Disasters and Ecosystems:
Resilience in a Changing Climate

SOURCE BOOK

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Centers for Natural Resources and Development

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List of acronyms

CBD
Convention on Biological Diversity

CCA
Climate Change Adaptation

COP
Conference of the Parties

CI
Conservation International

DRR
Disaster Risk Reduction

EbA
Ecosystem-based Adaptation

Eco-DRR
Ecosystem-based Disaster Risk Reduction

GWP
Global Water Partnership

ICZM
Integrated Coastal Zone Management

IFM
Integrated Fire Management

IFRC
International Federation of Red Cross and Red Crescent Societies

IPCC
Intergovernmental Panel on Climate Change

IUCN
International Union for the Conservation of Nature

IWRM
Integrated Water Resource Management

MDGs
Millennium Development Goals

NbS
Nature-based Solutions

NGO
Non-Governmental Organization

NOAA
National Oceanic and Atmospheric Administration

OECD
Organisation for Economic Co-operation and Development

PAM
Protected Area Management

PEDRR
Partnership for Environment and Disaster Risk Reduction

SDGs
Sustainable Development Goals

SFDRR
Sendai Framework for Disaster Risk Reduction

SPREP
Secretariat of the Pacific Regional Environment Programme

SREX
Special Report on Extreme Events (IPCC)

UNCCD
United Nations Convention to Combat Desertification

UNECE
United Nations Economic Commission for Europe

UNDP
United Nations Development Programme

UNFCCC
United Nations Framework Convention on Climate Change

UNDRR
United Nations Office for Disaster Risk Reduction (formerly UNISDR)

UNEP
United Nations Environment Programme

WBCSD
World Business Council for Sustainable Development

WMO
World Meteorological Organization

Contents

Executive summary

Disasters kill people, destroy infrastructure, damage ecosystems and undermine development, and could increase in frequency due to climate change. There is a need for increased awareness on the latest advances in disaster risk reduction (DRR) and climate change adaptation (CCA). A significant advancement is a better understanding of ecosystem-based approaches for reducing disaster risks and adapting to climate change. This book explains the importance of ecosystems and their management for DRR and CCA and provides guidance to plan and implement ecosystem-based disaster risk reduction and climate change adaptation (Eco-DRR/EbA).

DRR aims to work on reducing risk factors, by reducing exposure, vulnerability and hazards. A number of things can contribute to increasing risk in each of the risk factors, many of which are related either directly or indirectly to poor environmental management. The international policy field acknowledges the need to improve resilience through improving, maintaining and managing ecosystem function with a number of mentions and mandates in several important agreements, such as the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), the United Nations Framework Convention on Climate Change (UNFCCC), and the Convention on Biological Diversity (CBD).

Ecosystems provide important services that can address all risk factors. They reduce exposure to hazards by buffering their impact, such as mangroves attenuating waves or forests protecting against avalanches. Well managed, they reduce hazards; indeed degraded ecosystems are more prone to creating hazards such as landslides or desertification. Finally, they can reduce vulnerability by providing food, water and livelihoods to communities.

Eco-DRR is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development (Estrella and Saalismaa 2013). EbA is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (CBD 2009). While these two approaches have some differences due to being developed in silos, separately in the DRR and CCA communities, there is much overlap in practice.

We hope that readers of this source book will retain a few key messages about Eco-DRR/EbA and its core principles. These include: providing multiple benefits and offering a no-regrets strategy. Furthermore, ecosystem-based approaches to DRR/CCA are often more cost-effective over time than grey infrastructure alone, although in some cases, grey-green infrastructure combinations are the most optimal. And finally, gender-sensitive Eco-DRR/EbA is fundamental to transformational resilience, or resilience which leads to sustainable reduction of disaster risks. Our book concludes that there are still knowledge gaps and challenges to mainstreaming Eco-DRR/EbA, not the least being how to scale-up investments in ecosystems for DRR/CCA from a locally specific project to generalisable guidelines. This is indeed one of the main challenges of Eco-DRR/EbA: for example, vegetation that reduces erosion in one locality may not work in another. Nevertheless, this book aims to provide answers to overcome some of these gaps and challenges. It also challenges readers to engage in new research, find ways to incorporate Eco-DRR/EbA in development planning and join the growing community of practice working to advance this emerging field.

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For further information on our organisations and our MOOC, visit our websites.

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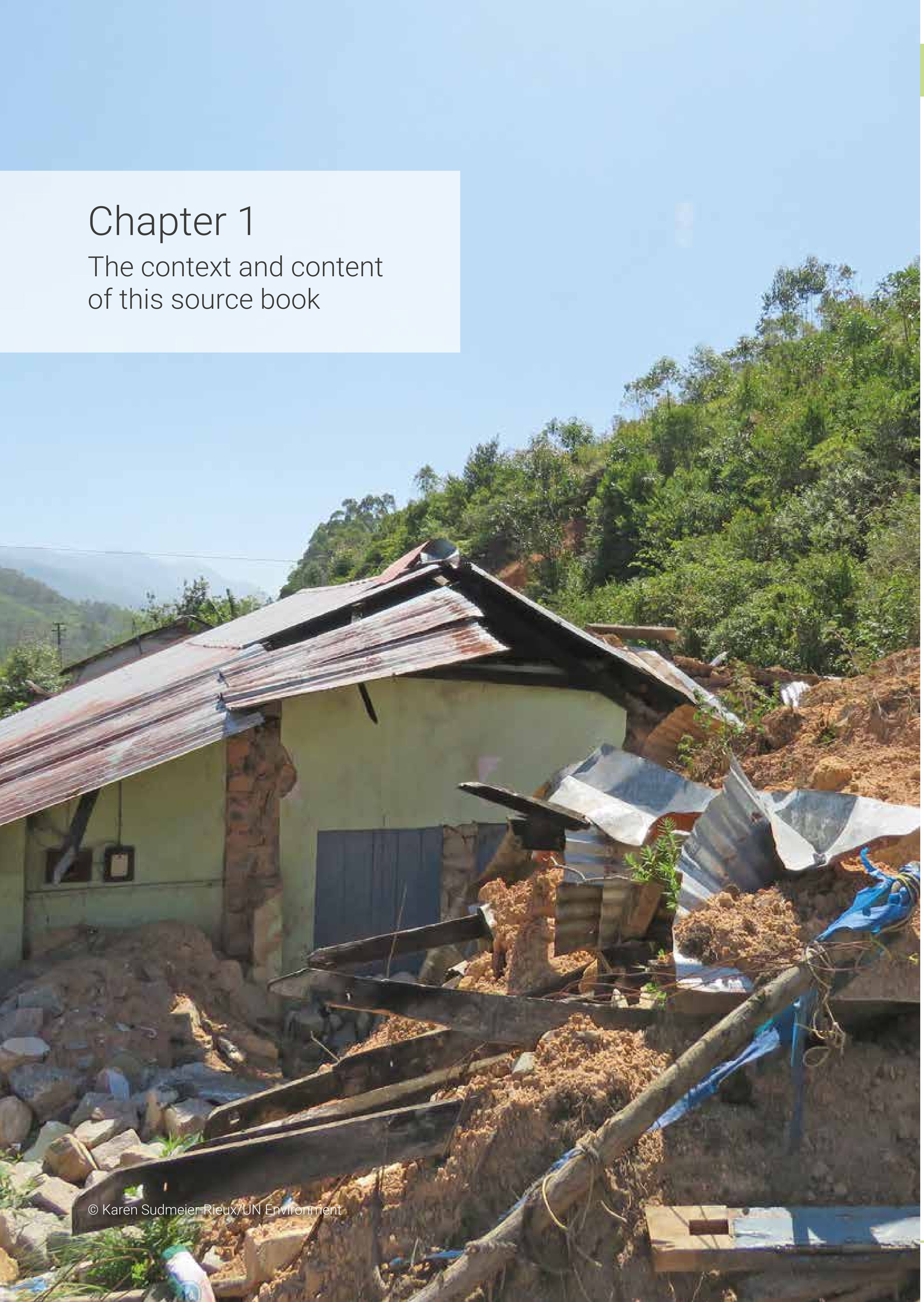
Chapter 1

The context and content of this source book



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1.1 Introduction

Disasters kill people, destroy infrastructure, damage ecosystems and undermine development. Climate change is expected to aggravate existing disaster risks in many regions of the world. There is a need for increased awareness amongst practitioners, policymakers and researchers on the latest advances in disaster risk reduction (DRR) and climate change adaptation (CCA). There is now a better understanding of ecosystem based approaches for reducing disaster risks and adapting to climate change. Natural solutions are now more commonplace to providing protective buffers and supporting food and water for increased resilience against disaster impacts. Ecosystem-based approaches for disaster risk reduction and climate change adaptation (or Eco-DRR/EbA) are considered by the IPCC (2012) as a "no-regrets" strategy, providing multiple socio-economic benefits regardless of disasters, including carbon storage and sequestration, biodiversity conservation, and poverty alleviation.

The promotion and uptake of so called 'Nature-based Solutions' (NbS) for DRR and CCA has grown and gained attention internationally since 2007, after the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP). Conservation organisations, such as the International Union for Nature Conservation (IUCN) and The Nature Conservancy (TNC), supported by some Member States, brought forth in their submissions to the 14th UNFCCC CoP in 2008 the concept of ecosystem-based adaptation (EbA) as an important element of the future adaptation framework under the UNFCCC (Vignola *et al*. 2009).

In the field of DRR, the importance of ecosystems has been recognised and discussed for some time prior to the push for EbA, and this recognition is found in the Hyogo Framework for Action (HFA) 2005-2015, mainly through HFA Priority 4, to "reduce the underlying risk factors". Contributing to this evolution, the Partnership for Environment and Disaster Risk Reduction (PEDRR) has been advocating for Eco-DRR to be mainstreamed in disaster and development planning globally since 2008.

Partnership for environment and disaster risk reduction

PEDRR is a global alliance of UN agencies, NGOs and specialist institutes. PEDRR seeks to promote and scale-up implementation of Eco-DRR/EbA and ensure it is mainstreamed in development planning at global, national and local levels, in line with the SFDRR.

For more information: www.pedrr.org

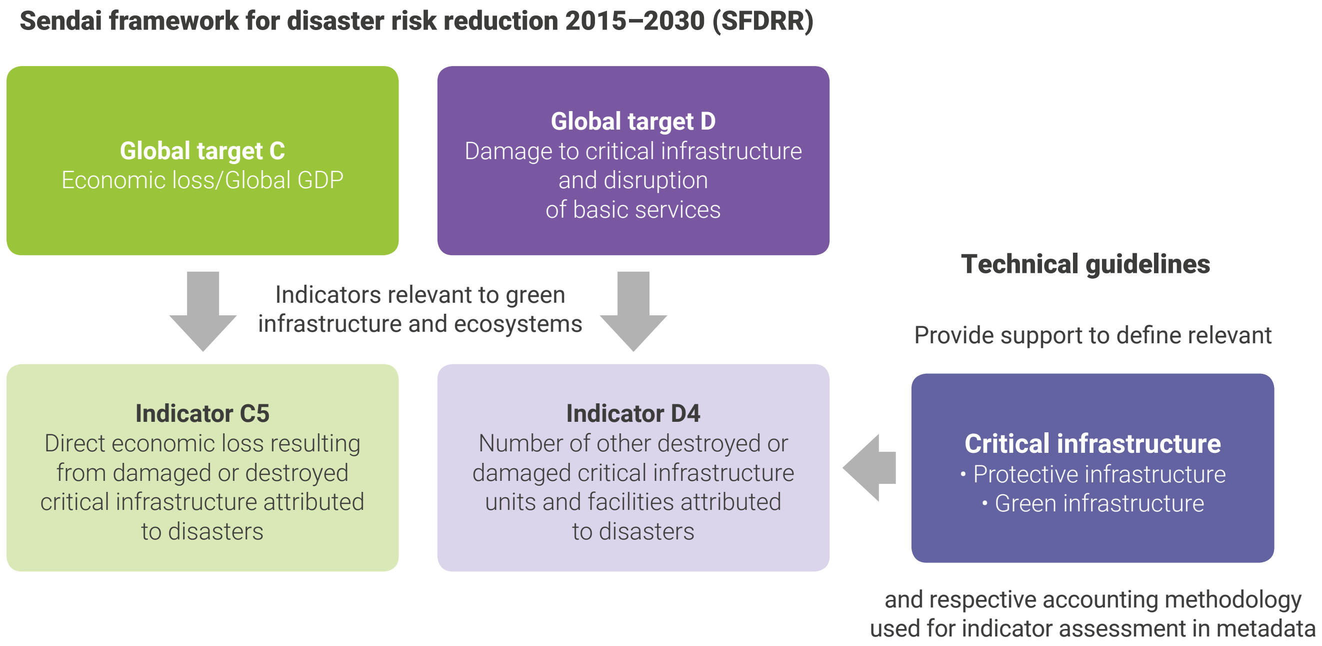

Figure 1.1
Indicators on green infrastructure and ecosystems in the SFDRR.
Source: Sebesvari *et al*. 2019. Redrawn by L. Monk

DEFINITIONS

EbA: The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (CBD 2009).

