River Commission (MRC) Climate Change and Adaptation Initiative (CCAI) conducted the formulation of a Mekong Adaptation Strategy and Action Plan (MASAP). The MASAP sets out strategic priorities and actions to address climate change risks at the basin level. In the process of formulation of the MASAP the first important step was to conduct a policy analysis of climate change and adaptation in the Lower Mekong Basin (LMB). The policy analysis aims to ensure that the MASAP is consistent with and does not contradict the national climate change policies of the Member Countries. The policy analysis comprised an analysis of the state of play on three main elements; policy setting, legal setting and institutional setting. In addition, two additional elements were analysed, namely information systems and the financing system.

From the policy analysis, it is concluded that there is an enabling environment for development and implementation of the MASAP. One of the main hindrances that needs to be addressed in the development of the MASAP is the limited availability of information, financial resources and the complexity of institutional settings. Minor issues in policies and legislation may occur over time but these are not prominent. Regular updates of the MASAP are needed to ensure that the proposed strategic priorities and actions remain relevant in view of the policy, legal and institutional setting.

In the context that all LMB Member Countries prioritise climate change adaptation by signing various global climate change agreements such as the Paris Agreement and having their own national strategies and plans, the added values of the MASAP will be its focus on critical climate change adaptation aspects that need to be addressed at transboundary level and positioning MRC as a leading regional institution in advancing the capacity of Member Countries in implementing their own national strategies (MRC 2017).

3.2.2. Identification of relevant stakeholders

The different actors have different instrument through which DRR can be mainstreamed, each with different potential and scope. Analyzing these different instruments is needed to identify the ones with more potential given the pursued objectives. Furthermore, decisions and actions are effective only if they are made with the right knowledge of the environment: who to target, when, at which scale, etc. This task is strongly linked to the identification and development of measures for water-related disaster risk reduction:

- I. the characterization of the environment will determine the possible frame for these measures and where to integrate them, for instance, the basin plan, a national strategy, a local project; and
- II. the stakeholder engagement need will identify which actor can and should (for higher efficiency) implement which measure, which actor is best suited given its influence, its strengths and position, etc..

The following steps are performed to come to an overall analysis of the relevant institutions and stakeholders:

- Determine the scope of the intended intervention, pursued objectives, etc.
- Map the stakeholders that have responsibilities in DRR.
 - The specific responsibilities of each stakeholder will have to be precisely identified. These responsibilities vary between institutions: from planning to implementation responsibilities and

- from regional to local scope.
- Given the transversal nature of DRR, a number of stakeholders have only partial responsibilities for DRR, typically, stakeholders active in the field of water management, climate change adaptation and hydro-meteorology (see Table ..). The role, mandate, responsibilities of these stakeholders regarding DRR should not be neglected as the interfaces can be significant.
- The existing mechanisms for cooperation, coordination and alignment between the previously identified stakeholders have to be determined too as well as the limitations of the existing (or non-existing) mechanisms and the suggestions to improve them.
- Identify the different policy and legal instruments for DRM which are existing at different levels and assess their effectiveness since these instruments are potential entry points for mainstreaming DRM.
 - These instruments, in a transboundary context, can exist at different levels. Typically, the following levels should be screened:
 - River basin organisations/ joint bodies: at this level a number of instruments might be existing for river basin management planning. It can consist in basin wide sectoral strategies and/or an overall basin plan. Also EIA and SEA can be performed as described under the Espoo Convention ([Section 3.3.2](#)).
 - National level: at this level instruments like EIA/SEA and IWRM approaches will need to be reviewed: i) EIA/SEA ([Section 3.3.2](#)); ii) IWRM ([Section 3.3.3](#)); iii) Other approaches that link to related sectors like agriculture, energy, industry, land use and ecosystems ([Section 3.5](#))
 - The instruments then will have to be analyzed in terms of:
 - suitability (are they representing good entry points for DRM measures?)
 - performance (under their existing form, are they efficient for DRM?)
 - completeness (under their existing form, is any aspect missing in order to achieve DRM?).

Having enough emergency responders is essential in any disaster. Emergency Services in general have agreements with neighboring areas and often have agreements/protocols for national and international assistance. The last assistance is often through the capital cities, and takes some time to organize. For emergency response from foreign countries to be effective to have frequent exercises, to get to know each other and practices in each country.

In each large disaster, the capacity of emergency services is overstretched. This is the case in both developed countries (e.g. Houston after Harvey) as in less developed countries. People often have to save themselves and their (remote or close neighbors). Saving other people however is dangerous. Disasters victims are often also their neighbors who use improvised methods to save other people. Involving communities organizing and training people before a disaster can reduce the number of fatalities.

3.3. River basin organizations/joint bodies

The need for a focused integrated river basin management of large rivers has developed over the past century, arising from the increasing human activities in the river basin areas of major rivers. A river basin is a set of interdependent and interconnected elements and activities within a river basin that affect water levels and social and economic conditions. It is therefore necessary to choose a comprehensive, coordinated and systematic process of planning, control, organization, leadership and management within the basin, based on starting point that water is one of the primary components of landscape structure; it is an integral part ecosystem as well as a socioeconomic resource. Such an approach should reflect the multidisciplinary nature, integrating, among others, water supply and sewerage systems, agriculture, industry, residential development, water works, transportation, recreation, fishing and other activities. This requires coordination between sectors and adaptation of different systems planning and management within an individual basin (Moravcová et al. 2016).

Many transboundary waters are not covered by agreements of the riparian states and do not have joint institutional structures in charge of their joint management and cooperation. Notably, more than a half of the world's 276 international river basins, plus transboundary aquifer systems, lack any type of cooperative management framework. Even where joint institutions exist, growing pressures on water resources coupled with the impacts of climate change, magnify the challenges for implementation of existing agreements and achieving progress in transboundary water cooperation, and therefore call for strengthening the governance frameworks and building a response capacity. In addition, many RBO's lack the mandate to deal with flood or drought issues. In some cases, economic and technological development, regional integration,

emergence of new stakeholders or other factors of evolving context require updating existing agreements and strengthening joint institutions.

The existing joint commissions and other joint bodies for transboundary water cooperation differ from one another for example in terms of the scope of application, competence, functions, powers and organizational structure. Nevertheless, principles of organization and activities have been developed for joint bodies that increase their efficiency and contribute to reaching a mature level of cooperation between the riparian States ¹⁷.

The current borders and agreements between many countries are often based on past conflicts. Cooperating between these countries is essential for economic growth and for the livelihood of the population. After the Belgian war of independence of 1830, Belgium received the right of corridor through parts of the Netherlands, which is essential for commerce in Belgium. Some of these corridors are waterways, like the Scheldt river. The state of the Western Scheldt Estuary is important for flood defence and for nature. Changes to the river for shipping are subject to national and international (EU) law. There are technical committees at a low level to inform each country of changes to legislation, the water system and the models to evaluate changes. Large changes to the water system are prepared by joint technical committees where experts from both countries are involved. The first objective is to solve technical issues, the political discussions come later on. There are always some differences to tackle that may take several years. But progress only comes through these technical working groups, which have to be creative and flexible to find solutions.

3.3.1. IWRM approach towards DRR

Integrated Water Resources Management (IWRM) is internationally the standard water management approach. A 2015 UN-Water study¹⁸ found that 84% of the 134 participating countries had engaged in the implementation of IWRM in some sort of form. 65% of the participating countries had developed IWRM plans. 75% of the participants had ranked DRR as a key priority for their IWRM activities.

Water is hardly mentioned in the Sendai Framework and IWRM is not included as a key approach on how to implement DRR strategies. Nevertheless, many commonalities exist between IWRM and DRR. GWP (*reference?*) identifies the following commonalities:

- both IWRM and DRR propose integrative and holistic approaches; take a systems approach (e.g. connect land and water, biophysical systems to social, economic and political systems) and acknowledge scale issues;
- both approaches stimulate and prefer preventive measures over curative measures and acknowledge the importance of healthy ecosystems as a regulatory force;
- both approaches are inclusive in nature and explicitly addresses the needs, interests and capacities of vulnerable groups, the poor and marginalized;
- both approaches acknowledge the need for decentralized approaches and the importance of participatory approaches, involving all stakeholders, at relevant levels of interventions;
- both propagate good governance under the responsibility of national governments; and
- both approaches understand the importance of understanding systems by means of data collection assessment and research.

Transboundary risk management should consequently be considered as a part of IWRM. General measures that are of special importance in transboundary basins include (UNECE 2009b):

- Water balance for the entire basin: a proper understanding of the overall hydrological functioning of the basin is needed to ensure that actions and measures will lead to the expected outcomes.

¹⁷ http://www.unece.org/fileadmin/DAM/env/documents/2014/WAT/04April_9-10_Geneva/Principles_jointBodies_final.docx

¹⁸ UN Water (2012). Status Report on the Application of Integrated Approaches to Water Resources Management; <http://www.unwater.org/rio2012/report/index.html>

- Proper communication between riparian countries. This is more a political and partly a legal issue and not so much a technical one. Informal meetings can be helpful in starting up communication.
- Joint problem definition and a common understanding of interests among all riparian countries are important for stimulating and improving transboundary cooperation. This includes issues on ecological functioning, reservoir and dam operations, etc..
- Sharing hydrometeorological data across borders is a fundamental basis for cooperation. Data sharing and also the quality and reliability of information need to be improved in many cases, inter alia, to help reach a common understanding of the situation.
- Joint bodies such as river basin commissions can help facilitate international cooperation, including the sharing of data. Where there are no transboundary river basin commissions, these should be established, preferably at a high institutional level and with political support to ensure sufficient funding for all joint activities. Institutional and political cooperation should aim to keep pace with the level of technical cooperation at the transboundary level.
- A joint legal framework is needed to sustain technical cooperation. Formal agreements for cooperation should be flexible and should be based on a cross-sectoral approach.
- Pilot projects and regional and subregional workshops on transboundary water management are a useful tool for exchanging good practices and discussing problems and experiences.
- Capacity-building and training at both the technical and the decision-making levels helps to improve both the knowledge base and international cooperation.
- Early warning: Combined meteorological and hydrological monitoring and forecasting systems can provide timely information on the extent and severity of extreme events. Imminent events can be detected at an early stage, allowing for timely responses. To this end, a basin-wide system is needed to ensure proper information. Such a system includes a range of agreements on, e.g., data-exchange protocols including frequency of exchange, contact points, warning levels, communication channels, etc.. Such a system should be accompanied by a disaster preparedness and response system that prescribes the necessary action in case an extreme event develops. Early warning should cover both quantity (floods and droughts) and quality (spills and accidents).

Taking into account that many of the hazards are propagated through water systems, often resulting from mismanagement of land and water resources and even from non-water related disasters, the availability of sufficient and clean water is a key factor for survival and recovery. The importance of IWRM to DRR is therefore evident and integrating DRR strategies in IWRM plans, policies and operations is a logical step. Making use of the institutional frameworks that have been developed for IWRM implementation is a quick way to operationalize parts of DRR strategies. For instance, to support transboundary cooperation on flood risk management, UNECE has developed the “Model Provisions on Transboundary Flood Management”¹⁹, that present example provisions for legal agreements, that countries can use to develop bi- or multilateral agreements.