Eco-DRR: The sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development (Estrella and Saalismaa 2013).

EbM: The use of ecosystems for their carbon storage and sequestration service to aid climate change mitigation.

Thanks to its advocacy, the post-2015 agenda of the SFDRR provides a more explicit recognition of the role of sustainable ecosystem management for reducing disaster risk and building resilience. Furthermore, the Sendai Framework Monitor (SFM), which includes 38 indicators to monitor progress towards seven targets, has provision to report upon green infrastructure, under two indicators (**Figure 1.1**). However, to date no government has reported on green infrastructure.

The different terminology used to denote NbS, within different agreements or documents, such as the ecosystem-based approaches mentioned in the SFDRR and green infrastructure in the SFM, or used by different organisations such as EbA in climate change discussions and Eco-DRR in DRR discussions, can create confusion and murkiness, which may also impede uptake and reporting by governments. Ensuring clarity and communication is therefore important.

While the importance of environmental management is not new, and one of the pillars of sustainable development, there is still a dominance of technical and structural solutions to problems such as disasters and climate change. Part of this reason is perhaps the lack of evidence, understanding and guidance for the implementation for NbS. However, thanks to policy developments and advocacy, as well as increased funding for such projects, implementation of natural solutions, or ecosystem-based approaches is increasing.

This is important because population and economic growth, particularly in many developing and newly industrialised countries will put increasing pressures on ecosystems and reduce their protective function against hazard events. Landscape and ecosystem degradation, for instance of mangroves, coastal dune systems, and mountain forests, can be observed in many parts of the world, and will likely continue or even accelerate if no suitable countermeasures are taken.

TERMINOLOGY

Several terms are used to denote the use of ecosystems or natural elements in a landscape. These terms are:

Natural Solutions (NS) or Nature-based Solutions (NbS) are defined by IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham *et al.* 2016). This is an umbrella term for all natural mangement approaches, including those undertaken for disaster-risk reduction or climate change adaptation.

Green-blue (or natural) Infrastructure (GI or NI): This term is often used to oppose what is called "grey (or hard) infrastructure", which refers to any hard structure such as a sea wall or dyke and is "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation, climate mitigation and adaptation, and management of wet weather impacts that provides many community benefits" (UNISDR, 2017: 96)

Natural buffers: similar to green infrastructure.

Ecosystem-based approaches: includes **Ecosystem-based adaptation (EbA), Ecosystem-based disaster risk reduction (Eco-DRR)**, and **Ecosystem-based mitigation (EbM)**.

Green and blue space: these terms are often used in urban climate change adaptation, and denote the provision of "green" areas, such as green roofs, parks, green corridors, and "blue" areas, such as ponds and water features, for urban cooling and water management.

Figure 1.2
Border between Haiti on left, Dominican Republic on right. © UNEP

Figure 1.2 is a striking illustration of the different levels of vegetation cover between Haiti (left of road) and the Dominican Republic (right of road). In Haiti, severe environmental degradation is one of the main underlying risk factors – leading to increased vulnerability and risk to hazard events. For example, the 2004 Tropical Storm Jeanne caused numerous mudslides and over 1,600 causalities in Haiti especially in the city of Gonaïves. In contrast, in the neighbouring Dominican Republic, the same storm caused much less damage and only 18 casualties were reported (NOAA, 2014).

Another example of natural coastal protection is from Sri Lanka, where human activities aggravated the impact from the Indian Ocean tsunami in 2004. **Figure 1.3** shows Yala National Park in Southern Sri Lanka, which was hit hard by the Indian Ocean tsunami in 2004. In the photo on the top, we barely distinguish a few green rooftops of an ecotourism resort that was protected by sand dunes. There the wave height was only 5 cm and there were no casualties. The photo on the bottom shows the Yala Safari Resort which lies right by the beach not far from the ecotourism resort, where the dunes had been removed for better ocean views. Here the wave height reached 7 meters and 27 people died. This is a good example of how ecosystems, such as sand dunes, can protect people and infrastructure against coastal hazards. It also illustrates how a hazard, such as a tsunami, can become a disaster when people are living in exposed places or degrade their environments.

Figure 1.3
Yala National Park, Sri Lanka and nested ecotourism resort.
© B. McAdoo

Yala Safari resort, Sri Lanka.
© B. McAdoo

Most disasters or at least some of their severe impacts are preventable and are often caused or aggravated by degraded environmental conditions. Eco-DRR/EbA is an approach where ecosystems (for e.g. mountain forests, wetlands and mangroves) are systematically harnessed to prevent, mitigate or buffer against natural hazards and the impacts of climate change, such as sea level rise. Eco-DRR/EbA recognizes that ecosystems can provide DRR services as well as offer other ecosystem services of productive, regulating and cultural value, which also contribute to building local resilience to disasters and climate change. Investments in Eco-DRR/EbA approaches thus provide multiple benefits – not only for increasing resilience to DRR and CCA – but especially for supporting livelihoods, human well-being and ecosystem health. However, just as there are limitations to engineered structures, there are also limitations to how much ecosystems, such as coastal sand dunes or mangroves, can protect from a hazard event such as a tropical cyclone or tsunami. This protection function depends on the health of the ecosystem and the magnitude of the hazard event. There is however a growing body of scientific evidence about the protective functions of ecosystems, upon which this source book is based.

This book was written for disaster managers and practitioners, CCA professionals, development planners, project implementers and policy makers, students and leaders in the fields of DRR, CCA, development, and natural resources management, including environmental engineering, regional, urban and environmental planning, geography, ecology, landscape ecology, agricultural sciences, and anybody else interested in learning about new solutions to addressing increasing disasters and climate risks.

1.2 Structure of the book

This book aims to provide readers with an understanding of the concepts of DRR and CCA, explain the importance of ecosystems and their management for DRR and CCA, and provide guidance and tools to plan and implement Eco-DRR/EbA. However, this book can only give general principles and overview of the issues. It cannot provide specific guidance for specific conditions because each situation is unique and requires in depth inquiry, and will depend on resources available for each context. Nevertheless, it is hoped that this book and the resources that are given at the end of some chapters can help towards mainstreaming Eco-DRR/EbA and be a reference source for this emerging field.

Chapters 2-5 introduce the subject of disasters and risk reduction, climate change and adaptation and the role of ecosystems and their management for DRR and CCA. Chapter 2 provides an overview of disasters and what is DRR, as well as how climate change impacts disaster risk. This chapter also introduces gender issues in DRR, which will be further elaborated upon in subsequent chapters. Being sensitive to gender when planning DRR and CCA is extremely important, not only due to the policy requirements for equity and equality, but also because of the inherent vulnerability of more marginalised groups as well as the contribution for long-term resilience that women and other minorities can provide. Chapter 3 discusses the differences and convergence between DRR and CCA as well as the main international agreements and actors relevant for Eco-DRR/EbA. Chapter 4 introduces the link between ecosystems and DRR, while Chapter 5 clarifies the differences and commonalities between Eco-DRR and EbA and argues for integration of both.

Chapters 6-8 develop on the principles of ecosystem-based approaches for DRR and adaptation, system thinking and resilience. Chapter 6 provides the core principles of Eco-DRR/EbA that can help to understand the underlying paradigm and briefly discusses some of the implementation challenges. Chapter 7 explains system thinking, and how it is important in developing Eco-DRR/EbA measures. Chapter 8 looks at what is resilience, which is a concept that is found in many of the international policy agreements and project development aims in CCA and DRR. It provides several ways at looking at resilience from short-term coping to longer-term transformation.

Chapter 9 looks more concretely at DRR and the different disaster phases, which can be categorised in four parts following an event: relief, recovery, reconstruction, and prevention. The chapter provides some ideas as to how to incorporate ecosystem and gender consideration into each phase.

Chapters 10-15 detail different tools for Eco-DRR/EbA: looking at risk assessments, planning, gender and community-based tools, management tools, ecological engineering, and finally economic tools. Risk assessments

TERMINOLOGY USED IN THIS BOOK

This book will be using terminology given by the United Nations Office for Disaster Risk Reduction – UNDRR [formerly the United Nations International Strategy for Disaster Reduction] (UNISDR) (2017)]. UNDRR is the main UN agency that advocates for disaster reduction policies and practices. It should be noted that there are however several different definitions for many of these terms. The Intergovernmental Panel on Climate Change (IPCC) definitions, for instance, are substantially different from those used by the "disaster risk reduction community", creating some confusions regarding terms. However, significant efforts have been made to consolidate the two sets of terms: **http://www.preventionweb.net/english/professional/terminology**

are introduced in Chapter 10 with some examples of projects that have included ecosystems in them. Chapter 11 gives a general overview of some planning tools from participatory rural appraisal, spatial planning using geographical information systems and environmental impact assessments. Risk assessment and planning are integral parts of DRR and CCA implementation. Chapter 12 delves a bit more into gender aspects of DRR and highlights how successful integration of gender into DRR can improve resilience. Moreover, involving the whole community in planning and implementation of Eco-DRR/EbA is important for sustainability and to address any conflict and find ways to cooperate for a better future. Chapter 13 explains the main management tools, which are: Integrated Water Resource Management (IWRM), Integrated Coastal Zone Management (ICZM), Sustainable Land Management, Integrated Fire Management (IFM) and Protected Area Management (PAM). Chapter 14 goes into more detail on using green infrastructure or hybrid green-grey approaches that are collectively called ecological engineering. It gives examples as well as the potentials and limitations of the approach. Chapter 15 highlights the importance of finance and tools that can be used to inform decision-making, such as cost-benefit analysis and ecosystem valuation. It also briefly introduces the concept of payment for ecosystem services, a mechanism which has originally been used in the climate mitigation/emissions reduction schemes but can also be important for other ecosystem services tied to DRR/CCA.

The last three chapters aim to bring everything together. Chapter 16 looks at key entry points for mainstreaming Eco-DRR/EbA. The chapter once again highlights the importance of finance and financing Eco-DRR/EbA and provides examples of some national and international policy entry points. Chapter 17 provides a general operational framework for Eco-DRR. It gives a structure of five points/questions that need to be considered when creating a project plan that aims for resilience. Finally, Chapter 18 wraps things up with the opportunities and challenges for Eco-DRR/EbA going forward.

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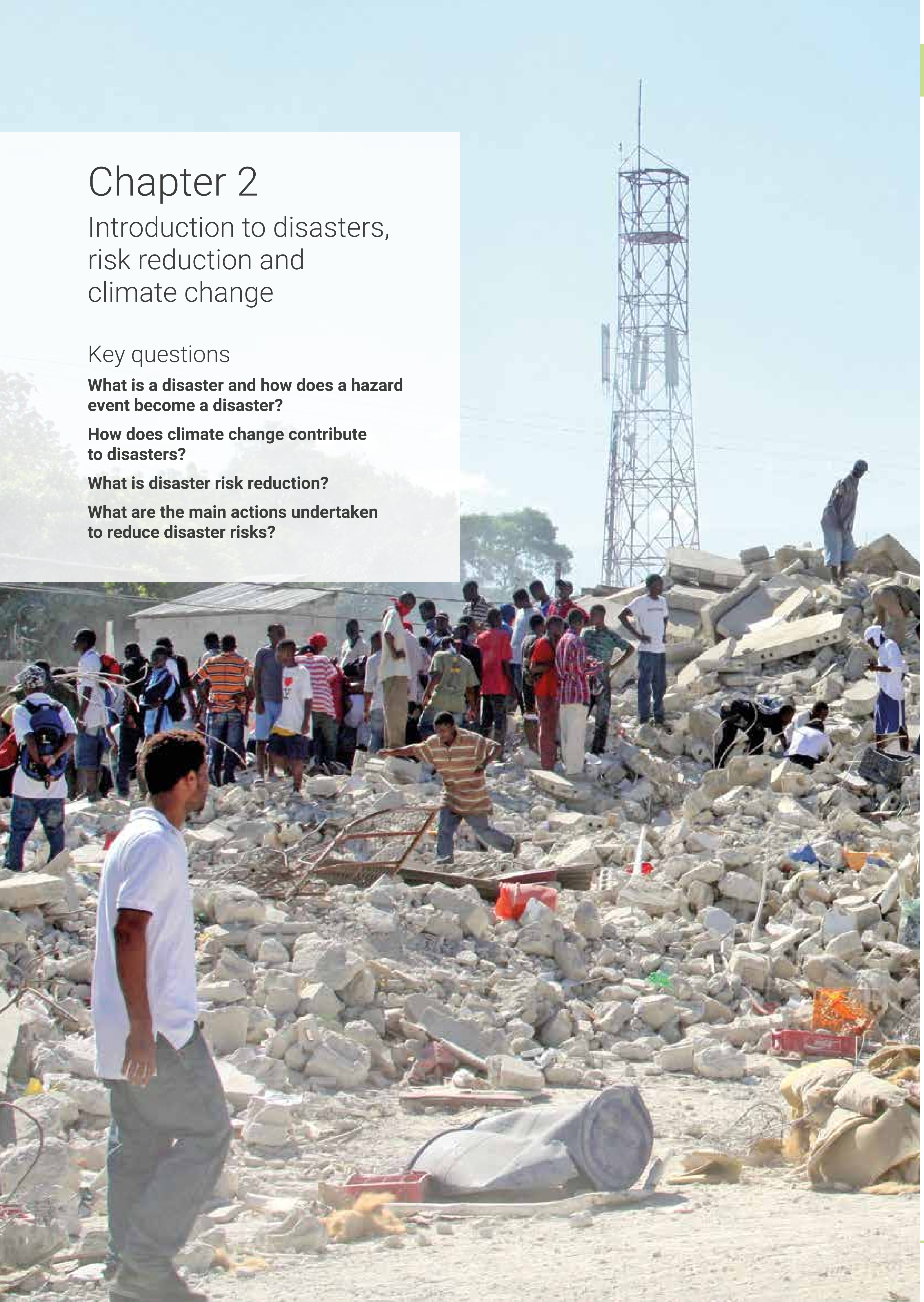


Chapter 2

Introduction to disasters, risk reduction and climate change

Key questions

What is a disaster and how does a hazard event become a disaster?

How does climate change contribute to disasters?

What is disaster risk reduction?

What are the main actions undertaken to reduce disaster risks?

2.1 Hazard events and disasters

For a disaster to be entered into the official database on disasters, EM-DAT, the International Disaster Database, it must meet at least one of four criteria:

- **Ten (10) or more people reported killed.**
- **Hundred (100) or more people reported affected.**
- **Declaration of a state of emergency.**
- **Call for international assistance.**

In other words, natural hazard events, such as landslides, tropical cyclones, floods, avalanches, etc., become disasters if they exceed the capacity of a community or society to cope using its own resources. Even a severe hazard event would not be declared disaster if no one is affected (directly or indirectly). For example, an avalanche happening in some remote and uninhabited area would not be considered a disaster. Thus, whether a hazard event becomes a disaster depends largely on the magnitude of the event but also on how well a society is prepared to cope with it. For example, a flood of the same magnitude may not be considered a disaster in a country such as Bangladesh which often experiences severe flooding as compared to a country such as Sweden where large-scale flooding is less common. **Disasters** can be classified in different ways although the first distinction is between man-made[1] disasters (chemical accidents, oil spills, industrial pollution) as caused by technological hazards versus disasters associated with natural hazards.

Natural hazards can be classified in several ways but are usually broken down into the two broad categories: geophysical and biological hazards (Burton *et al.* 1993). **Figure 2.1** shows the classification used in EM-DAT (2015). Landslides can be triggered either by earthquakes or most commonly by rainfall. Floods and wildfires can be related to a combination of geological, hydrological and meteorological phenomena. According to UNISDR (2009) a biological hazard can be defined as a "process or phenomenon of organic origin or conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bioactive substances that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage." In the 2015 Global Assessment Report by UNISDR, natural hazards were referred to as "physical hazards" although this definition has not yet replaced natural hazards in the official terminology. This book addresses geophysical, hydro-meteorological and climatological hazards as these are the hazards that are the most common and can be attenuated to various degrees through ecosystem management and restoration.

Natural hazards

GEOPHYSICAL
Earthquakes
Volcanic eruptions
Tsunamis
Landslides

HYDRO-METEOROLOGICAL
Avalanches
Floods
Storm surges
Cyclonic storms
Droughts
Heat waves
Wind storms
Wild fires

DEFINITION: DISASTER

"A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."

UNISDR 2009

Figure 2.1 Disaster types. EM-DAT 2015

1. In some instances the term "environmental disasters" is used to describe man-made or technological disasters

Another important distinction is between sudden or slow onset disasters, also referred to as intensive or extensive hazards (UNISDR 2011). UNDRR (formerly UNISDR) defines the threshold variables between intensive and extensive disaster losses in terms of mortality and housing destruction. The thresholds are fixed at: Mortality: less than 30 people killed (extensive); 30 or more killed (intensive); Housing destruction: less than 600 houses destroyed (extensive); 600 or more houses destroyed (intensive) (UNISDR 2015).

Earthquakes, tsunamis or sudden landslides are examples of intensive hazards while, droughts and slow-moving landslides are examples of extensive hazards (although a very sudden and intense drought could be considered intensive). Extensive hazards also affect the vulnerability and resilience of communities and will likely increase in some regions due to climate change impacts (IPCC 2012).

DISASTER TRENDS AND STATISTICS

Disasters have become more frequent during the past 20 years (**Figure 2.2**). While the number of people affected has decreased, only partly explained by population growth, death rates on the other hand, have increased over the same period, reaching an average of more than 99,700 deaths per year between 2004 and 2017.

This partly reflects the huge loss of life several mega disasters during that time period: for example, the Asian tsunami in 2004, cyclone Nargis in 2008 and the earthquake in Haiti in 2010 (**Figure 2.3**).

Although countries have made quite some progress in reducing mortality from intensive disasters through improved disaster management (early warning systems, preparedness programs and evacuation plans), the increase in extensive risk demonstrates that countries have not adequately addressed underlying risk drivers that are anchored in poverty and poor governance (UNISDR 2015). **Figure 2.4** shows how global processes and underlying risk drivers affect the risk-poverty nexus. Decreasing the underlying drivers of risk, which impact the vulnerability of people, would help to decrease the magnitude of disasters.

This fact is further mirrored by the UNDRR statistic: almost 90% of the mortality recorded since 1990 in internationally reported disasters has

Figure 2.2
Number of disasters 1980-2015
Munich Re NatCatSERVICE 2017

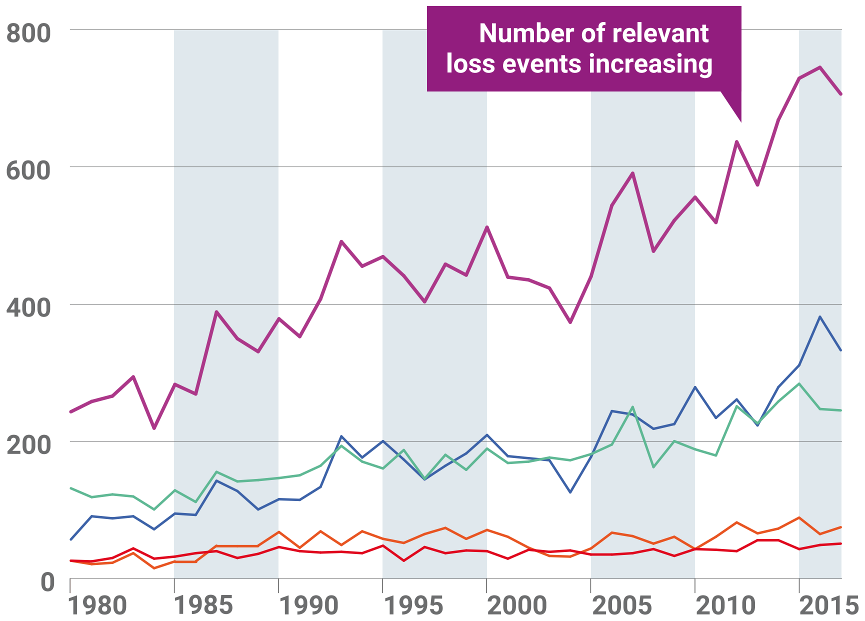
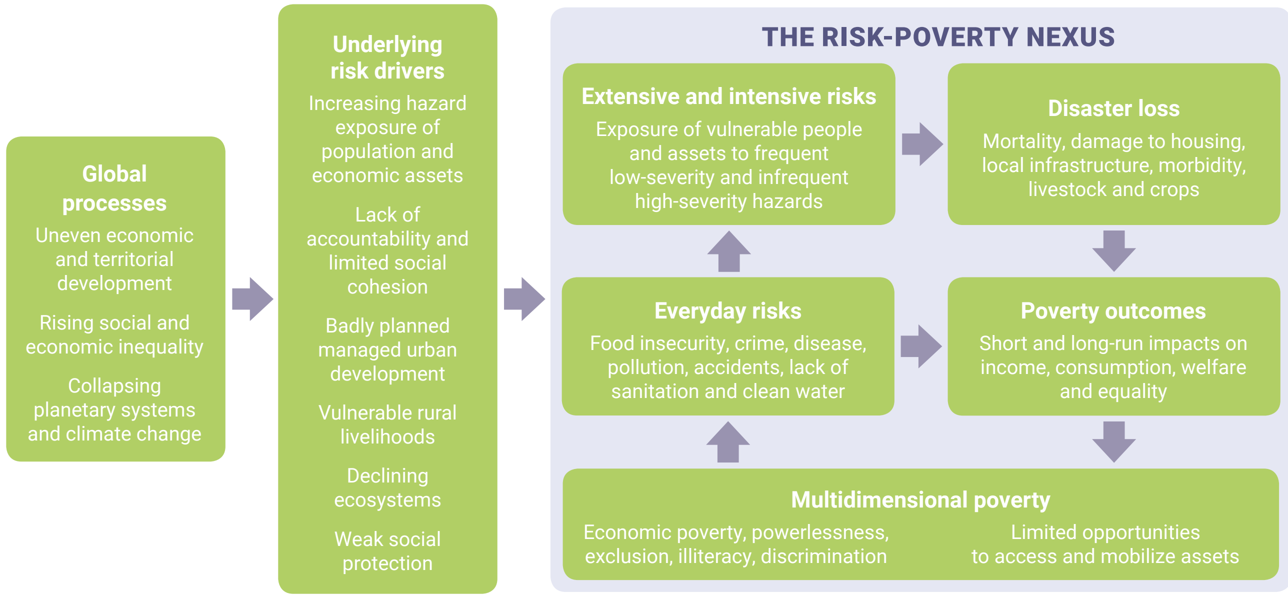


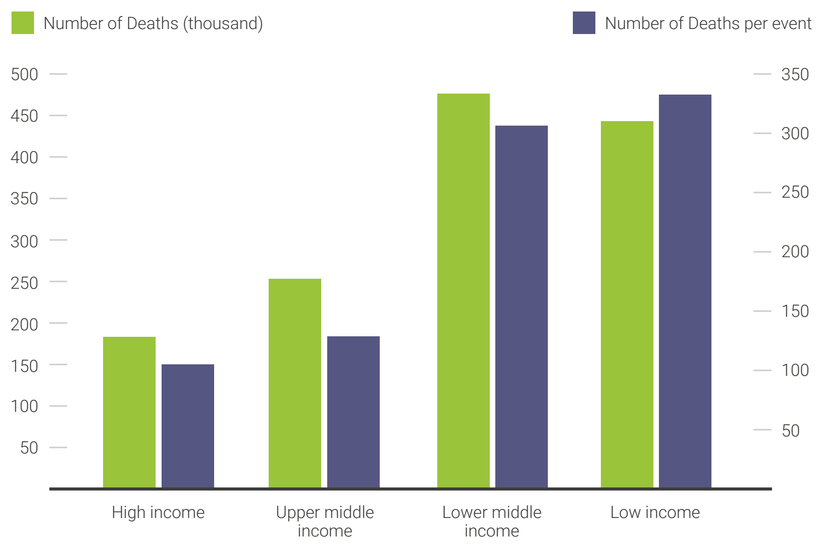
Figure 2.3
Mortality from disasters concentrated in a few intensive events.
UNISDR 2015

Figure 2.4
The risk-poverty nexus.
UNISDR 2015. Redrawn by L. Monk



occurred in low and middle-income countries (UNISDR/UNDRR 2015, 2019). According to EM-DAT, during the period 2004 and 2013, on average, more than three times as many people died per disaster in low-income countries (332 deaths) than in high-income nations (105 deaths). When combining higher-income with upper-middle-income countries, 56% of the countries experienced disasters but accounted for 'only' 32% of deaths, while low- and lower-middle-income countries experienced 44% of disasters but suffered 68% of deaths (EM-DAT 2015) (**Figure 2.5**).