3.4. Links to related sectors like agriculture, energy, industry, land use and ecosystems

As mentioned before, the current global agreements all take an holistic approach. Besides the more common integrated approaches to deal with water resources (IWRM) and natural resources (INRM) the so called water food energy nexus adds a new paradigm to integration. At this nexus' core is natural resources scarcity and the interdependencies due to making use of the same resource base, resulting from simultaneously trying to achieve water, food and energy security (Leck et al., 2015). The nexus explicitly focuses on these complex relationships in order to find synergies and avoid unintended consequences and at least to show possible trade-offs resulting from chosen development paths and how this results in distributional and equity effects. The nexus approach suffers from governance integration issues such as departmentalization, silo-thinking and sectoral target setting, programming budgeting and monitoring.

With the nexus approach looking at interdependencies and trade-offs, it is an interesting concept to apply in transboundary context, also addressing transboundary DRR aspects. Obviously one of the most obvious water related interdependencies is the upstream-downstream relationship. An upstream country unilaterally deciding to achieve sovereign food and energy securities by means of dams and irrigation schemes can influence downstream hydraulic regimes so much that the likelihood of, for example, droughts changes significantly. Hence, non-cooperation can lead to DRR externalities. On the other hand, bi- or even

¹⁹ https://www.unece.org/fileadmin/DAM/env/documents/2006/wat/ece.mp.wat.19_ADD_1_E.pdf

multilaterally cooperation trying to achieve water, food and energy securities in a basin-wide context can result in optimal use of scarce land and water resources sharing, based on countries' comparative advantages and natural resources endowment. Such transboundary nexus cooperation reduces the disaster risk context for a wider region and provides societal resilience which helps to overcome disaster impacts.

Various organizations have adopted the nexus approach as a possible new paradigm to deal with complex and related environmental issues such as sustainable development, climate change adaptation and disaster risk reduction. UNECE²⁰ and FAO²¹ have developed their own task forces which try to develop and promote nexus concepts further. The Water, Energy & Food Security Resource Platform (www.water-energy-food.org) is an independent information and facilitating platform funded by the German Federal Ministry of Economic Cooperation and Development and the European Union. Organizations like SEI, SIWI and GWP all are contributing in developing this nexus further.

3.5. The role of ecosystems

A common thread running through all the earlier global policy agreements in 2015 is a clear recognition of the role that ecosystems play in safeguarding development gains, and in building resilience against disasters and climate change (PEDRR, 2016). The Sendai Framework clearly recognizes that degraded ecosystems are a contributing factor to the development of hazards and that they reduce the landscape and societies ability to absorb the shocks from hazards.

The role of ecosystems (especially related to the water body network) in helping to sustain developments has been increasingly acknowledged as being essential. The concept of ecosystem services based on how humans benefit from ecosystems in the form of derived goods and received services. Some of these services are perceived as being able to reduce disaster risks. Examples of such ecosystem services are natural floodplain systems or meandering river systems that can store large volumes of water, reduce runoff and hence are able to dampen out flood waves. Slow release of water from densely vegetated backwater maintain certain levels of baseflow into river reducing the risk of drought development. Many of such examples can be found in Renaud et al. (2016).

The Partnership for Environment and Disaster Risk Reduction (PEDRR) is a global alliance of UN agencies, NGOs and specialist institutes that seeks to promote and scale-up implementation of ecosystem-based disaster risk reduction and ensure it is mainstreamed in development planning at global, national and local levels, in line with the Sendai Framework for Disaster Risk Reduction. They developed an implementation strategy for ecosystem-based approaches within Sendai. Key messages from this strategy and contextualized towards a transboundary basin context are:

- Degraded ecosystems (like floodplains with built infrastructure, silted up wetlands, deforested hinterland) are an important contributing factor for the onset of water-related disasters that can propagate downstream in transboundary systems
- Ecosystems themselves such as wetlands can be heavily damaged from disasters, disturbing ecological balances and or even completely turning an ecosystem into a different regime. If people are locally depending on the goods and services from such damaged ecosystem then this may impact the livelihood sustainability
- Ecosystem-based approaches into DRR includes maintain or restoring ecosystems into a good ecological state such that they do not cause natural hazards, protect ecosystems from being damaged by disasters especially the one that provide high value of ecosystem services and use ecosystems as naturally "engineered" landscape entities that can help to dampen impacts of hazards. Building with nature like approaches, Room for the River and the removal of drainage and re-meandering of the creeks and rivers that were canalized during phases of strong intensive agricultural development are all examples of the latter
- To operationalize ecosystem approaches into DRR, one needs to include DRR (and Climate change Adaptation Measures) into wetlands and other ecosystem management plans and vice-versa eg. one needs to include the ecosystems and its services in all the national and transboundary plans that deal with disaster risk reduction, climate change mitigation and adaptation and sustainable development.

²⁰ UNECE Task Force on the Water-Food-Energy-Ecosystems Nexus:

https://www.unece.org/env/water/task_force_nexus.html

²¹ FAO Water-energy-food nexus: <http://www.fao.org/land-water/water/watergovernance/waterfoodenergynexus/en/>

4. Understanding the risks

4.1. Identification and assessment of transboundary effects of disasters

4.1.1. Basin-wide disaster Risk Assessment²²

Disaster Risk Assessment is an important step of disaster risk management, as became clear from Figure 1. A basin-wide disaster risk assessment is needed to assess the risks as a result of disasters (potentially) occurring in the basin. The assessment determines the nature and extent of the disaster risks with a focus on identifying disasters that have a transboundary nature or spread. Following the concept of disaster risk (Figure 3), disaster risk assessment will analyze potential hazards, evaluating the conditions that lead to exposures and vulnerabilities that pose disastrous consequences or losses. Disaster risk assessment helps decision makers and related stakeholders of a river basin:

- To understand (and agree on) the priority hazards on the basin that need to receive attention;
- To understand the nature and extent of risks associated with the hazards of priority;
- To identify potential measures and actions for risk reduction; and
- To identify (and agree on) actions for risk reduction on the basin.

Disaster risk assessment is important as it provides a basis to set the risk management objectives and to identify potential DRR measures. Given the inherent uncertainty in the location, timing, severity and impacts of hazards the role of disaster risk assessment is to reduce effects of such events. This is done by bringing together the best information and judgment into the assessment and using that to design appropriate strategies to lessen the disaster risks.

Depending on time, resource, data and expertise available a basin-wide disaster risk assessment can be done either in a simple way and qualitative or in a more comprehensive way and qualitative. The confidence among riparian countries on the results of a basin-wide disaster risk assessment however will depend not only on the methodology used but also on the data and knowledge deployed and level of agreement reached in the assessment. The focus of a disaster risk assessment could be on either an asset or an event (Figure 2). Basin-wide disaster risk assessment often falls in the “baseline screening assessment” quarter. The methodology used for risk assessment of an intensive disaster risk, a disaster risk with high probability but low-impact events, is different from that for an extensive disaster risk, a disaster risk with low-probability but high-impact events.

Extreme weather events can also impact the operation of water-supply, drainage and sewerage infrastructure, and the functioning of wastewater treatment plants, thereby posing threat to public health. The Guidance on Water Supply and Sanitation in Extreme Weather Events²³ was developed under the UNECE-WHO/Europe Protocol on Water and Health to highlight how adaptation policies should consider the new risks from extreme weather events, how vulnerabilities can be identified and which management procedures can be applied to ensure sustained protection of health and proper functioning of key water and sanitation infrastructure at the times of floods and droughts.

²² A policy guidance for conducting national disaster risk assessment and establishing understanding risk system is provided by the UNISDR Words into Action Guideline National Disaster Risk Assessment 2017: <http://www.unisdr.org/we/inform/publications/52828>

²³ Available from <http://www.unece.org/index.php?id=29338>

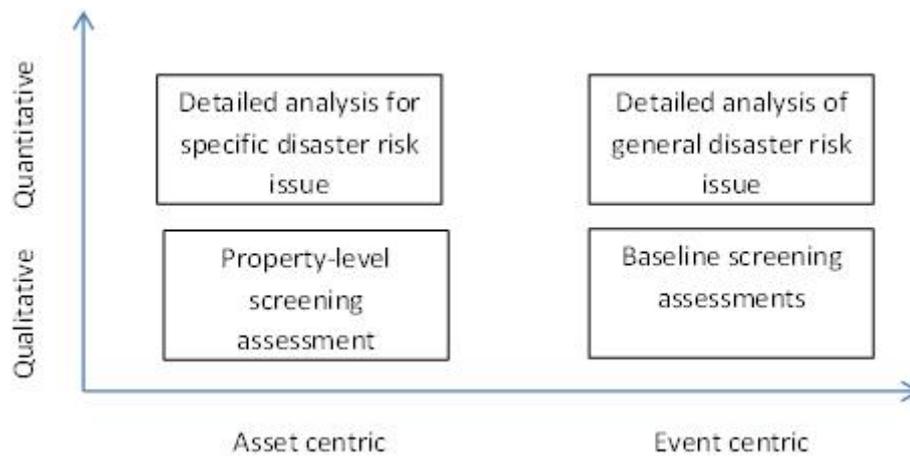


Figure 2- Disaster risk assessment approach continuum (add reference)



Figure 3-Risk as a function of Hazard, Exposure and Vulnerability (<http://www.un-spider.org/risks-and-disasters/disaster-risk-management>)

4.1.2. Steps in assessing disaster risks

The basic steps for disaster risk assessment include:

- Determine the priority hazards. Due to time and resource constraints for Disaster Risk Assessment (DRA), riparian countries will need to define the priority disasters among the many occurring in the basin. Prioritization can be done via workshops facilitated by information briefs prepared by an assessment team. The assessment team prepares the information brief through researching previous events and interviews with experts in the region. The information brief can also include “worst-case scenarios” relating to each priority hazard.
- Assess the hazards, exposure and vulnerability to hazards. This includes hazard data collection and mapping, losses and damages data collection and mapping, and exposure and vulnerability analyses. In case of future disaster risk assessment, the impacts of climate change and regional economic connection should be considered.
- Evaluate the disaster risk and confidence on the results. The confidence in the results of the DRA is defined as a combination of confidences on data and information, knowledge of the assessment team

and experts, and the level of agreement reached. A matrix can be built to facilitate the assessment of confidence on risk assessment results based on certain criteria, for example:

- Whether data and information is sufficient and specific on site/location/community.
- Whether team knowledge on the hazards and on the assessment process is specific enough.
- Whether agreement has been reached on the interpretation and rating of the risks.
- Evaluate disaster risk acceptability / tolerability. The acceptability or tolerability of a disaster risk is primarily assessed in consultative workshops and then presented to decision makers for final decision. Acceptability of disaster risk depends on mutual/agreeable judgment on the likelihood of the impacts, the level of impacts, and the confidence in the assessment of the disaster / future disaster. Decision making on whether further action need to be done or not will depend on this acceptability of risks as shown in Figure 4. Disaster risks can be broadly classified into three levels of acceptability/tolerability. Participants of consultation workshops and/or decision makers will be invited to define and/or classify the level of acceptability for each disaster risk into these three types.:
 - Broadly acceptable: Risks that are acceptable or so small that no additional actions are required. They have insignificant consequences or rarely occur. The aim of risk management is to drive as many risks into this category as practicable through risk reduction measures.
 - Tolerable: Risks that can be managed by existing risk management systems. Active steps and financial management to reduce these risks are likely to be already taking place because a positive cost – benefit analysis ratio for investment is expected or because public expectation demands it.
 - Generally intolerable: Risks are too high and require further actions to lower or even eliminate the likelihood or the consequences.

The last step of this methodology focuses on identifying adaptation measures to address vulnerabilities in strategic assets and systems, prioritizing these measures, ensuring that they are robust with respect to CC effects and drawing up adaptation plans to implement the selected measures.

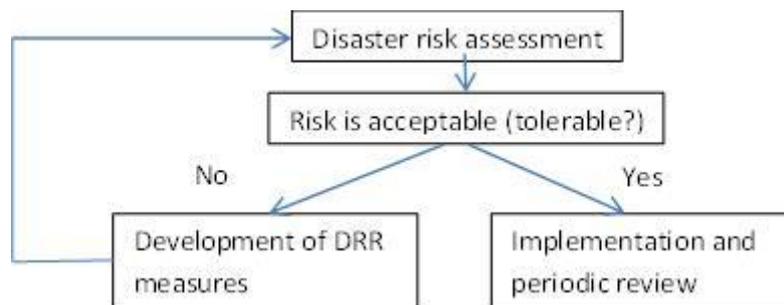


Figure 4. Linkages between disaster risk assessment and development of measures.

4.1.3. Cost-benefit analysis

The aim of a cost-benefit-analysis is to find the optimum between the cost of an intervention and the cost of damages due to a disaster (Eijgenraam 2006 and Kind 2014), if unnecessary measures are taken there is an over-investment.. The driving forces are economic growth, which increases damages and climate change, which increases the probability of disasters and thus the cost of measures to compensate for increased damages due to both issues.

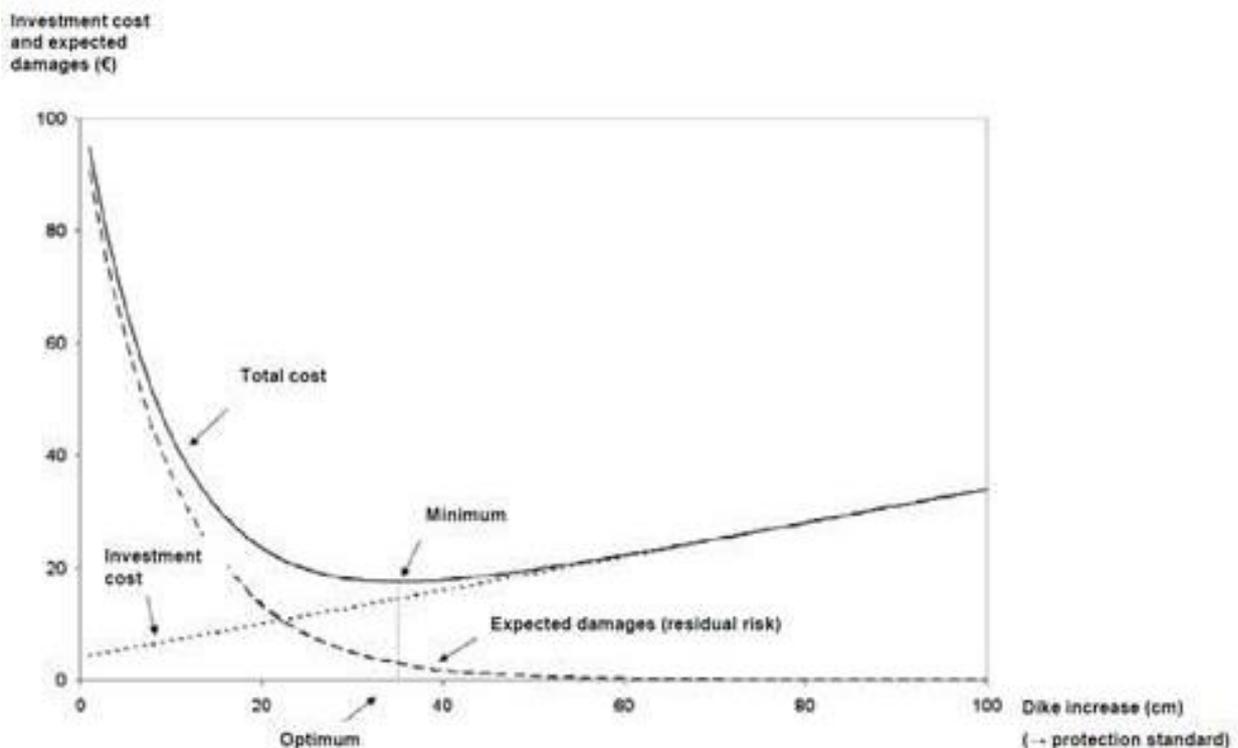


Figure x.1: Cost-benefit-analysis, the principle of marginal benefits equal to marginal costs for dike increase as an intervention (Kind 2014).

Depending on the amount of time available for a study and the precise question one has to choose the model needed. Therefore it is important to have more than one model available to carry out risk analyses. Probability of flooding can often be derived from historic events and it can be corrected for climate change. This estimation can be improved on using probabilistic models fed by hydrodynamic models (Geerse, 2011). Information from hydrodynamic models can be improved on using climate models to generate artificial times series of thousands of years.

Consequences, damages and casualties can be estimated by using population data and population density for a certain area. This can be improved on using damage modules en GIS information for how and area is built up.

Investment costs can be estimated by determining using average costs from past projects and using a nation price index to account for future corrections.

4.1.4. General considerations in disaster risk assessment

A common risk analysis between riparian states starts with determining the goals, for instance, if the study is just meant to identify hazardous areas or if a common flood risk management plan is the objective. Once the goals have been set a common methodology has to be established. The success of the common methodology depends on the availability of comparable information from each country and the availability of common tools.

Certain tradeoffs have to be made. In some countries a lot of the information is in the public domain while in other countries the information has to be collected or purchased. Sufficient time is needed to develop common tools and a common vocabulary. Choosing the languages in which to publish and in which to communicate within the team is essential. Formal documents will often be in the formal languages of each country; borders are often both administrative and linguistic. Choosing a common language for oral communication is important to create a level playing field in the team.

During the study the common methodology will need to be adapted. Sometimes information may ultimately

not be available within the budget of the study. Solving problems takes time to create results and analyze them. Once the results are there, time is needed to inform the public officials of all countries involved and develop a common communication strategy. This communication strategy should take into account the issues for each country. Flood risk awareness varies between neighboring countries. Impact assessments, risk mapping and risk analysis can be very confrontational. For a study to succeed all riparian states have, e.g., to identify flood prone areas in the same way. This may also imply that some new areas are identified as flood prone. To avoid such surprises a structured communication approach is necessary.

Defining a common vocabulary and methodology is essential. Some essential concepts to reach agreement upon are:

- The hazard as a physical event or human activity with the potential to result in harm to people and damage to goods and property.
- Areas at risk from flooding (inhabited flood prone areas) or drought.
- Probability of an occurrence and the methodologies to determine this probability.
- Consequences, potential damages and fatalities
- Risk, the combination of the probability and consequences

Communicating the results is often done through maps. Maps have to be adapted to the user, this means common concepts can be used. Examples of mapping methods are given in (Martini and Loat 2007). Hazard maps are often based on historical information and information from hydrodynamic models in large river systems. Due to climate change and river training works new areas may be at risk. For flood risk modelling model chains can be used.

The vulnerability of strategic systems and assets of a hotspot community to extreme events depends upon the impacts of these events (as discussed above) and the community's adaptive capacity, or the community's ability to minimize or avoid impacts. Key elements of a community's 'adaptive capacity' are:

- Access to knowledge, both within the community (education) and to external knowledge;
- Access to technology, again both within and outside the community;
- Access to institutions, and their inherent capacities and efficiencies; and
- The economy of the area of interest

Again, the methodology provides a matrix to assist in determining levels of vulnerability based on assessed impacts and adaptive capacity, which can also vary in five steps from 'very low' to 'very high'.

4.2. Information collection and sharing among riparian states

The process of monitoring and assessment should principally be seen as a sequence of related activities that starts with the definition of information needs, and ends with the use of the information product. Successive activities in this monitoring cycle should be specified and designed on the basis of the required information product as well as the preceding part of the chain. Information needs related to climate change adaptation not only relate to climate prediction but include, inter alia, geographic and socio-economic information (from e.g. national census data, development plans, etc.). These data must be available in order to enable development of adaptation measures at a scale ranging from local to national and transboundary levels. Where such data are not available and will take a long time to generate (as is the case in much of the less-industrialized world) robust approaches for understanding and guiding adaptation in data-limited environments are essential. The design of a monitoring programme includes the selection of parameters, locations, sampling frequencies, field measurements and laboratory analyses. The parameters, type of samples, sampling frequency and station location must be chosen carefully with respect to information needs. Data needed for impacts modelling and subsequent vulnerability assessment at the national, international and river basin levels include hydrological, meteorological, morphological and water quality characteristics. Statistical analysis of the previous data series, as well as statistics on diseases caused by water factors (taking into consideration age, sex, local geographical conditions, etc.) is also essential (UNECE 2006).

Information sharing for flood alerts is essential for both coastal areas and rivers. The 1953 disastrous coastal flood in The Netherlands, for instance, shows that the high water levels arrived in England more than 6 hours before they hit the French, Belgian and Dutch coasts. This information never arrived at the other side of the North Sea coast on time. The information from the UK Meteorological office might have

increased the sense of urgency in The Netherlands.

Information collection and sharing among riparian states for flood risk analysis depends on the type of impact assessment and/or risk analysis chosen (also see next section). This determines which indicators will be collected together. For instance, along rivers information on precipitation (measured, expected) and river water levels is crucial for countries downstream. The level of detail will determine the necessary effort. If a Geographical Information System (GIS) is used, data as provided by the riparian countries will have to be consistent. Map systems have to be aligned and often a common reference point for the maps in the study has to be chosen.

The European Flood Awareness System (EFAS) is the first operational European system monitoring and forecasting floods across Europe. It provides complementary, flood early warning information up to 10 days in advance to its partners: the National/Regional Hydrological Services and the European Response and Coordination Centre (ERCC) ²⁴. The European Union has made the EFAS ²⁵ operational for some years now. The JRC of the EU is currently developing a similar global model ²⁶. Information on drought can be obtained in the Global Drought Observatory. This system is the onset of a Global Drought System ²⁷ mainly targeting at emergency response issues.

4.3. Consultation and participation

Stakeholder participation is crucial for all steps of the development and implementation of disaster risk management strategies and measures. From risk assessment to planning and choosing priority risk reduction measures, the knowledge, capacity and views of everyone involved are crucial to ensure sound, effective and sustainable adaptation. Including utilities managers, for instance, is crucial to ensure that the water supply and sewerage services continue to function under changing conditions.

Increasing access to information, public awareness and public participation in decision-making are foundations for the development and implementation of policies related to disaster risk issues. Focusing on these aims will be helpful in building the political commitment and capacity needed to understand and address the causes, impacts and approaches for mitigating climate change.

Public participation is a generally accepted approach in water management, but implementing it is still difficult. The single most important problem is the lack of clarity about the role of stakeholder involvement. Stakeholders often doubt that their input would make a difference, which is critical for motivating people to participate. Apart from this, the existing governance style is often not participatory, and it takes a lot of effort to move towards a more collaborative approach. In many cases, authorities lack experience with multi-party approaches, rely heavily on technical expertise, are not willing to change, fear to lose control or fear that too broad participation could threaten the confidentiality of proceedings.