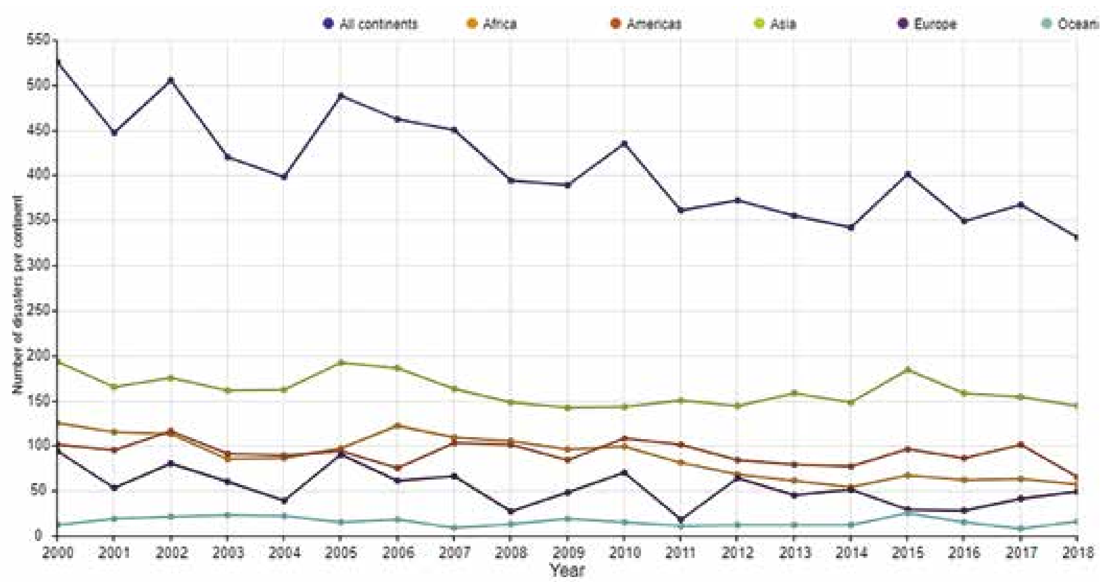
Figure 2.5
Total number of deaths compared to the average number of deaths per disaster by income group (1994-2013).
EM-DAT 2015. Redrawn by L. Monk



As critical infrastructure, such as roads and hospitals, is constructed, the expectation is that disaster-affected people will be provided with better chances of avoiding and recovering from hazard events. Improved levels of economic development should lead to advances in early warning systems, ranging from more accurate monitoring of weather events to vastly increased mobile phone access and real improvements in disaster preparedness and response.

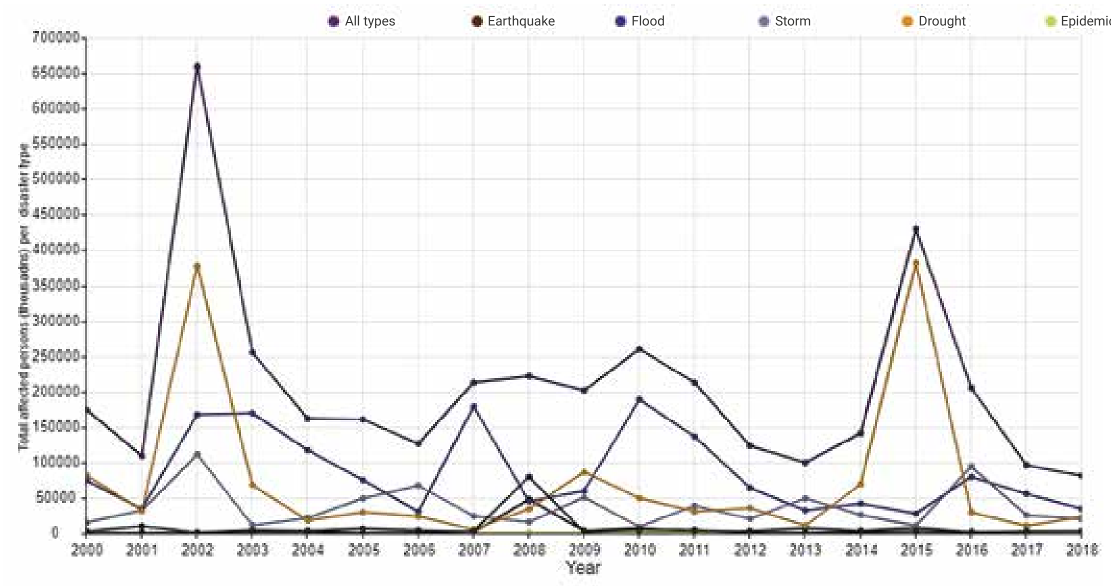
Figure 2.6 illustrates that Asia continues to be the continent with the greatest number of disasters. According to EM-DAT, in 2018, 53% of disasters occurred in Asia and 85% of those affected by disasters were also in Asia.

Figure 2.6
Disasters worldwide by continent 2000-2018.
EM-Dat 2019



The type of disaster caused by natural hazards that affects most people worldwide is weather-related, with drought, floods and storms being the leading cause of disasters (**Figure 2.7**).

Figure 2.7
Share of occurrence of disasters by type (2000-2018).
EM-DAT 2019



According to UNDRR (UNISDR 2015), absolute economic losses due to disasters are rising, but in relative terms, the global increase in economic loss from disasters is statistically not significant. However, whereas absolute economic loss is concentrated in higher-income countries, in relative terms, it remains a far greater problem for low income countries. During the period 1994-2013, high income countries recorded losses of an estimated US$ 1,660 billion dollars due to disasters, while low income countries recorded only US$ 71 billion. In relation to GDP, this corresponds to 0.3% losses for high income countries compared to 5.1% in low income countries (**Figure 2.8**). As underreporting of economic losses is especially common in low income countries the above statistics reflect a disproportionate impact from disasters on low income countries.

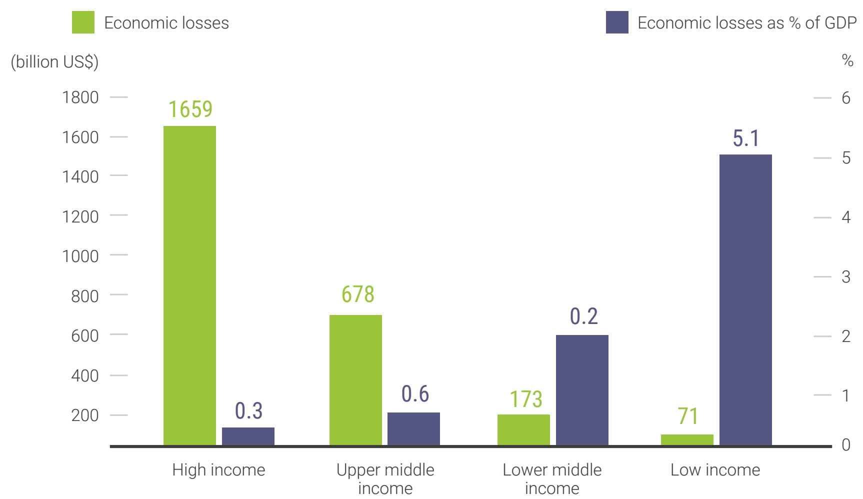


Figure 2.8
Economic losses in absolute value and compared to GDP 1994-2013.
EM-DAT 2015. Redrawn by L. Monk

DISASTERS AND GENDER

It is well understood that natural hazards do not discriminate, but people do. When a natural hazard turns into a disaster affecting people, it can affect people even within the same community differently. Various axes of inequality – class, race, gender, caste, ethnicity, religion – all can affect how disasters impact individuals and communities (**Figure 2.9**). This hints at a gendered impact of disasters, whether due to the impact during or in the aftermath of a disaster where social inequalities can be exposed in terms of burden of impact, the help received or even in post disaster violence that can ensue.

Figure 2.9
Flooding in Haiti 2007.
© UNEP

The gendered impact of disasters was investigated by Neumayer and Plümper (2007). They analysed data relating to 4,605 disasters caused by natural hazards between 1981 and 2002. Examining disaster mortality, they show that the gender gap between life expectancy (generally more for women than men) decreases during and in the aftermath of a disaster. The stronger the disaster, the more severe its impact on female life expectancy. From this study, they argue that it is the "socially constructed gender-specific vulnerability of females built into everyday socioeconomic patterns that lead to the relatively higher female disaster mortality rates compared to men" (Neumayer and Plümper 2007:551). Their argument about gender specific vulnerability due to pre-existing discriminations in the social structure is bolstered by their finding that "the adverse impact of disasters on females relative to men vanishes with rising socioeconomic status of women" (Neumayer and Plümper 2007:562). However, the data available preclude coming to any general conclusions applicable across the board about the gendered impact of disasters.

Subsequent studies have shown that in several disasters women frequently outnumber men in terms of casualties or being affected. In Indonesia, in the four villages in the Aceh Besar district surveyed by Oxfam in the aftermath of the 2004 Tsunami, only 189 of 676 survivors were female. Male survivors outnumbered female survivors by a ratio of almost 3:1. In four villages in North Aceh district, out of 366 deaths, 284 were females: females accounted for 77% of deaths in these villages. In the worst affected village, Kuala Cangkoy, for every male who died, four females died — or in other words, 80% of deaths were female (Oxfam 2005). In the Great East Japan Earthquake in 2012, Iwate, Miyagi and Fukushima prefectures were the worst affected, with 8,363 female and 7,360 male casualties recorded in total (the gender of 63 further casualties was not identified). Female casualties outnumbered male by around 1,000. The majority of these additional 1,000 female casualties were aged 70 years or older (Government of Japan 2014). Of course, an aspect not necessarily revealed by some of these statistics is the proportion of men to women within the community to begin with.

Field-work based observations and anecdotal accounts of practitioners and experts reinforce this analysis of differential impact across genders exacerbated by vulnerability. Some of the reasons that contribute to this are well known: dress codes can restrict women's ability to move quickly; girls and women are not taught to swim or climb trees, which can affect their chances of surviving floods; insufficient access to early warnings affect women's chances to leave disaster areas; domestic and caring jobs that women do often make them less inclined to immediately leave a disaster area.