Therefore, in general, implementing public participation requires political, institutional and cultural change. Sometimes opportunities for truly participatory approaches may arise at the local level or in specific policy processes - an influential politician may for instance favor public participation, or there is a public controversy that cannot be resolved without involving the public. Provided these processes are well organized, they increase positive experiences with and support for public participation.

When stakeholders get a better understanding of the management issues at stake and get to know and appreciate each other's perspectives. This opens up possibilities for win-win solutions and solutions that the authorities had not previously considered. Often, the participatory process results in clearly identifiable improvements for the stakeholders and for the environment.

Important preconditions for public participation are to clearly define the aims and ambitions of water managers and authorities and the ways that the output of the participatory process will be incorporated into management and policy processes. While participatory methods may succeed in providing the informed views of a selection of citizens, and in producing recommendations that can contribute to the quality of the decision-making, the process has to also allow the views and interests of these groups to be included in the decision-making and policy processes that determine the scope and outcomes of water

²⁴ <http://ec.europa.eu/echo/en/what/civil-protection/emergency-response-coordination-centre-ercc>

²⁵ <https://www.efas.eu/>

²⁶ <http://globalfloods.jrc.ec.europa.eu/>

²⁷ <http://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2001>

management (UNECE 2009).

In the consultation and participation process care should be taken that participation of representatives of all riparian countries is ensured to create a common understanding as well as improved decision-making.

The Strategic Framework for Adaptation to Climate Change in the Dniester River Basin,²⁸ completed in 2015 by the basin countries - Republic of Moldova and Ukraine - was one of the first transboundary basin climate change adaptation strategies in the world. With a population of approximately 7 million people, the Dniester River basin is an essential source of water for industry, agriculture, energy and population centers in both countries, as well as beyond the limits of the basin itself. The Dniester River is expected to be significantly affected by climate change leading to warmer and wetter winters and hot, dry summers, including floods and droughts

Produced through a project jointly managed by the OSCE and the UNECE Water Convention secretariat, the Strategic Framework brought together the data available today on the current and possible future trends in climate change in the Dniester basin. It contains a set of measures, the joint and coordinated implementation of which will make it possible to respond to the anticipated changes in a timely manner. The document builds on and complements different national policy documents and strategies, e.g. the Climate Change Adaptation Strategy of the Republic of Moldova and the Dniester river basin management plan. The Framework was subsequently supplemented by an implementation plan serving to attract funding for basin-wide adaptation measures in an effective and coordinated way. The Implementation Plan²⁹ provides a detailed breakdown of adaptation measures with a total budget of 235 million Euros, pointing to potential sources of finance and links to ongoing projects and activities in the two basin countries.

Potential transboundary disaster risks such as floods, hydrological droughts and low flows, and contaminated water plumes are relatively easy to detect when meteorological monitoring and monitoring of water quantity and quality is in place and used for early warning purposes. However some transboundary disaster effects are less pronounced. This is especially the case of cascading effects and/or when effects transfer from water systems to other systems and only become manifest with a delay.

The Inner Niger Delta in Mali illustrates some of these issues. The Inner Niger Delta is an inland delta of more than 30,000 km² in Mali in the Niger River Basin. A flood pulse (mostly resulting from precipitation falling in the Guinean highlands) annually propagates through the delta in the months from August to November increasing flood levels up to 6 meters. During that flooding period the Sahelian barren landscape changes into a Mosaic of braiding river channels, lakes and a multitude of ponds. This flooding is usually non-hazardous but triggers all kinds of ecosystem functions delivering services and goods to the people in the delta on which they depend for subsistence and even survival.

When the flood pulse is less than average, which might result from less upstream precipitation but is often a result from upstream water allocation to generate hydropower and supply irrigation water, this does not necessarily lead to a classical drought disaster situation with dry wells and dying livestock. However, ecosystems dynamics change dramatically. Fish rejuvenation during such a low flow year is much lower, resulting in decreased fish catches the following year. Farmers applying flood recession agriculture need to shift to different (lower) parts of the floodplains to be able to grow their crops, requiring extra from their scarce resources and time. Enlarging areas with low velocity or stagnant water increase the prevalence of waterborne and vector borne diseases. Taking into account the normally already high vulnerability of these livelihood groups in the delta, such changes in the ecosystem services provisioning may become disastrous, especially when they occur in a high frequency.

²⁸ Available from <http://www.unece.org/index.php?id=45918>

²⁹ Available at http://dniester-basin.org/wp-content/uploads/2011/05/ImpPlan_Engl_web.pdf

In the Lower Mekong Basin, the Mekong River Commission assessed the current and future flood risk in a number of flood prone pilot areas, taking into account future climate scenarios. The developed methodology integrated social and economic vulnerabilities to facilitate formulation, prioritization and cost justification of adaptation measures. The social vulnerability assessment involved a risk matrix methodology and involved extensive community consultation, household surveys and analysis. The economic vulnerability was based on annual average damage analysis for the three sectors of agriculture, housing and infrastructure for the moderate climate change scenario projection to 2030.

Hotspot areas were identified based on flood simulation modelling and later confirmed by field visits. Future projected climates for the Lower Mekong Basin were selected and a 'change factor' approach was adopted to project current climate conditions from a selected baseline (1986-2005) into the future (2030). Daily runoff and daily streamflow sequences were generated via hydrological modelling as well as possible future flood behavior. The impact of climate change on flood behaviour (the distribution of peak annual flood discharges and water levels) was assessed by comparing existing flood behavior with flood behavior under CC.

Existing flood behavior was determined using data on the behavior of and damage caused by floods in the past. The 2011 flood was selected as designated 'existing' flood for the hotspot areas in Cambodia, Lao PDR and Viet Nam. In Thailand, the 1994 flood was selected as the designated 'existing' flood, given that it had considerably larger impacts in the Thai hotspot areas than the 2011 Flood.

Flood behavior (and damage) under the 'existing' flood was surveyed during community surveys. Hydrodynamic models were used to provide additional information on 'existing' flood behavior. The 'CC-induced flood behavior' of the pilot adaptation studies, however, does not represent 'future' flood behavior. Rather, it represents the impact of CC on 'existing' flood behavior, as defined by 'existing' upstream catchment conditions and 'existing' floodplain developments.

To assess the vulnerability of a community's socio-economic systems to climate change the methodology consisted of i) determining the scope of the adaptation planning exercise (in our case the strategic socio-economic systems and assets at risk of flooding in the hotspot areas), ii) assessing the vulnerability of the 'existing' socio-economic fabric of the hotspot areas to 'existing' flooding behavior, i.e. the 'existing vulnerability' and eventually iii) assessing the possible impact of CC on existing flood behavior and the associated effects on existing vulnerability.

The impact of flooding on the socio-economic systems and assets of hotspot areas depends upon the 'exposure' of these areas to flooding and the 'sensitivity' of the systems and assets to the adverse effects of this flooding. The methodology provides a matrix to assist in determining the level of 'impact', which can vary in five steps from 'very low' to 'very high'. The level of impact is to be determined for each identified significant adverse impact, e.g. ill-health, disruption to schooling, etc.

5. Develop strategies to reduce the risk

5.1. The disaster risk management cycle

Disaster risk management not only targets the events around disasters, but should also target reduction of risks and mitigation of effects from extreme events. To this end, a cascade of phases is distinguished (Figure)(APFM 2017):

- Prevention/mitigation: measures and activities, incorporated in regional and national development planning, that reduce the probability and/or the impacts of disasters;
- Preparedness: the aim of preparedness programmes is to reach an appropriate level of readiness to respond to any emergency situation that might arise, through programmes that strengthen the technical and managerial capacity of governments, organizations and communities to respond;
- Response: the aim is to provide immediate assistance to maintain life and improve health of the affected population during an emergency situation. The focus in this phase is on meeting the basic needs of people until permanent and more sustainable solutions are in place;
- Recovery: activities aimed at restoring livelihood and supporting infrastructure, making use of opportunities to reduce future vulnerability by enhancing prevention and increasing preparedness.

For each of the phases, specific measures should be identified and designed as will be discussed in this chapter.

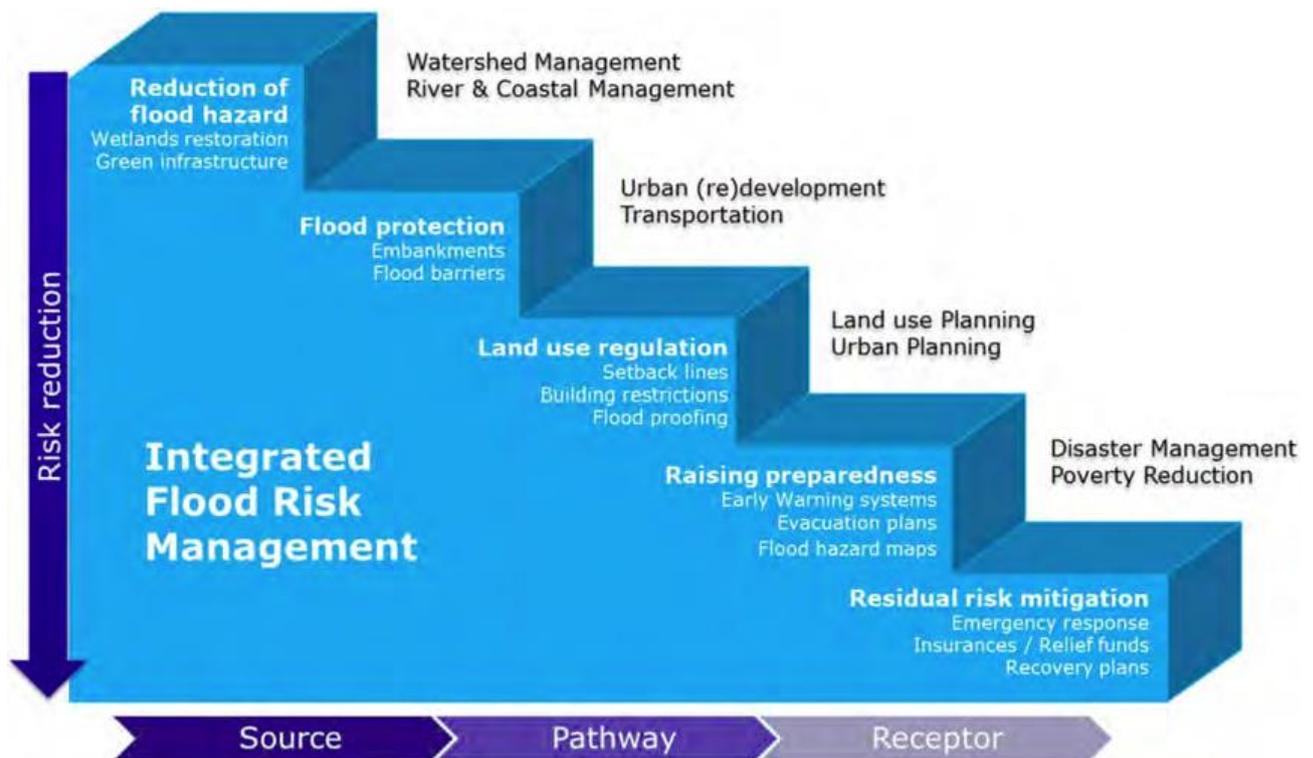


Figure: Cascade with potential integrated flood management measures and associated policy and management fields (APFM 2017)

Disaster management cycle according to Khan (2008).