Through her work in regions in Tamil Nadu, India affected by the 2004 Indian Ocean Tsunami, Pincha (2008) describes the impact of gender norms. She writes,

"During the Tsunami in Tamil Nadu, strong internalized values of nudity and shame prevented women from running to safety as their saris had been removed by the sheer force of the waves. The women preferred to drown rather than come out of waters without their clothes. Since the incident many of them have started using inner wear as it will provide minimal cover in case they have to discard or raise their sari and run." (Pincha 2008:24)

There are circumstances where gendered social expectations can affect men more. Gender roles within the prevailing social relations may also lead to more men losing their lives in certain situations. For example, it is estimated that more men than women were killed when Hurricane Mitch struck Central America in 1998 (Bradshaw and UNECLAC 2004). More recently in the floods of 2018 in Kerala, South India, it is reported that of the 433 lives lost in the floods and landslides, 268 were men, 98 women, and 67 children , as men were expected to assist others during the emergency (Government of Kerala 2018).

Gender aspects also play a crucial role in disaster recovery and reconstruction. The Post Disaster Needs Assessment (see also Chapter 15) carried out after the 2015 Gorkha earthquake in Nepal showed that disaster impacts on infrastructure, social and production sector put a huge strain on the ability of poor households to sustain their livelihoods, thus promoting negative coping strategies, such as child labor, early marriage, and sexual and gender-based violence. It increased the time women and girls had to spend collecting water and firewood by another three hours in some remote settlements. Social norms expecting females to be responsible for these basic household supplies can thus result in long-term negative impacts on girl education (Government of Nepal 2015). These experiences with disasters show that our gendered social lives increase women's vulnerability in general, whereas social expectations of bravery or risk-taking may cost men their lives.

Beyond the binary nature of men and women, other gender minorities can find themselves more vulnerable during and after disasters especially if they are already marginalised in society (Gorman-Murray *et al*. 2014). Studies in various countries reveal that discrimination and access to assistance can increase the impact of disasters on LGBTI (lesbian, gay, transgender and intersex) communities, or other gender minorities, such as the *bakla* in the Philippines (Gorman–Murray *et al*. 2014; Gaillard *et al*. 2016). Other disadvantages such as disability, being a religious minority or belonging to any oppressed group – race/caste/class/religion – etc. could also exacerbate the gendered impact of disasters. UN Department of Economic and Social Affairs (2019) states that "Individuals with disabilities are disproportionately affected in disaster, emergency, and conflict situations due to inaccessible evacuation, response (including shelters, camps, and food distribution), and recovery efforts." Enarson and Fordham (2000 (200:50)) researching flood recovery in the US and UK found that "flooding reflected and exacerbated economic, racial/ethnic and gender inequalities".

EXPOSURE AS A MAIN DRIVER OF DISASTER RISK

Following the section on disasters and gender, this section explores the importance of exposure as a driver of disaster risk. One of the main messages of this source book is that most disasters are actually preventable and mainly result from people living in hazard exposed places, such as along coastlines, rivers and steep slopes (UNISDR 2011). It is thus crucial to know how disasters of various types may be preventable and what actions we need to undertake to reduce the occurrence of preventable disasters. **Figure 2.10** illustrates urban growth in a city in eastern Nepal, where over 200 households settled by the banks of the river over a time period of five years (2004-2009), mostly in shanty houses. A large flood from the river in 2013 created massive damage to this section of the city (in red).

What this example demonstrates is how exposure is a main driving factor for disaster risk, not only in Nepal but worldwide.

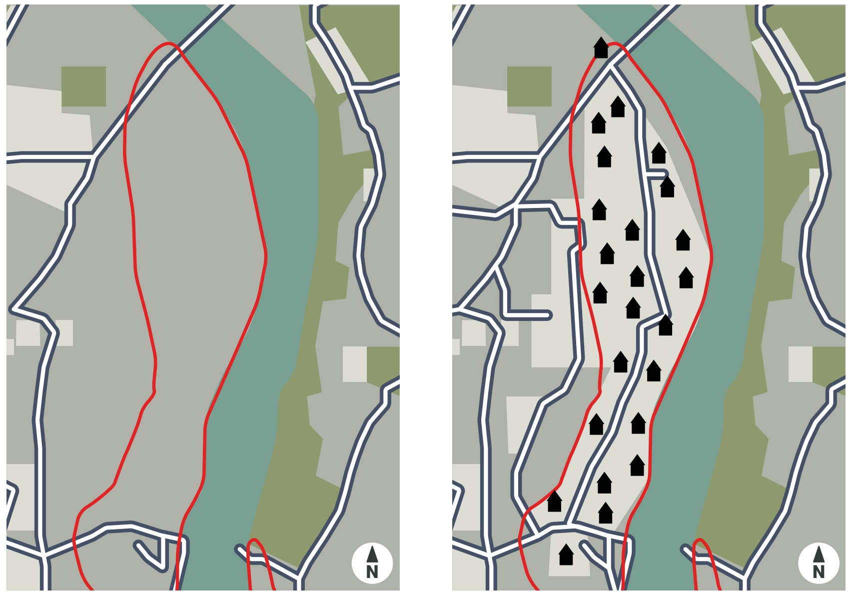


Figure 2.10
Redrawn maps by Sabine Plog.
***Left*: Seuti Khola River, Dharan Nepal in 2004;**
***Right*: Seuti Khola River, Dharan Nepal in 2009.**
© Sudmeier-Rieux 2009

Figure 2.11 compares the exposure of the population in different categories of countries from 1980 to 2010. It differentiates between low-income, lower-middle-income, upper-middle-income and OECD countries worldwide. We clearly observe that people in low-income countries are the most exposed with an almost linear increase from 1980 to 2010 and a total increase of 250% since the baseline year 1970. In contrast, people in OECD countries are the less exposed with a flattening growth.

The most at risk to disasters due to exposure and vulnerability are the tropics and subtropics (**Figure 2.12**).

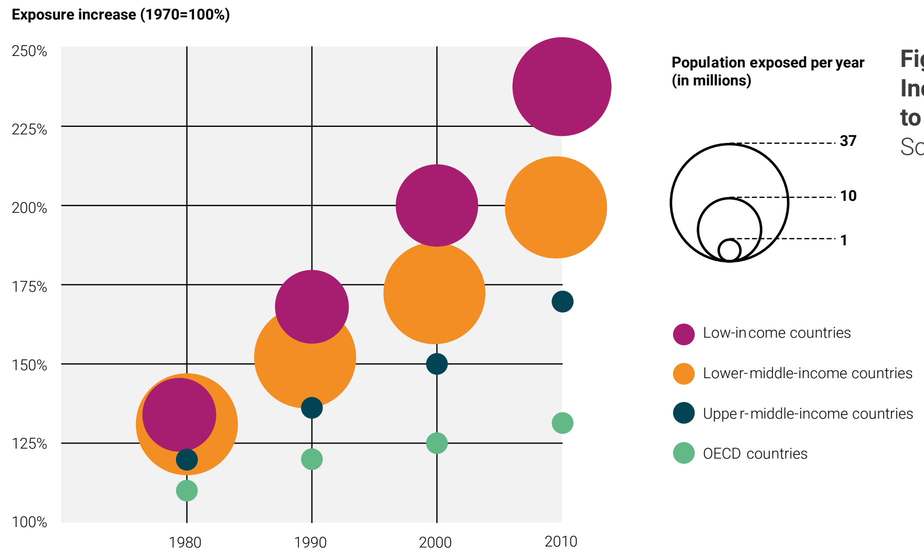


Figure 2.11:
Increase of exposure of populations to hazard events from 1980 to 2010.
Source: UNISDR 2011

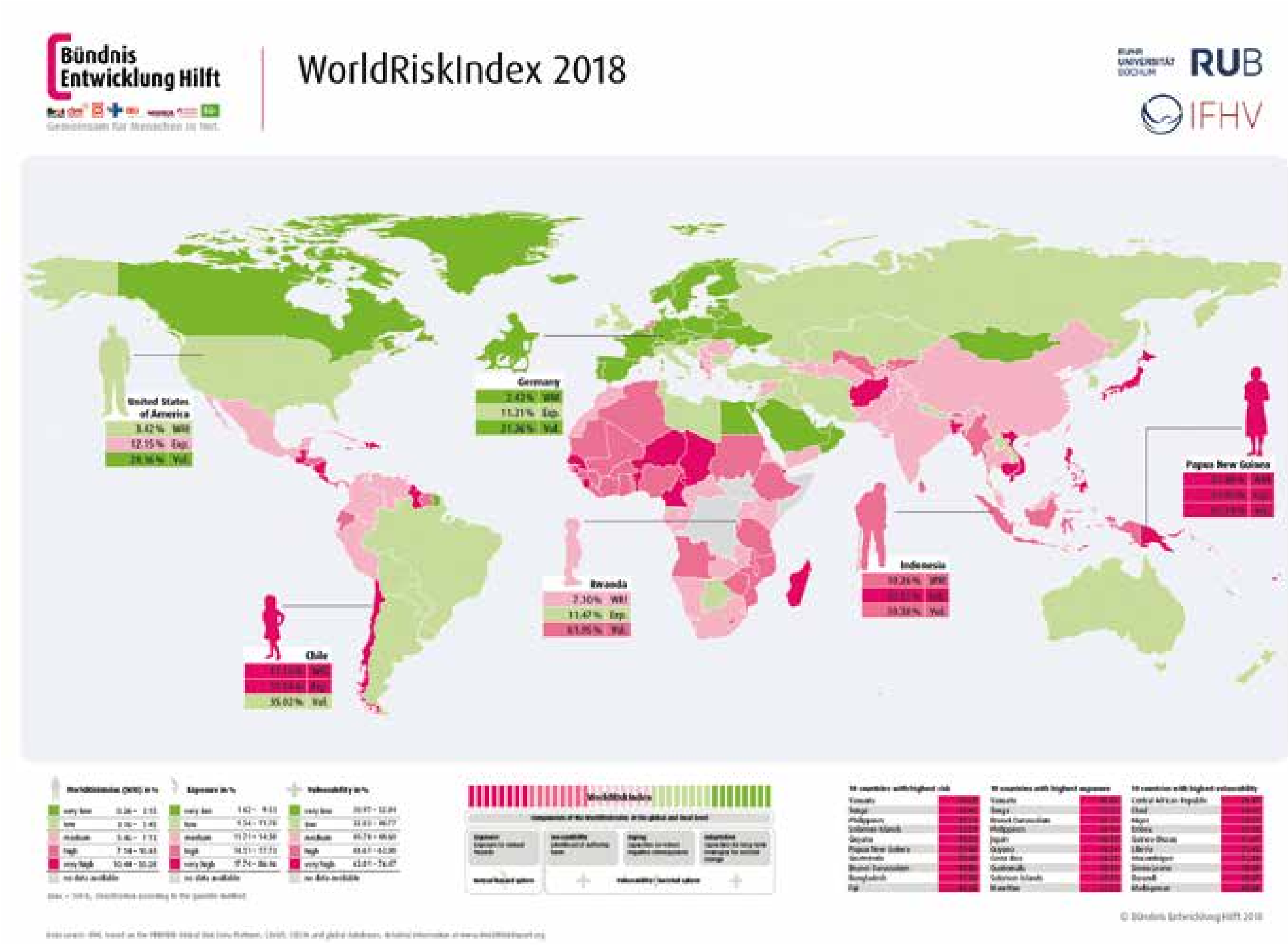


Figure 2.12
World risk index 2018.
Credit: 2019 Münchener Rückversicherungs-Gesellschaft, NatCatSERVICE

Climate change

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased".

IPCC 2013, SPM-3

CLIMATE CHANGE AND DISASTER RISK

The Special Report on Extreme Events (SREX) of the IPCC (IPCC 2012) was quite nuanced in its findings linking climate change with extreme weather events and disaster occurrence. It presented its findings in terms of various degrees of agreement and evidence among scientists as confidence levels (**Table 2.1**).

There is evidence from observations gathered since 1950 of change in some extreme hazard events. Confidence in observed changes in extremes depends on the quality and quantity of data and the availability of studies analyzing these data, which vary across regions and for different extremes. Assigning «low» confidence in observed changes in a specific extreme on regional or global scales neither implies nor excludes the possibility of changes in extremes. Extreme events are rare/infrequent, which means there are few data available to make assessments regarding changes in their frequency and intensity (IPCC 2012). Climate change impacts in terms of extreme events vary according to the type of hazard and across geographical locations.

PHENOMENA	CONFIDENCE LEVELS
Models project ***substantial warming in temperature extremes*** by the end of the 21st century	***Virtually certain*** that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century. ***Very likely*** that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas.
Frequency of ***heavy precipitation*** or proportion of total rainfall from heavy falls	***Likely*** to increase in many areas of the globe. Particularly the case in the high latitudes and tropical regions, and in winter in the northern mid-latitudes.
Average ***tropical cyclone*** maximum wind speed and global frequency of tropical cyclones	Speed ***likely*** to increase, although increases may not occur in all ocean basins. Global frequency ***likely*** to decrease or be essentially unchanged.
Number of average ***extra tropical cyclones***	***Medium confidence*** of them being reduced as averaged over each hemisphere.
Intensification of ***droughts*** in the 21st century due to reduced precipitation and/or increased evapotranspiration	***Medium confidence*** of them being intensified in some seasons and areas
Occurrence of ***floods***	***Low confidence*** of changes (limited evidence, complexity of regional changes)
Coastal high water levels	***Likely*** to increase (mean sea level rise)
High mountain phenomena such as ***slope instabilities, movements of mass, and glacial lake outburst floods***	***High confidence*** to increase due to changes in heat waves, glacial retreat, and/or permafrost degradation
Impact on ***large-scale patterns of natural climate variability*** (monsoons, ENSO)	***Low confidence*** of changes

Table 2.1
Hazards caused by climate change impacts and the confidence levels attributed to each.
(Modified from IPCC 2012)

The IPCC Fifth Assessment Report (AR5) 2013-2014 compiles the current state of scientific knowledge relevant to climate change. It is comprised of Working Group (WG) reports and a Synthesis Report (SYR). The AR5 is divided into:

- WG I: The Physical Science Basis
- WG II: Impacts, Adaptation and Vulnerability
- WG III: Mitigation of Climate Change

The WG I report highlights in great detail the various impacts that climate change is having on the natural spheres (atmosphere, hydrosphere, cryosphere, lithosphere, biosphere), discusses the climate models and the extent to which observed changes are due to human activity.

The WG II report evaluates how patterns of risks and potential benefits are shifting due to climate change. "It considers how impacts and risks related to climate change can be reduced and managed through adaptation and mitigation. The report assesses needs, options, opportunities, constraints, resilience, limits, and other aspects associated with adaptation" (IPCC 2014: 3).

The main findings of WG II are summarised below:

- In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans.
- In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (*medium confidence*).
- Many terrestrial, freshwater, and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances, and species interactions in response to ongoing climate change (*high confidence*).
- Based on many studies covering a wide range of regions and crops, negative impacts of climate change on crop yields have been more common than positive impacts (*high confidence*).
- At present the world-wide burden of human ill-health from climate change is relatively small compared with effects of other stressors and is not well quantified.
- Differences in vulnerability and exposure arise from non-climatic factors and from multidimensional inequalities often produced by uneven development processes (*very high confidence*). These differences shape differential risks from climate change.
- Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (*very high confidence*).
- Climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty (*high confidence*).
- Violent conflict increases vulnerability to climate change (*medium evidence, high agreement*).

(IPCC 2014)

The IPCC 6th Assessment Report is currently underway and is due in 2021.

2.2 Disaster risk reduction

Disaster risk has become shorthand for the risk of a disaster occurring. It refers to the potential disaster losses – in lives, assets, livelihoods, etc. – which could occur to a particular community or society over some specified future time period. The term disaster risk is used to distinguish from other types of risk, such as financial risk. Risk refers to the probability of future losses.

Risk is often expressed in terms of three factors (Hazard, Vulnerability and Exposure), which are sometimes represented as an equation:

Risk = Hazard * Vulnerability * Exposure

It is important to distinguish between these three factors as they require different sets of actions and policies in order to reduce disaster risk. This risk formula (and its numerous variations) is used differently depending on the context, whether political or for measuring risk, i.e., developing risk maps for determining dangerous areas for human settlement.

Vulnerability is composed of several components, including physical, social, economic and environmental. Vulnerability is often considered the most difficult component of risk to assess and evaluate because there are many different ways to interpret vulnerability. For example, a geologist may measure vulnerability as the degree of loss of infrastructure due to a landslide, while an economist may measure vulnerability in terms of per capita GDP or household income, and a social scientist may use literacy rates or social status.

A number of things can contribute to increasing risk in each of the risk factors, many of which are related either directly or indirectly to poor environmental management (**Figure 2.13**). Indeed, environmental issues, governance, social factors and lack of awareness or preparedness contribute to creating hazards and increasing exposure and vulnerability.

Addressing these factors is therefore important to reduce disaster risk. As stated earlier, working on exposure gives the most immediate potential to reduce the risk from disasters. Working on hazard and vulnerability reduction are longer term processes that can be more challenging because they span multiple sectors and the organisation of societies.

**DEFINITION:
DISASTER RISK**

"The potential disaster losses – in lives, assets, livelihoods, etc. – which could occur to a particular community or society over some specified future time period"

UNISDR 2009

**DEFINITIONS
RISK COMPONENTS**

Hazard
"A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage."

Exposure
"People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses."

Vulnerability
"The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard."

UNISDR 2009

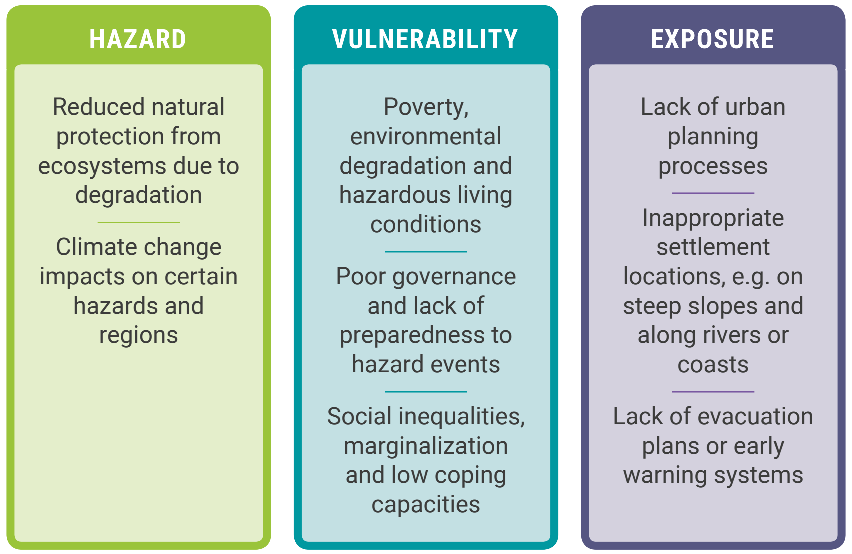


Figure 2.13
Some examples of the factors leading to increased disaster risk for each component of risk.
Source: authors

WOMEN AND DISASTER RISK REDUCTION

As seen earlier, women may be affected differently by disasters. Clearly, when women's vulnerability is reduced, it can have a great impact on DRR. This can be done by addressing the following:

- **Hazards** – In some places, women's roles as stewards of natural resources means they have the potential to reduce environmental degradation and the likelihood of hazards. UN WOMEN (2016) notes that women are "change agents, leaders and innovators. In devising climate responses, including those relating to adaptation and capacity-building, women should not be passive recipients but play an active role in identifying solutions." (UN WOMEN 2016:3)
- **Exposure** – Women can be more exposed than men to certain natural hazards due to their gender specific roles and responsibilities; although sometimes the opposite can be true. Women may be involved and affected differently at each phase of the DRR cycle (**Figure 2.14**) – both in the pre-disaster phase starting from the risk and vulnerability assessment to risk reduction, to disaster preparedness, as well as in the post-disaster phase including relief, early recovery/transition, reconstruction, and development and ongoing risk reduction. Women need to be kept informed about evacuation procedures, early warning systems in order to reduce their and their family's exposure. When empowered, women may also have different influence at each phase of the cycle. This view is echoed by UNDRR in their 2008 report on how gender perspectives can be integrated into DRR (UNISDR 2008). The report notes that "when women are supported to be active participants in preparedness and response efforts, their role within families and communities has been used to great advantage. Women's responsibilities in households, communities, and as stewards of natural resources, position them well to develop strategies for adapting to changing environmental realities." (UNISDR 2008: v)
- **Vulnerability** – As discussed above, gender cuts across poverty and other forms of inequalities and more women than men are considered to be vulnerable. This is due to a host of factors, including socio-cultural norms, economic factors and gender-biased perspectives of policy makers and practitioners. Since there is a demonstrable link between vulnerability and the likelihood of being affected by disasters, it is imperative that DRR measures specifically address gender considerations. Therefore, it is necessary to address gender-based inequalities with a focus on how they intersect with one's class, sexual orientation, ethnicity, minority, disability, and displacement, marital status, among other factors.

EXAMPLES: NON-STRUCTURAL AND STRUCTURAL HYBRID MEASURES

Non-structural measures:

Emergency drills, early warning and monitoring, training search and rescue teams, stocking up on emergency supplies...

Land use planning/zoning to reduce exposure, developing guidelines on what to do during an emergency...

Structural/hybrid measures:

Building seawalls, dykes, dams, and raising houses to avoid flooding...

Ecological engineering by restoring wetlands, forests on slopes...

DISASTER RISK REDUCTION MEASURES

There are several phases to DRR (**Figure 2.14**), and actions are usually divided into two main categories of measures:

1) **Structural measures**, which relate to any physical construction to reduce or avoid possible impacts of hazards;

2) **Non-structural measures**, which relate to knowledge, policies, laws, public awareness raising, training and education for disaster prevention and preparedness.

These measures are implemented at different times of the disaster management cycle. The actors involved in these types of measures range from government agencies to local communities.

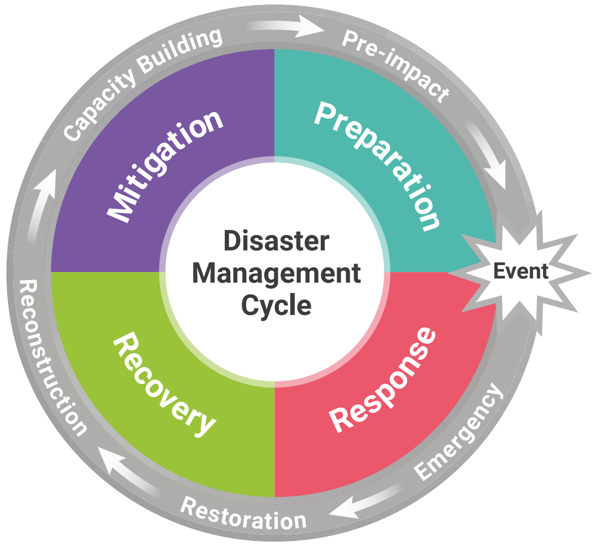


Figure 2.14
Disaster management cycle
Redrawn by L. Monk

The disaster management cycle comprises of four categories (see Chapter 9 for a more in-depth discussion). It typically starts at the event, i.e. as soon as a disaster hits. This is the state of emergency and response needs to be immediate focusing on saving lives. The second phase starts the process of recovery where restoration and reconstruction take place. The third phase is mitigation, decreasing vulnerability and building capacity. Finally, preparation is important so that if there is another disaster, plans are in place to reduce the impact of the disaster. These phases will be revisited in later chapters with an emphasis on prevention by reducing vulnerability.

2.3 Conclusions

Disasters affect a large number of women and men with an unequal distribution worldwide of hazard events and impact and therefore disaster risk. There are different types of disasters and some are more devastating than others, either due to their sudden and wide impact (e.g. earthquakes, storms and tsunamis) or due to their length and difficulty to cope with (e.g. drought) because they impact so many vital systems over time.

Exposure and vulnerability are two key factors that need to be understood. In some cases, disaster risk could more easily be mitigated if people did not settle in exposed areas such as in proximity to flood-prone rivers. Reducing exposure also involves measures such as seawalls or early warning systems and evacuation plans, which reduce exposure at least temporarily. Vulnerability is tied to underlying drivers such as poverty, environmental degradation, governance and preparedness amongst others and requires multidisciplinary interventions to reduce vulnerability. Sustainable development and its goals, such as reducing poverty and increasing and coping capacities, is an important avenue to tackle vulnerability (UNISDR 2015a).