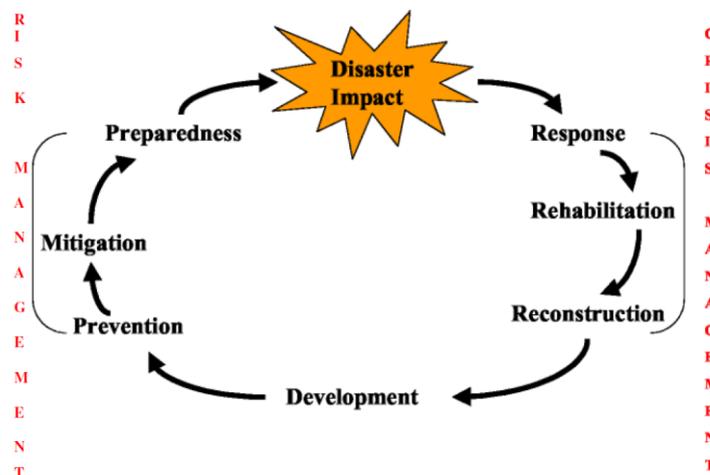


Pre-disaster activities are taken to reduce human and property losses caused by a potential hazard like carrying out awareness campaigns, strengthening weak structures, preparation of disaster management plans, etc. Such risk reduction measures taken under this stage are termed mitigation and preparedness activities.

During a disaster initiatives are taken to ensure that the needs and provisions of victims are met and suffering is minimized. Activities taken under this stage are called emergency response activities.

After a disaster (post-disaster) initiatives are taken in response to a disaster with the purpose to achieve early recovery and rehabilitation of affected communities, immediately after a disaster strikes. These are called response and recovery activities.

The disaster management phases illustrated here do not always, or even generally, occur in isolation or in this precise order. Often phases of the cycle overlap and the length of each phase greatly depends on the severity of the disaster.



5.1.1. Prevention and mitigation of disasters

Links with climate change adaptation (CCA)

Prevention and mitigation: Understanding the residual risk and the potential ‘what-if’ scenarios following implementation of other prevention and mitigation measures provides the starting point of the emergency planning process (Sayers et al. 2013).

Prevention measures are taken to prevent the negative effects of climate change and climate variability on water resources management. Prevention measures are based on risks, hazards and vulnerability maps under different scenarios. To support them, projections are needed both on a medium- and long-term basis. Prevention measures can include, for instance, the minimization or complete prevention of urban development in flood-prone areas or development and implementation of water-efficient methodologies in water-dependent sectors (such as agriculture, industry), but also measures to improve the retention of water such as wetland restoration/protection or afforestation which also help to prevent landslides and land degradation. Prevention measures may be targeted to long-term developments (for example afforestation or wetland restoration/protection), to medium-term developments (for example reduction in water use in industries and agriculture) and short-term developments (for example population migration from flood-prone areas), but are often of a long-term nature. Where the threat of climate change makes continuation of an economic activity impossible or extremely risky, consideration can be given to changing the activity. For example, a farmer may choose a more drought-tolerant crop or switch to varieties with lower moisture. Similarly, cropland may be returned to pasture or forest, or other uses may be found such as recreation, wildlife refuges or national parks (UNECE 2009a).

Measures to improve resilience aim to reduce the negative effects of climate change and variability on water resources management by enhancing the capacity of natural, economic and social systems to adapt to the impacts of future climate change. Resilience is often enhanced by diversification into activities that are less inherently vulnerable to climate. Measures to improve resilience target long-term developments, such as switching to crops that are less water demanding or are salt-resistant. Improving resilience can also be done on a short-term horizon, for instance by operating dams and water reservoirs (surface and underground) in such a way that sufficient water is retained and stored in the wet season to balance the water needed in the dry season. Ecosystems play an important role in climate adaptation. For instance they can contribute to flood regulation by attenuating the variability of hydrological events. Forests, for instance, can retain water, thus slowing down run-off, and wetlands have a buffering effect against floods and droughts. Healthy ecosystems can thus increase resilience. Conservation and restoration of ecosystems should therefore be an integral part of adaptation strategies (see box 28). Measures to enhance the resilience of ecosystems and to secure essential ecological services for human society are of high importance. These include: (a) protection of adequate and appropriate space; (b) limitation of all non-climate stresses; and (c) use of active adaptive management and strategy testing. Conservation of keystone species, planning along climate gradients (e.g. mountain altitudes), promoting connectivity (e.g. protected areas and corridors), fragmentation avoidance and protection of climate refuges with especially resistant habitats can help to conserve vital ecosystems and their habitats (UNECE 2009).

5.1.2. Preparedness for disasters

Preparation: When an alarm is activated, how can the impact of the event be minimized? Actions could include improved forecasting and warning, creation of safe refuges/havens, and preferential routes of access and egress from potential flood areas. Additionally, pre-emergency plans can be used to communicate to the affected stakeholders, and alert the appropriate decision-makers to what might be required during an event and where resources should be stationed (Sayers et al. 2013)

Preparation measures aim to reduce the negative effects of extreme events on water resources management. Such measures are based on risk maps under different scenarios. To support preparation measures, short-term weather forecasts are needed as well as seasonal forecasts. Preparation measures include early warning systems, emergency planning, raising awareness, water storage, water demand management and technological developments. Preparation measures are usually established to run over a long period, but are often only active at the operational level (see, for example, box 29) (UNECE 2009a)

5.1.3. Response actions

Response: Coordinated response across all emergency services and the provision of real-time information to responders and the public alike is central. Communication systems must however be reliable; as has been shown through many events worldwide, technology can fail (mobile networks jam and internet sites go down). Nonspatial information like procedures, emergency plans and authorization modules should be readily accessible and easily communicated. Further, information on critical infrastructures and services damaged by the event will be needed to prioritize actions to protect the affected area. Finally, efficient and reliable communication channels will be necessary to assure the transportation of this information between the appropriate decision-makers and other emergency management actors (Sayers et al. 2013).

Response measures aim at alleviating the direct effects of extreme events. To support response measures, seasonal and short-term weather forecasts are needed. Response measures include, for instance, evacuation, establishing safe drinking water and sanitation facilities inside or outside affected areas during extreme events, movement of assets out of flood zones, etc. Response measures target the operational level (UNECE 2009)

5.1.4. Recovery

Recovery: Information on damaged infrastructure and services will be needed as well as the location of the population at risk, in order to prioritize actions. This stage often focuses on reconstruction (Sayers et al. 2013).

Recovery measures aim to restore the economic, societal and natural system after an extreme event. To support recovery measures, predictions are needed both on a seasonal and a long-term basis. Recovery measures include, for instance, activities for the reconstruction of infrastructure and operate at the tactical level – short term and long term – e.g. restoration of electricity supply etc. Recovery measures also include insurance, as a risk transfer mechanism. Recovery measures do not necessarily aim at restoring the situation that existed before the extreme event. Especially when the existing systems are very vulnerable, severe damage to or destruction of the systems may be an occasion to change to less vulnerable systems. Rebuilding of houses or industries that were destroyed by floods may for instance be done in places that are less flood-prone. Destruction of crops by severe or prolonged droughts may be an occasion to change to less drought sensitive crops or to alternative economic activities. Especially during and after response and recovery, an evaluation should be made of the prevention, resilience improvement, preparation, response and recovery measures related to the extreme event (see, for example, box 34) (UNECE 2009a)

5.1.5. Examples

Pilot projects represent an important method for assessing the effectiveness of a DRR strategy. They can focus on a specific step of the strategy, a specific city or region, or any other aspect of the strategy. In order to enable effective learning to happen, pilot projects should include clear indicators of success and sufficient resources for monitoring and evaluation. In this way, they also support a learning-by-doing approach which enables users:

- To make midcourse corrections to the implementation of DRR strategies, so that they meet their objectives more efficiently;
- To improve their understanding of what determines adaptive capacity, so that capacity development activities can be more successful from the start.

To learn from mistakes and successes, it is important to combine these insights into:

- A comparison of the actual experience with the initial appraisal of the situation and with the criteria adopted;
- The construction of a revised DRR baseline that describes how the system would have performed in the absence of DRM.

5.2. Identify measures

Once acceptability or tolerability has been determined (see [1.4.2](#)), priority areas for risk reduction on the basin can be decided upon and disaster risk reduction measures / options can be developed. The risk assessment team (or risk management planning team) can use risk assessment consultation workshops to identify possible measures for risk reduction. Workshop participants will be asked to think broadly about possible options that may help reduce risks. This aims to draw out potential opportunities while participants are engaged in the assessment process. The identified options will then be presented to the decision making committee for inclusion into the framework of the DRR strategy or the DRM plan. To facilitate decision making, a review of the proposed options and measures and risk reduction priorities is required. This aims to provide decision makers with information regarding the anticipated level of effectiveness of the proposed options and whether there is any overlap or potential synergy with the ongoing disaster risk management activities.

Once the DRR measures are selected they become part of a basin risk reduction project or basin-disaster risk reduction plan. Steps for developing a disaster risk reduction project or plan include:

- Establish disaster risk reduction objectives, based on the disaster risk assessment.
- Identify, develop and design options for risk reduction to (1) avoid, share and retain risks, (2) remove sources of risks, (3) reduce the likelihood of risks through either reducing the event occurring or reducing the effects of the event.
- Evaluate the risk reduction options. This includes first-pass cost benefit analysis, analysis of effectiveness of the options, revisiting or extending of the risk assessment, etc.
- Develop a risk reduction plan, including how the risk reduction options will be implemented (when, how and by whom).

The principles and strategies to reduce risks include:

- Avoid the construction of new risks
- Address pre-existing risk
- Share and spread risk

For measures to reduce exposure and vulnerability, it is necessary to identify and reduce the underlying drivers of risks which are particularly related to poor development choices and practices, degradation of environment, poverty and inequality, and climate change. At basin level, IWRM and DRR planning processes should be integrated. The entry points for integration are suggested in Figure 5.

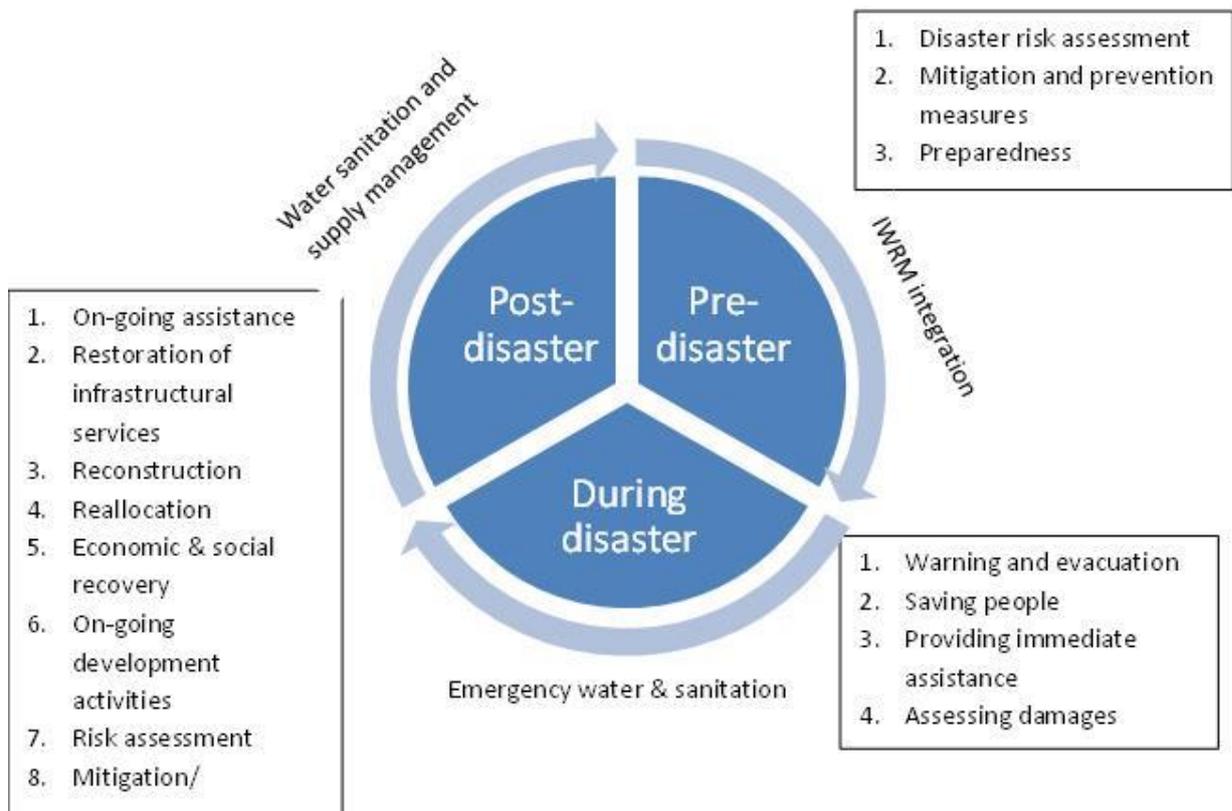


Figure 5. Integration of IWRM and DRR at basin level.

MRC developed and operates a regional flood forecasting system for the Mekong in the Lower Mekong Basin. Being transboundary, this system on the one hand relies largely on the collaboration between countries in terms of data sharing for its overall performance and on the other hand benefits for the four countries in different dimensions, depending on the specificities of the national contexts (forecast per se, forecast benchmark, methodological support, etc.).

The system uses satellite estimates of rainfall. These estimates are corrected using ground truth stations, provided the countries send the data in time and that they are of good quality. These estimates are then processed in a modelling platform (hydrological, hydrodynamic and transfer models) to generate water level forecasts for 22 stations along the Mekong mainstream.

The forecast is issued daily, with a 5-day range forecast. It is disseminated through different canals (website, bulletin, social media, fax, etc.) to a variety of actors. The response mechanisms to potential alarms are arranged at the national levels.

5.3. Different types of measures

Measures should focus on actions aimed at specific issues. Measures can be individual interventions or they can consist of packages of related measures. Measures should be based on generally available global or local information, like predictions of changes in hydrology, combined with expert and local knowledge. The portfolio of policies and measures should be designed on the basis of a thorough consideration of costs and benefits, and aiming to ensure that measures complement and reinforce one another. Care should be taken that both structural and non-structural options (see Box) are included in selecting measures. Structural measures do not necessarily involve concrete structures, ecosystem based adaptation measures are also structural measures while likewise mixtures of concrete structures and nature-based structures are possible.

Box . Structural and non-structural measures (UNISDR 2009)

Structural measures: Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems;

Non-structural measures: Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education.

Criteria to select relevant risk management options include (WWF 2015):

1. Will this option be effective? How effective would this measure be in achieving the overall aim of reducing vulnerability to risk and/or climate change?
2. Is the option technically feasible? Does the technology and/or expertise exist to carry out this measure?
3. Is the option financially/logistically feasible? Are there sufficient resources available to carry out this measure? How much would it cost to implement this measure and who would pay?
4. Are there any risks/negative effects associated with this option? Could there be any detrimental impacts on the ecosystem, local communities, agricultural production, etc.? Might the results of implementing this measure be unacceptable?

Additional criteria may be used that are not directly linked to the measures by itself, but are related to conditions that are in favor of that option. Such additional criteria include (GIZ 2011):

5. Are there strong co-benefits? For instance, reforestation to avoid landslides also contributes to carbon sequestration and groundwater recharge.
6. Is there a high urgency? Is urgent action needed or what happens if no action is taken?
7. Is there a windows of opportunity? If a plan comes into revision, there is a need for reconstruction of infrastructure, a certain person is in charge that is in favor of certain ideas, alignment with funding requirements, etc.
8. Is the option a "no-regret"-option? Is the measure also beneficial in case the projected climatic changes do not occur.
9. When should the option be implemented? The timing of implementation of the option is relevant to determine the urgency of the measure. It is suggested to classify into short (< 5 years), mid-term (5-15 years) and long term (>15 years).

To be successful, any risk reduction strategy should include measures covering all the steps of the disaster risk management cycle (see 4.5): prevention/mitigation, preparedness, response and recovery. Measures for prevention and mitigation should take into account the gradual effects of climate change. Preparedness, response, and recovery measures are mainly relevant for extreme events such as floods and droughts. As there is a continuum of risk reduction measures, it is not always feasible to categorize certain measures as one specific type (see table) (UNECE 2009).

Table : Overview of possible risk management measures (after UNECE 2009)

The table provides an overview of possible risk management options. In italics are those adaptation options that are most likely to have a transboundary effect. The list is not exhaustive.

Type	Flood-prone situation	Drought-prone situation	Impaired water quality	Health effects
Prevention / improving	Restriction of urban development in flood	<i>Reducing need for water</i>	<i>Prevention of and cleaning up of dump</i>	Strengthen capacity for long-term preparation and

Type	Flood-prone situation	Drought-prone situation	Impaired water quality	Health effects
resilience	<p>risk zones</p> <p><i>Measures aiming at maintaining dam safety, afforestation and other structural measures to avoid mudflows</i></p> <p><i>Construction of dykes</i></p> <p><i>Changes in operation of reservoirs and lakes</i></p> <p><i>Land use management</i></p> <p><i>Implementation of retention areas</i></p> <p><i>Improved drainage possibilities</i></p> <p><i>Structural measures (temporary dams, building resilient housing, modifying transport infrastructure)</i></p> <p><i>Migration of people away from high-risk areas</i></p> <p><i>Improved land management, e.g. erosion control and soil protection through tree planting</i></p> <p><i>Relocation of infrastructure</i></p> <p><i>Protection of existing natural barriers</i></p>	<p><i>Water conservation measures / effective water use (industrial and other sectors' practices and technologies, recycling / reusing wastewater)</i></p> <p><i>Water saving (e.g. permit systems for water users, education and awareness-raising)</i></p> <p><i>Land use management</i></p> <p><i>Fostering water efficient technologies and practices (e.g. irrigation)</i></p> <p><i>Enlarging the availability of water (e.g. increase of reservoir capacity)</i></p> <p><i>Improving the landscape water balance</i></p> <p><i>Introduction of strengthening of a sustainable groundwater management strategy</i></p> <p><i>Joint operation of water supply and water management networks or building of new networks</i></p> <p><i>Identification and evaluation of alternative strategic water resources (surface and groundwater)</i></p> <p><i>Identification and evaluation of alternative technological solutions (desalination; reuse of wastewater)</i></p> <p><i>Increase of storage capacity (for surface and ground waters)</i></p>	<p><i>sites in flood risk zones</i></p> <p><i>Improved wastewater treatment</i></p> <p><i>Regulation of wastewater discharge</i></p> <p><i>Improved drinking water intake</i></p> <p><i>Safety and effectiveness of wastewater systems</i></p> <p><i>Isolation of dump sites in flood risk zones</i></p> <p><i>Temporary wastewater storage facilities</i></p> <p><i>Catchment protection (e.g. increasing protected areas)</i></p>	<p>planning, especially to identify, address and remedy the underlying social and environmental determinants that increase vulnerability</p> <p>Use existing systems and links to general and emergency response systems</p> <p>Ensure effective communication services for use by health officials</p> <p>Regular vector control and vaccination programmes</p> <p>Public education and awareness-raising</p> <p>Measures against the heat island effect through physical modification of built environment and improved housing and building standards</p>

Type	Flood-prone situation	Drought-prone situation	Impaired water quality	Health effects
		<i>both natural and artificial</i> Economic instruments like metering, pricing Water reallocation mechanisms to highly valued uses Reducing leakages in distribution network Rainwater harvesting and storage		
	Implement emergency, contingency and disaster planning Construct new housing and infrastructure			
Preparation	<i>Flood warning (incl. early warning)</i> <i>Emergency planning (incl. evacuation)</i> <i>Flash-flood risks (measures taken as prevention because the warning time is too short to react)</i> <i>Flood hazard and risk mapping</i>	<i>Development of drought management plan</i> <i>Change in reservoir operation rules</i> <i>Prioritization of water use</i> Restrictions for water abstraction for appointed uses <i>Emergency planning</i> Awareness-raising Risk communication to the public Training and exercise	<i>Restrictions to wastewater discharge and implementation of emergency water storage</i> Regular monitoring of drinking water	<i>Strengthen the mechanism for early warning and action</i> <i>Improved disease / vector surveillance/ monitoring</i> Ensuring well-equipped health stations and availability of communication and transportation facilities <i>Developing water safety plans</i>
Response	Emergency medical care Safe drinking water distribution Safe sanitation provision Prioritization and type of distribution (bottled water, plastic bags, etc.)			
Recovery	Clean-up activities Rehabilitation options such as reconstruction of infrastructure Governance aspects such as legislation on, inter alia, insurance, a clear policy for rehabilitation, proper institutional settings, rehabilitation plans and capacities, and information collection and dissemination. Specially targeted projects: new infrastructures, better schools, hospitals, etc. All kinds of financial and economic support Special tax regimes for investments, companies, people Insurance Evaluation.			

5.4. Financing risk management measures

In general, costs of implementation of adaptation measures should be borne by each country and governments should make efforts to include budgets and economic incentives in relevant bilateral and multilateral programs. Regarding the financial arrangements, riparian countries should focus on generating

basin-wide benefits and on sharing those benefits in a manner that is agreed to be fair. A focus on sharing the benefits derived from the use of water, rather than the allocation of water itself, provides far greater scope for identifying mutually beneficial cooperative actions. Payments for benefits (or compensation for costs) might be made in the context of cooperative arrangements. For instance, in a transboundary context, measures that support adaptation in one country might be more effective if they are implemented in another country. Prevention of drought or flooding, for instance, might be realized by creating retention areas upstream and such areas may be located in an upstream country. Financing of such measures should be equitably shared, where the party that gains most, pays most. Riparian countries can be compensated, for example, for land flooding as a consequence of water impoundment by another riparian. In some instances, it might be appropriate to make payments to an upstream country for management practices of the basin that bring benefits downstream (e.g. reduced flooding and sediment loads or improved water quality). This solidarity in the basin might entitle upstream countries to share some portion of the downstream benefits that their practices generate, and thus share the costs of these practices. The poorest countries, that are often also most vulnerable to climate change, should be supported by more affluent countries in their development towards climate proofing of water management. Financial as well as ecological sustainability can be improved by recognising water as an economic good and recovering the costs as much as possible from the users. Cost recovery from the users of the resource is an important funding source which can be directly linked to the intensity of use. This makes the users aware of the consequences of their activities and helps to avoid overexploitation (Timmerman and Bernardini 2009).