DRR involves working through different phases following and prior to a disaster event to reduce risk and increase preparedness. It includes a wide range of structural and non-structural measures. The phases of disaster risk and the types of measures undertaken will be addressed in further chapters.

Climate change increases disaster risk and is an additional component that needs to be taken into account when working through DRR measures, not only because climate change may increase the frequency of hazards, but also because climate change can potentially impact the sustainability of measures implemented. For example, if temperature conditions change and the current building materials or green infrastructure do not cope with different temperature ranges, these could undermine the DRR measures.

DRR and CCA are undertaken within a policy landscape both at the international and national levels that are important to understand. The next chapter will discuss the policy landscape for both DRR and CCA.

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DATABASE RESOURCES

EM-DAT website: ***www.emdat.be***

DesInventar database website: ***www.desinventar.net***

NatCatService – Munich Re: ***www.munichre.com/en/reinsurance/business/non-life/georisks/natcatservice/default.aspx***

Disaster/climate data

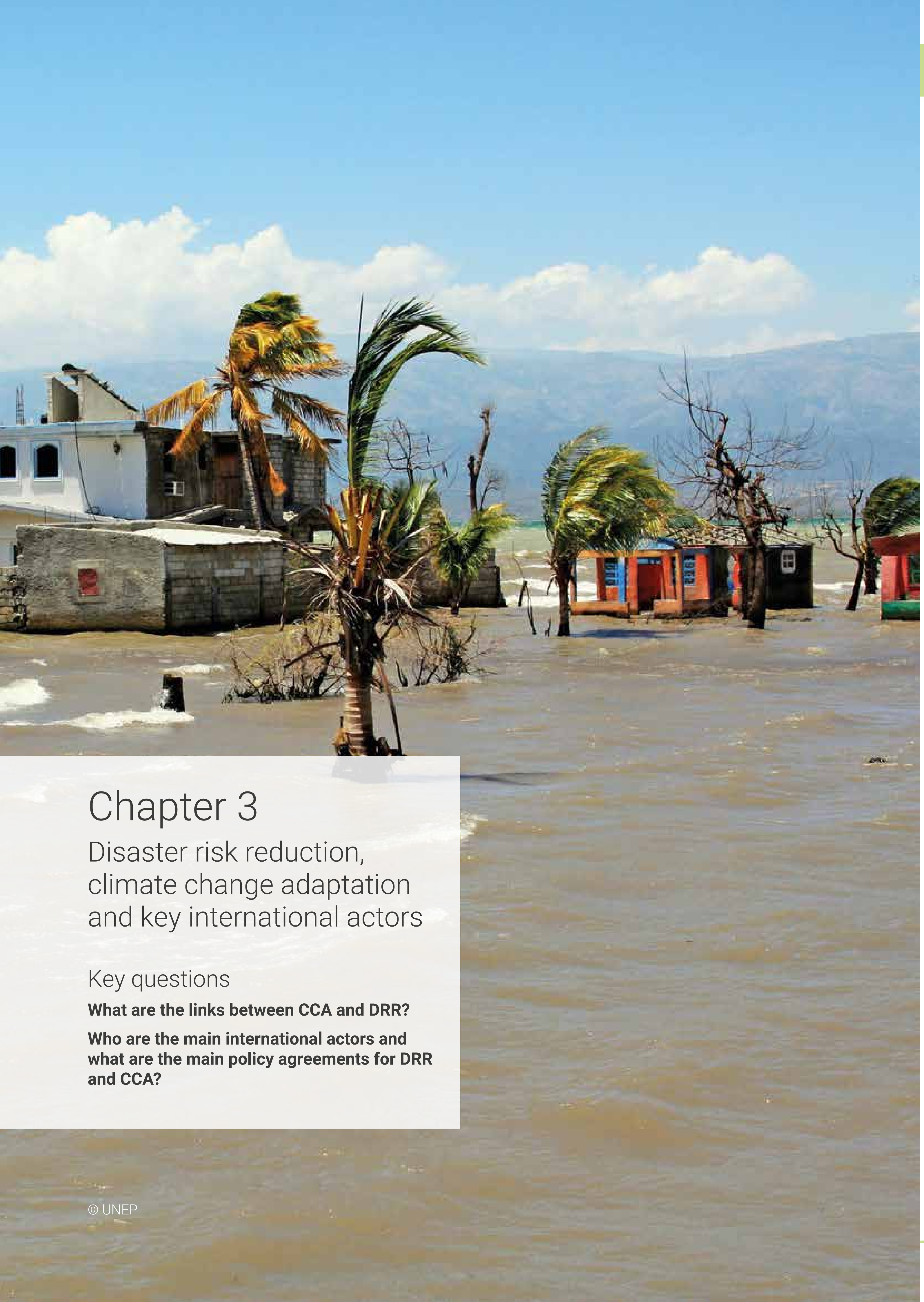
NOAA, USA uses space technology for hurricane and tropical storm predictions: ***www.noaa.gov***

PREVIEW Global data on disasters and risk: ***www.preview.grid.UNEP.ch***

USGS, USA monitors earthquake activity around the work and other geological phenomenon: ***www.usgs.gov***

World Meteorological Organisation: ***www.wmo.int***

IPCC: ***www.ipcc.ch***



Chapter 3

Disaster risk reduction, climate change adaptation and key international actors

Key questions

What are the links between CCA and DRR?

Who are the main international actors and what are the main policy agreements for DRR and CCA?

3.1 Disaster risk reduction, climate change adaptation and international policy

As seen in Chapter 2, the number of disasters and people affected are increasing, largely driven by more people living in exposed areas. However, climate change is accelerating the number of disasters. DRR and CCA are two approaches, with some similar goals and activities but that operate in different policy landscapes. Internationally DRR is the province of UNDRR, while CCA is the province of UNFCCC.

These two spheres, DRR and CCA are separate largely because of the policies and institutions involved in each. However, international agreements relating to both CCA and DRR reference each other, although it is clear that the mandates of each are separate. Despite this, there is some cross-over between CCA and DRR (as well as some differences) which has resulted in calls for and signs of convergence between these two spheres.

In this chapter we will define CCA, look at the similarities and differences between the CCA and DRR, and then provide an overview of the international agreements and actors related to CCA and DRR.

CLIMATE CHANGE ADAPTATION

CCA is defined as "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 2014:118). CCA is based on the notion of vulnerability, which includes the factors of exposure, sensitivity and adaptive capacity, stemming from the 4th IPCC Assessment Report (AR4). As can be seen this representation is different to the DRR configuration of risk. However, the 5th IPCC Assessment Report (AR5), which had input from SREX (IPCC 2012) uses the DRR equation, although it includes within the vulnerability factor, sensitivity and adaptive capacity (**Figure 3.1**). The assessment methodology undertaken for DRR and CCA are therefore sometimes quite different depending on the factors used. We will come back to assessments in a later chapter.

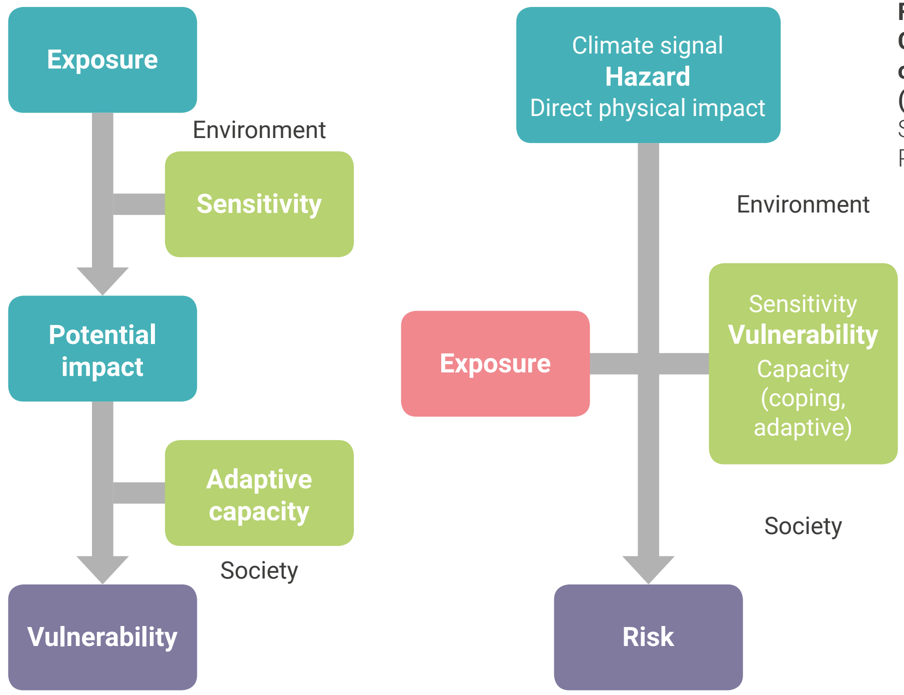


Figure 3.1
Comparison of the components of climate change vulnerability (AR4) and climate risk (AR5).
Source: Adaptationcommunity.net. Redrawn by L. Monk

Aside from terminology and understanding of factors creating risk or vulnerability in DRR and CCA, there are other differences and similarities.

SIMILARITIES AND DIFFERENCES BETWEEN CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION

1. **The type of hazard in focus.** CCA generally focuses on hydro-meteorological hazards; while DRR encompasses different types of hazards.
2. **Timeframes.** CCA generally takes a longer term approach (projecting into the future), incorporating notions of uncertainty, while DRR generally focuses on preventing hazards in the short-to-medium time frame.
3. **The range of activities.** DRR encompasses a wider range of risk management from early warning to response and reconstruction, rehabilitation and recovery. CCA usually covers prevention and mitigation and sometimes also preparedness, while it has less to offer for emergencies, disaster response, recovery and reconstruction. CCA has certainly gone further in modeling and predicting future events, with data that can assist in disaster prevention.
4. **Types of actors and institutions involved.** Although the two domains are very much overlapping, two parallel sets of actors, institutions and agreements have evolved. This will be discussed in more detail later.
5. **Vulnerability definitions.** CCA and DRR have used quite different types of terminology, with vulnerability being one of the terms with most differences. However, there is growing convergence towards DRR terminology.

Table 3.1 provides an overview of the main differences and signs of convergence. According to Mitchell and van Aalst (2008), DRR originates in humanitarian assistance and experience following a disaster event, while CCA originates in scientific theory. The authors enumerate a number of points of differences as well as signs of convergence.

The IPCC AR5 WG II report on Impacts, Adaptation and Vulnerability (2014) highlights the adaptation experiences, adaptation choices, future risks and opportunities for adaptation. The report stresses a number of ecosystem-based approaches, which are already part of CCA, such as coastal zone and water management, environmental protection and land-use planning, integrated water resource management, agro-forestry, community management of natural areas, protected areas management and coastal reforestation of mangroves.

Recommendations for adaptation to future climate change include:

- Reducing vulnerability and exposure to present climate variability by protecting vulnerable groups, by supporting economic diversification, and by providing information, policy and legal frameworks, and financial support.
- Supporting actions with co-benefits for other objectives and providing incentives such as public-private finance partnerships, loans, payments for environmental services, improved resource pricing, charges and subsidies, norms and regulations, and risk sharing and transfer mechanisms.