Example from the Dniester CCA strategy

The Strategic Framework for Adaptation to Climate Change³⁰ in the Dniester River Basin is the result of joint efforts by international experts and organizations – the United Nations Economic Commission for Europe (UNECE) and the Organization for Security and Co-operation in Europe (OSCE) – and experts and organizations from the Republic of Moldova and Ukraine with an interest in the protection and sustainable use of natural resources in the transboundary Dniester River basin under the conditions of a changing global climate.

The Strategic Framework for Adaptation to Climate Change offers a set of measures, the joint and coordinated implementation of which will make it possible to respond to the coming changes in a timely manner. In the example below measures dealing with extreme flooding events are summarised. They are classified as:

- JOINT actions by countries at the basin level (transboundary cooperation required).
- COORDINATED actions by countries in order to do a better job of protecting the interests of the basin as a whole (transboundary cooperation desirable).
- AUTONOMOUS harmonized actions in countries and individual sections of the basin (transboundary cooperation useful).

Strategic Framework for Adaptation to Climate Change in the Dniester River Basin and groups of proposed measures

Risk forecasting and analysis measures	Risk prevention and reduction measures	Remediation measures
Reduction in losses from extreme flooding		
<ul style="list-style-type: none"> ●● improved monitoring and forecasting of flow and information sharing ● inventory of flood protection infrastructure ○ analysis and mapping of flood risk 	<ul style="list-style-type: none"> ●● updating and observance of rules for the operation of the Dniester's system of reservoirs ● updating of flood protection plans ● restoration and optimization of the system of flood protection structures and culverts 	<ul style="list-style-type: none"> ●● providing the public and local authorities with timely information about the flood risk ○ updating and implementation of emergency response plans ○ insurance of risks (including insurance provided with government support)

³⁰ <http://www.unece.org/index.php?id=45918>

Designation of mechanisms for implementation of the proposed adaptation measures:

- **JOINT** actions by countries at the basin level (transboundary cooperation required) – coordination of and direct support for adaptation measures requiring direct cooperation among countries and parts of the basin, including the initiation of and support for measures at the level of individual countries and sections of the basin that are being carried out in the interests of the basin as a whole.
- **COORDINATED** actions by countries in order to do a better job of protecting the interests of the basin as a whole (transboundary cooperation desirable) – coordination, assistance and partial support for the coordinated implementation of adaptation measures at the level of individual countries and sections of the basin that could have an impact on other countries and administrative units within the basin.
- **AUTONOMOUS** harmonized actions in countries and individual sections of the basin (transboundary cooperation useful) – sharing of positive and negative experience at the basin level; initiation of and limited assistance for general measures at the level of individual countries and sections of the basin that are being carried out on a common methodological, organizational and financial basis.

5.5. Prioritizing measures in transboundary basins with the use of cost-benefit analysis

The basic concept of a cost benefit analysis was explained in Section 3.2. Measures have to reduce flood risk. The definition of flood risk is essential. Reduction of design water levels can sometimes be an indicator of flood risk if flood defenses all meet a certain standard. This was the case in the Room for the river project in the Netherlands from 2003-2015. In river areas protected by dikes/levees the most important failure modes for the flood defenses determine the flood risk. Often overtopping, piping/ internal erosion, slope failure, failure of hydraulic structures, revetment failure and scouring are the main failure modes (International Levee Handbook).

Economic growth often increases flood risk faster than climate change. If flood defenses do not increase people enter and investments are made in flood prone areas . These developments result in an increase of the consequences of a flood event (Hallegatte, 2011). This means it makes it necessary to improve flood defenses over time (Kind 2011; Figure x.1). If the measures (e.g. dike strengthening) do not keep up with increased flood risks, policy goals are eroded. Long term funding has proven to be a difficult issue to cover decade after decade, even if cost benefit analysis proves they are worthwhile. In the end, a catastrophic flood will happen.

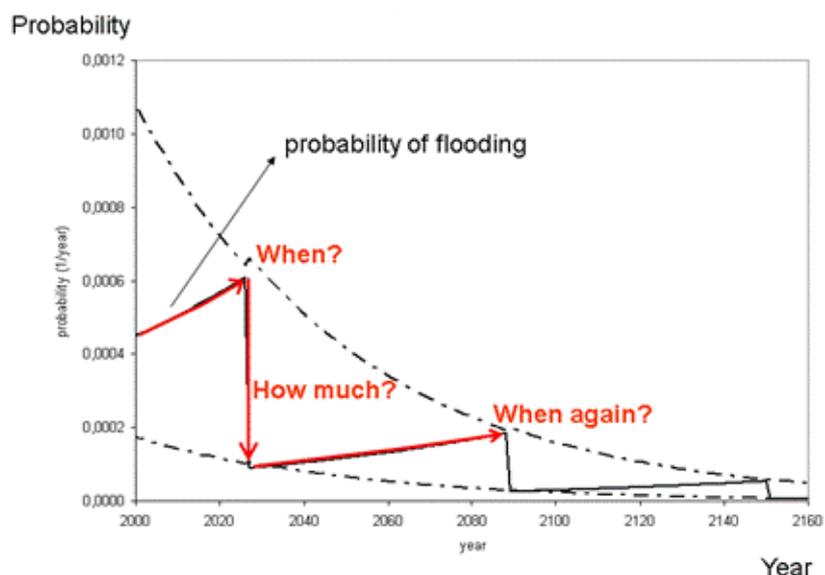


Figure x.1 Dynamic optimization of flood defenses, when and when again? (Kind, 2011)

6. Monitoring and evaluation

6.1. How is it implemented?

Evaluation is a process for determining systematically and objectively the relevance, efficiency, effectiveness and impact of the strategies in the light of their objectives. Evaluating DRR strategies is imperative to assess their results and impacts and to provide a basis for decision-making about amendments and improvements to policies, strategies, programme management, procedures, and projects. Evaluation is the responsibility of decision makers and should guide and support governmental decision-making and policy-making, as well as international aid and investment. It should support prioritizing strategies and initiatives that reduce vulnerability to disasters.

A basin-wide assessment is necessary to be able to implement a basin-wide DRR strategy. The evaluation should therefore be done as a joint activity of riparian countries, based on their shared objectives. It should for example consider whether benefits have accrued to all riparian countries as planned, or whether adjustments need to be made. Consultations and preferably the establishment of a joint evaluation committee will be needed.

In order to perform an evaluation, a range of tools is available, from which the most suitable should be chosen. This choice should also be based on a theoretical approach to what determines the changes in the basin; a theory of change. At the project and programme level, a theory of change developed at the outset can help map the multiple pathways to the identified objectives, determine which pathway to choose and decide the relationship between the different components and the reported outcomes. In a dynamic context, like that of transboundary basins, a theory of change enables managers and evaluators to situate the local DRR initiative within the basin scale of the DRR strategy. Further, it recognizes that reported outcomes cannot be solely attributed to individual initiatives, but rather reflect changes brought about by a diverse portfolio of initiatives and socioeconomic change.

Evaluation and monitoring activities are essential for verifying the effectiveness and efficiency of the measures taken and for facilitating adjustments. Evaluation is carried out during implementation (ongoing evaluation), at the completion of a project (final evaluation), and some years after completion (post evaluation). Part of the evaluation can be based on self-assessment by the staff responsible, but external evaluation is also recommended.

Evaluation should be based on indicators that focus on the progress in the implementation of a policy (process indicators) and indicators that represent progress towards a specific objective (outcome indicators). The policy and institutional framework can best be evaluated by process indicators, which demonstrate actual, on-the-ground institutional and political progress in the often time-consuming, step-by-step journey to solving complex problems. They assist in tracking the domestic and regional institutional, policy, legislative and regulatory reforms necessary to bring about change. Monitoring progress in DRR includes collecting information on the progress made towards achieving objectives; the outcome indicators. Six types of outcome indicators to measure the success of DRR strategies can be distinguished:

- Coverage: the extent to which projects reach vulnerable stakeholders (e.g. individuals, households, businesses, government agencies, policymakers) and ecosystems;
- Impact: the extent to which projects reduce risk and/or enhance adaptive capacity (e.g. through bringing about changes in the DRM processes: policy making/planning, capacity-building/ awareness-raising, information management);
- Sustainability: the ability of stakeholders to continue the DRM processes beyond project lifetimes, thereby sustaining development benefits;
- Replicability: the extent to which projects generate and disseminate results and lessons of value in other, comparable contexts;
- Effectiveness: the extent to which the objective has been achieved, or the likelihood that it will be achieved;
- Efficiency: the outputs in relation to inputs, looking at costs, implementation time, and economic and financial results. In measuring efficiency, it is important to remember that long-term objectives (as dealt with in climate change adaptation) require cost-benefit analysis that takes account of long-term developments.

Indicators can be quantitative or qualitative and should describe the positive and negative effects of project interventions. They should be defined from the beginning, i.e. when DRR measures and objectives are

decided upon, in order to enable continuous data collection and evaluation. Evaluating DRR strategies includes evaluating the constituent elements of a given strategy: the policy, legal and institutional setting; financial arrangements; vulnerability assessment; and the choice and implementation of measures. It also includes monitoring progress towards achieving its objectives.

Evaluation of DRR strategies should also include performance under climate impacts (e.g. is the overall impact of an extreme event lower than before given similar circumstances), comparison of the project area with another similar area where no intervention took place, measuring outcome against standards (e.g. benchmarking) and targets (OECD 2015; UNECE 2009; UNECE 2015).

6.2. Reporting under the Sendai Framework and the SDG's

To support effective cooperation in climate adaptation at the transboundary basin level, the development of joint monitoring and joint information systems (such as databases or GIS systems) is recommended. Such systems should be based on an agreement on the information to be shared and on which country will be responsible for producing what information. Existing systems should be adapted to include disaster risk and climate change issues. Where they exist, joint bodies should be responsible for this.

If a joint information system is not feasible, regular and also operational data and information exchange between different countries, bodies and sectors is needed. This includes exchange of information on risk management and adaptation plans and measures to enable riparian countries to harmonize their activities, and the exchange of data permitting the improvement of climate and hydrological prediction models. A data comparability procedure has to be established between countries adopting different methods of data collection (different methods of data surveying, instruments, procedures, etc.).

Data should also be made publicly available, except in cases where disclosure to the public might damage confidentiality provided for under national law; international relations, national defence or public security; the course of justice; the confidentiality of commercial and industrial information (where such confidentiality is protected by law to protect a legitimate economic interest); intellectual property rights; etc. In such cases, data should be processed so that it cannot be used for purposes other than risk assessment and/or climate change adaptation.

A set of 38 indicators were identified to measure global progress in the implementation of the Sendai Framework for Disaster Risk Reduction by the Open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction (OIEWG). The indicators will measure progress in achieving the global targets of the Sendai Framework, and determine global trends in the reduction of risk and losses. These metrics, together with indicators that can be employed by countries to measure nationally-determined targets, will allow an appraisal of the impact actions of stakeholders supporting the achievement of the outcome, goals and targets of the Sendai Framework. The indicators will generate the information base for the development of Sendai Framework implementation strategies, facilitate the development of risk-informed policies and decision-making processes, and guide the allocation of appropriate resources.

Key indicators, measuring the global targets of the Sendai Framework, have been adopted for use in measuring disaster-related goals and targets of the 2030 Agenda for Sustainable Development; thereby allowing the simultaneous and coherent monitoring and reporting on the Sendai Framework and the SDGs 1, 11 and 13.

In recommending draft Resolution Work of the UN Statistical Commission pertaining to the 2030 Agenda for Sustainable Development for endorsement by the Economic and Social Council, the Statistical Commission adopted the global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development, developed by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs).

UNISDR continues to work with the members of the IAEG-SDGs, the UN Statistical Commission, their observer agencies and other relevant partners to undertake the substantive and technical work to develop international statistical standards, metadata, computation methodologies and guidelines to implement the global indicator framework to follow up and review the goals and targets of the 2030 Agenda and the Sendai Framework.

Progress in implementing the Sendai Framework will be assessed biennially by UNISDR; analysis and trends will be presented in the Sendai Framework Progress Report. Countries will be able to report against

the indicators for measuring the global targets of the Sendai Framework, and disaster risk reduction-related indicators of the SDGs, using the online Sendai Framework Monitor. The Sustainable Development Goals Report is submitted every year to the High-level Political Forum for Sustainable Development (HLPF), for which countries are expected to collect data and report on an annual basis.

The Sendai Framework recognises that the Global and Regional Platforms for Disaster Risk Reduction have a key role in its implementation. In accordance with the Sendai Framework's paragraphs 28 (c) and 49, the Global Platform and Regional Platforms are, inter alia, expected to periodically monitor and assess progress in implementation, and contribute to the deliberations of the HLPF, the General Assembly and the Economic and Social Council, including the integrated and coordinated follow-up processes to United Nations conferences and summits and the quadrennial comprehensive policy reviews of the UN operational activities for development.

6.3. Transboundary context

Establishing an international platform is important for exchanging lessons learnt, best practices and failures. Since little experience is available yet in developing DRR strategies and measures at the transboundary level knowledge developed by countries and experiences in implementing measures in basins, both successful and less successful examples, can help other countries to reduce risks, including environment-related health-risks, and to improve their DRR strategies.

Evaluation of DRR strategies also includes cost-benefit analysis. Adapting to climate change entails costs (at least those of implementation), but should also yield significant benefits – those of reduced impacts or enhanced opportunities. Any assessment of the economic efficiency of DRR actions requires consideration, including at the transboundary level, of: (a) the distribution of their costs and benefits; (b) the costs and benefits of changes in those goods that cannot be expressed in market values; and (c) the timing of DRR actions.

Decision makers have found that scheduling reviews and updates of the adaptation strategy on a fixed schedule is a useful means of ensuring its long-term flexibility. Political processes may benefit by having fixed-term re-assessments of vulnerability (and the processes of evaluating vulnerability), which can then explicitly inform transboundary institutions, such as the reallocation of water resources, the planning of new infrastructure, or the operating regime of existing infrastructure to match shifting conditions and changing needs.

Participatory processes in support of DRR can add value, enhance feasibility and acceptance and lead to more accurate results. Engaging as many stakeholders as possible can democratize the overall process of adapting to climate change and climate variability. For example, stakeholder engagement can uncover obstacles and reasons for the failure of adaptation projects, such as scepticism on the part of stakeholders about the information provided by government. However, participatory evaluation needs to go hand-in-hand with scientific evaluation which often takes into account more long-term issues (OECD 2015; UNECE 2009a; UNECE 2015).

6.4. What are the effects?

Sound evaluations can be carried out with simple, careful examinations of success, relative to what was expected. The following list provides examples of questions that can contribute to this evaluation:

- If, for instance, DRR involved investing in a protection project in response to a climate hazard, then the evaluation should determine whether losses have continued, grown or been abated;
- If the protection project simply tried to reduce sensitivity to extreme events, has it worked, and how?;
- Have episodes of intolerable exposure become more or less frequent?;
- Has the definition of “intolerable” in terms of physical effects changed?;
- Has the investment expanded the coping range, reduced exposure to intolerable outcomes that exceed the range, or both?;
- Have things stayed the same or grown worse because the DRR measure was ineffective, or because unanticipated stresses have aggravated the situation?;
- Is there a causal relationship between the vulnerability reduction and the strategy/measure?

If the aims of a DRR strategy have not been reached, the root causes of both successes and failures should be analyzed. This can be done through various methods such as a survey among the population, expert interviews, site visits, etc.

7. Glossary

Adaptation

- Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNFCCC 2017).
- The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities (IPCC 2014).

Adaptive capacity

The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC 2014).

Capacity

The combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management (UNISDR 2017).

- **Coping capacity** is the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during disasters or adverse conditions. Coping capacities contribute to the reduction of disaster risks.
- **Capacity assessment** is the process by which the capacity of a group, organization or society is reviewed against desired goals, where existing capacities are identified for maintenance or strengthening and capacity gaps are identified for further action.
- **Capacity development** is the process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals. It is a concept that extends the term of capacity-building to encompass all aspects of creating and sustaining capacity growth over time. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems and the wider enabling environment.

Capacity building

In the context of climate change, the process of developing the technical skills and institutional capability in developing countries and economies in transition to enable them to address effectively the causes and results of climate change (UNFCCC 2017).

Climate change

Refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes (IPCC 2014).

Disaster

- Serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts. The effect of the disaster can be immediate and localized, but is often widespread and could last for a long period of time. The effect may test or exceed the capacity of a community or society to cope using its own resources, and therefore may require assistance from external sources, which could include neighbouring jurisdictions, or those at the national or international levels (UNISDR 2017).

- Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC 2014).

Disaster risk

The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. The definition of disaster risk reflects the concept of hazardous events and disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio economic development, disaster risks can be assessed and mapped, in broad terms at least. It is important to consider the social and economic contexts in which disaster risks occur and that people do not necessarily share the same perceptions of risk and their underlying risk factors (UNISDR 2017).

Disaster risk assessment

A qualitative or quantitative approach to determine the nature and extent of disaster risk by analyzing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend. Disaster risk assessments include: the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities with respect to likely risk scenarios (UNISDR 2017).

Disaster risk governance

The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy. Good governance needs to be transparent, inclusive, collective and efficient to reduce existing disaster risks and avoid creating new ones (UNISDR 2017).

Disaster risk management

Application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. Disaster risk management actions can be distinguished between prospective disaster risk management, corrective disaster risk management and compensatory disaster risk management, also called residual risk management (UNISDR 2017).

Disaster risk reduction

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. Disaster risk reduction is the policy objective of disaster risk management, and its goals and objectives are defined in disaster risk reduction strategies and plans. Disaster risk reduction strategies and policies define goals and objectives across different timescales and with concrete targets, indicators and time frames. In line with the Sendai Framework for Disaster Risk Reduction 2015-2030, these should be aimed at preventing the creation of disaster risk, the reduction of existing risk and the strengthening of economic, social, health and environmental resilience (UNISDR 2017).

Early warning system

An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events. Effective “end-to-end” and “people-centered” early warning systems may include four interrelated key elements: (1) disaster risk knowledge based on the systematic collection of data and disaster risk assessments; (2) detection, monitoring, analysis and forecasting of the hazards and possible consequences; (3) dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and (4) preparedness at all levels to respond to the warnings received. These four interrelated components need to be coordinated within and across sectors and multiple levels for the system to work effectively and to include a feedback mechanism

for continuous improvement. Failure in one component or a lack of coordination across them could lead to the failure of the whole system (UNISDR 2017).

Exposure

- The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest (UNISDR 2017).
- The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2014).

Flood

The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods and glacial lake outburst floods (IPCC 2014).

Hazard

- A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socio-natural in origin. Natural hazards are predominantly associated with natural processes and phenomena. Anthropogenic hazards, or human-induced hazards, are induced entirely or predominantly by human activities and choices. This term does not include the occurrence or risk of armed conflicts and other situations of social instability or tension which are subject to international humanitarian law and national legislation. Several hazards are socio-natural, in that they are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability. Biological hazards are also defined by their infectiousness or toxicity, or other characteristics of the pathogen such as dose-response, incubation period, case fatality rate and estimation of the pathogen for transmission (UNISDR 2017).
- The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts (IPCC 2014).

Impacts (consequences, outcomes)

Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea level rise, are a subset of impacts called physical impacts (IPCC 2014).

Mitigation

- The lessening or minimizing of the adverse impacts of a hazardous event. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness. It should be noted that, in climate change policy, "mitigation" is defined differently, and is the term used for the reduction of greenhouse gas emissions that are the source of climate change (UNISDR 2017).
- In the context of climate change, a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere (UNFCCC 2017).

- A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). This report also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter emissions that can directly alter the radiation balance (e.g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides, Volatile Organic Compounds and other pollutants that can alter the concentration of tropospheric ozone which has an indirect effect on the climate (IPCC 2014).

Preparedness

The knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters. Preparedness action is carried out within the context of disaster risk management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response to sustained recovery. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, the stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. The related term “readiness” describes the ability to quickly and appropriately respond when required (UNISDR 2017).

Prevention

The activities and measures to avoid existing and new disaster risks. Prevention (i.e., disaster prevention) expresses the concept and intention to completely avoid potential adverse impacts of hazardous events. While certain disaster risks cannot be eliminated, prevention aims at reducing vulnerability and exposure in such contexts where, as a result, the risk of disaster is removed. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high-risk zones, seismic engineering designs that ensure the survival and function of a critical building in any likely earthquake and immunization against vaccine-preventable diseases. Prevention measures can also be taken during or after a hazardous event or disaster to prevent secondary hazards or their consequences, such as measures to prevent the contamination of water (UNISDR 2017).

Reconstruction

The medium- and long-term rebuilding and sustainable restoration of resilient critical infrastructures, services, housing, facilities and livelihoods required for the full functioning of a community or a society affected by a disaster, aligning with the principles of sustainable development and “build back better”, to avoid or reduce future disaster risk (UNISDR 2017).

Recovery

The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and “build back better”, to avoid or reduce future disaster risk (UNISDR 2017).

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UNISDR 2017).

The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC 2014).

Response

Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called disaster relief. Effective, efficient and timely response relies on disaster risk-informed preparedness measures, including the development of the response capacities of individuals, communities, organizations, countries and the

international community. The institutional elements of response often include the provision of emergency services and public assistance by public and private sectors and community sectors, as well as community and volunteer participation. “Emergency services” are a critical set of specialized agencies that have specific responsibilities in serving and protecting people and property in emergency and disaster situations. They include civil protection authorities and police and fire services, among many others. The division between the response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage (UNISDR 2017).

Risk

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. In this report, the term risk is often used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure (IPCC 2014).

Risk management

The plans, actions or policies to reduce the likelihood and/or consequences of risks or to respond to consequences (IPCC 2014).

Structural and non-structural measures

Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems. *Non-structural measures* are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education. Common structural measures for disaster risk reduction include dams, flood levies, ocean wave barriers, earthquake-resistant construction and evacuation shelters. Common non-structural measures include building codes, land-use planning laws and their enforcement, research and assessment, information resources and public awareness programmes. Note that in civil and structural engineering, the term “structural” is used in a more restricted sense to mean just the load-bearing structure, and other parts such as wall cladding and interior fittings are termed “non-structural” (UNISDR 2017).

Sustainability

A dynamic process that guarantees the persistence of natural and human systems in an equitable manner (IPCC 2014).

Sustainable development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (IPCC 2014; UNFCCC 2017).

Uncertainty

A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements (e.g., reflecting the judgment of a team of experts) (IPCC 2014).

Vulnerability

- 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 (UNISDR 2017).
- The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (UNFCCC 2017).
- The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014).

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