DIFFERENCES		SIGNS OF CONVERGENCE
DRR	**CCA**	
Relevant to all **hazard** types: geological, hydro-meteorological, climatic, biological, as well as technological/industrial hazards	Addresses climate related **hazards**, but also looks at additional gradual effects of climate change (e.g. sea level rise, air temperature increase, snowmelt, biodiversity loss)	Both focus on increased climate-related hazards, and climate extremes (e.g. floods, storms, landslides, droughts), although DRR is also increasingly addressing gradual climate change impacts e.g. sea level rise
Timeframe: immediate to medium-term. Most concerned with the present, i.e. addressing existing risks	**Timeframe**: long-term. Most concerned with the future, i.e. addressing uncertainty/new risks	DRR is increasingly forward-looking. Existing climate variability is an entry point for CCA
Origin and culture in humanitarian assistance following a disaster event	**Origin and culture** in scientific theory	N/A
Actors: traditionally coming from humanitarian sectors and civil protection	**Actors**: traditionally from the scientific and environmental community	Both DRR and CCA are increasingly multi-disciplinary and reliant on multiple stakeholders across sectors (e.g. engineering, water, agriculture, health, environment, etc.)
Activities generally more wide-ranging, from disaster preparedness (early warning, contingency planning, etc.), prevention, mitigation to post-disaster including disaster response, recovery, rehabilitation and reconstruction	**Activities generally more restricted** to prevention, mitigation, preparedness and building adaptive capacities, typically excluding post-disaster activities	DRR and CCA typically overlap in the area of disaster preparedness and prevention/mitigation, although there is growing attention towards mainstreaming climate change considerations in post-disaster recovery and reconstruction
Full range of established and developed **tools**	Limited range of **tools** under development	Increasing recognition that more adaptation tools are needed and must learn from DRR
Often low to moderate **political interest**	New, emerging agenda, high **political interest**	Climate-related disasters events are now more likely to be analysed and debated with reference to climate change

Table 3.1
Comparison between Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA)
Source: Doswald and Estrella 2015. Modified from Mitchell and van Aalst 2008

- Supporting the co-benefits and synergies between mitigation and adaptation, such as:
  - i) improved energy efficiency and cleaner energy sources, leading to reduced emissions of health-damaging climate-altering air pollutants;
  - ii) reduced energy and water consumption in urban areas through greening cities and recycling water;
  - iii) sustainable agriculture and forestry; and
  - iv) protection of ecosystems for carbon storage and other ecosystem services.

The above suggested CCA solutions seem very similar to solutions put forward for DRR (see previous chapter). So what are the main differences? As discussed above, CCA may refer to longer term impacts, or chronic, slow on-set change requiring human systems to adapt to new contexts over the long term, at the global scale and with considerable uncertainty. DRR impacts are often acute but can result from either extreme events or smaller, cumulative events, which are often underestimated although equally devastating to livelihoods. Although disaster impacts may take years for full recovery, they are often considered short-term as compared to climate change impacts and are usually locally specific because societies will have differing capacities to cope and recover from a hazard event. However, in reality and at the local level there are actually very few differences in addressing CCA versus DRR. Communities are more often not likely to make any distinction, although governments and non-governmental organizations (NGOs) have more often unfortunately divided their mandates and activities related to CCA and DRR. **Figure 3.2**. summarises the main differences and similarities between CCA and DRR.

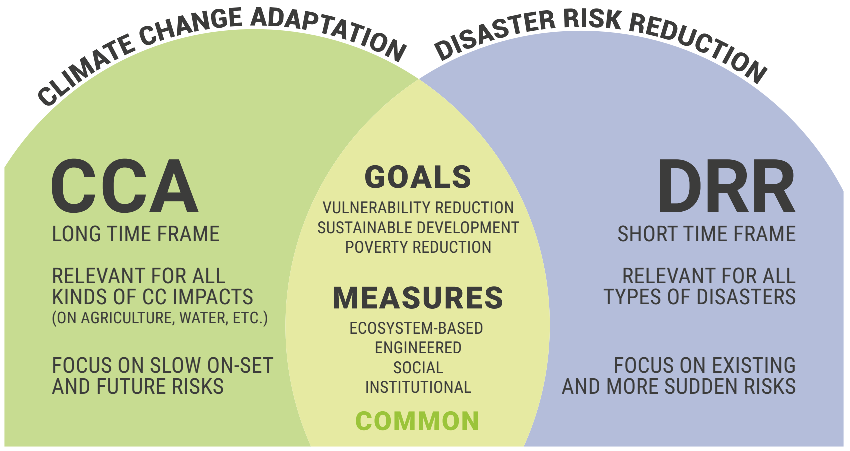


Figure 3.2
A comparison between CCA and DRR in terms of time frames, types of hazards, focus, goals and measures.
Credit: W. Lange and S.Sandholz.
Design: S.Plog

In the following chapters, we will be exploring in more detail how ecosystem-based management approaches (i.e., IWRM, ICZM) address both CCA and DRR, acting as a *de facto* bridge between CCA and DRR; Doswald *et al.* 2017.

3.2 The main international actors and agreements relevant for disaster risk reduction and climate change adaptation

One of the main issues is that the actors coordinating DRR and CCA issues reside within separate agencies with different mandates from different international agreements and are often using different terminology related to DRR and CCA. Fortunately, there has been significant effort to streamline the terminology and improve coordination between agencies (**Table 3.2**).

In the following sections, we list the most important international organisations and agreements that address DRR and CCA. We also list environmental conventions and initiatives that have included CCA and DRR elements, highlighting the importance placed on ecosystems and their management. Although there is still a long road ahead toward mainstreaming environment and ecosystem-based approaches in CCA and DRR, in recent years there has certainly been progress in this direction.

	CCA	DRR
Organisations and institutions	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Office for Disaster Risk Reduction (UNDRR)
	Intergovernmental Panel on Climate Change (IPCC)	Partnership for Environment and Disaster Rsk Reduction (PEDRR)
	The two other Rio Conventions: Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD)	International Federation of Red Cross and Red Crescent Societies (IFRC)
	Academic research institutions	International, national and local civil society organisations
	National environment and energy authorities	National civil defense authorities *(and environment authorities for Eco-DRR)*
	Conservation non-governmental organisations (NGOs)	*Conservation NGOs for Eco-DRR*
International conferences	Conference of the Parties (CoP)	World Conference on Disaster Risk Reduction
Strategies	National communications to the UNFCCC	UN International Strategy for Disaster Risk Reduction (ISDR)
	National Adaptation Plans for Action for Least Developed Countries (NAPAs)	Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR)
	National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs)	Sendai Framework Monitor
Funding	Special Climate Fund	National civil defense/ emergency response
	Least Developed Countries Fund	International humanitarian funding
	Adaptation Fund	Multi-lateral banks
	Green Climate Fund	Bi-lateral aid
	Multi-lateral and Bi-lateral funding	Multi-lateral and Bi-lateral funding

Table 3.2
Main actors, agreements, strategies and funding of CCA and DRR.
Source: Doswald and Estrella 2015

THE SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030 (SFDRR)

The **Hyogo Framework for Action** (HFA) was the key international agreement to reduce disaster risk during the period 2005-2015. It was adopted by 168 governments in 2005 at the United Nations' World Conference on Disaster Reduction, held in Kobe, Hyogo, Japan. Preceded by the International Decade for Natural Disaster Reduction, the United Nations Office for Disaster Risk Reduction (UNDRR) was adopted by the UN General Assembly in 1999, to ensure implementation of the HFA and its renewal. Various UN agencies, the World Bank as well as many international NGOs and inter-governmental groups are involved in DRR and support governments in the implementation of DRR strategies.

Currently, the **SFDRR** is the major agreement for 2015-2030. It is the follow-up to the HFA and aims to reach targets which the HFA did not accomplish. SFDRR was adopted by 187 UN member states at the Third UN Conference on Disaster Risk Reduction which took place 15 to

SENDAI FRAMEWORK PRIORITIES FOR ACTION

Priority Action 1:
Understanding disaster risk;

Priority Action 2:
Strengthening disaster risk governance to manage disaster risk;

Priority Action 3:
Investing in disaster risk reduction and resilience;

Priority Action 4:
Enhancing disaster preparedness for effective responses and to "Build Back Better" in recovery, rehabilitation and reconstruction.

18 March 2015 in Sendai, Japan. It was the product of three years of stakeholder consultations and inter-governmental negotiations. UNDRR is the main agency which will support the implementation, follow-up, and review of this new framework. The agreement spans until 2030, is voluntary and non-binding, and recognizes states as having the main responsibility in reducing disaster risk. This framework makes the link between environment and DRR clear, and includes ecosystem-based approaches to DRR policy, actions and activities. This focus on environment in the SFDRR is, in part, thanks to the advocacy of the Partnership on Environment and Disaster Risk Reduction (PEDRR).

The SFDRR is guided by the desired outcome of reducing risk as well as economic, physical, social, cultural and environmental losses caused by disasters – from the local to the national level. It has outlined *seven global targets and four priorities* which guide the framework:

- Priority Action 1: Understanding disaster risk;
- Priority Action 2: Strengthening disaster risk governance to manage disaster risk;
- Priority Action 3: Investing in disaster risk reduction and resilience;
- Priority Action 4: Enhancing disaster preparedness for effective responses and to "Build Back Better" in recovery, rehabilitation and reconstruction.

The SFDRR identifies poor land management, unsustainable use of natural resources and degrading ecosystems as underlying risk drivers that need to be tackled. Furthermore, reference is made to the inclusion of ecosystems in risk assessments (Priority 1), risk governance and planning (Priority 2) and investing in resilience (Priority 3). Environment will thus underpin achievement of outcomes across the SFDRR seven global targets.

The SFDRR mentions climate change and adaptation within the agreement. However, it amends its involvement by stating "The climate change issues mentioned in this Framework remain within the mandate of the UNFCCC under the competences of the Parties to the Convention".

The **Sendai Framework Monitor (SFM)** comprises of a set of 38 indicators over seven targets, which were recommended by an Open-ended Intergovernmental Expert Working Group and will track progress in implementing the seven targets of the SFDRR as well as its related dimensions reflected in the Sustainable Development Goals (SDGs) 1, 11 and 13.

What is PEDRR?

"Formally established in 2008, the Partnership for Environment and Disaster Risk Reduction (PEDRR) is a global alliance of UN agencies, NGOs and specialist institutes. As a **global thematic platform of the International Strategy for Disaster Risk Reduction (ISDR)**, PEDRR 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 SFDRR**. It provides technical and science-based expertise and applies best practices in ecosystems-based DRR approaches. PEDRR is guided by its vision of **"Resilient communities as a result of improved ecosystem management for disaster risk reduction (DRR) and climate change adaptation (CCA)"**. Its objective is to pool expertise and advocate for policy change and best practice in ecosystem management for DRR and CCA, based on science and practitioners' experiences."

See: **http://pedrr.org/**

The seven targets are:

a) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015;

b) Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015;

c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;

d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;

e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;

f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;

g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

Each target has between three and eight indicators for monitoring progress towards the target. At the national level, custom indicators can be created to measure progress towards the four priority areas of the SFDRR. They are based on the priorities of respective countries and will be reflected in the national DRR reports of the countries.

Ecosystems and green infrastructure can be considered in indicators D-4 and C-5 of the SFM (see box). That opportunity is however not a very practical or straightforward one. Custom targets and custom indicators according to countries' needs within the SFM might open up a more intuitive opportunity to report on both ecosystem losses and progress made on Eco-DRR (Sebesvari *et al*. 2019).

UN FRAMEWORK CONVENTION ON CLIMATE CHANGE

In 1992, the world's governments adopted the **UN Framework Convention on Climate Change (UNFCCC)**. Five years later, in December 1997, **the Kyoto Protocol** was adopted. This protocol legally binds developed countries to emission reduction targets. The first commitment period of the Kyoto Protocol was from 2008 to 2012. The second commitment period began in 2013 and will end in 2020. Key international actors in CCA include the IPCC, which is the leading international body for the scientific assessment of climate change. The IPCC was established by United Nations Environment and the World Meteorological Organization (WMO) in 1988 to provide a clear and up-to-date view on the current state of knowledge relevant to climate change and its potential socio-economic and environmental impacts. Adaptation to climate change first appeared in the 2007 report (AR4). The AR5 is an important landmark report for providing scientific evidence and guidance to governments on CCA. The AR6 is due in 2021.

The Sendai Framework Monitor and Green Infrastructure

In the Technical Guidance for Monitoring and Reporting on Progress in Achieving the Global Targets of the SFDRR (UNISDR 2017), green infrastructure is referred to as a category of possibly damaged or destroyed infrastructure.

Green infrastructure is thus relevant to targets C and D. Indeed, the indicators under Target C5 focus on "direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters" and Target D4 on "the number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters", have a footnote, which denotes that "*green infrastructure should be included where relevant*".

Despite this reporting option, countries have not yet considered green infrastructure in their reporting efforts to date. Understanding of green infrastructure and guidance on how to monitor it would be of help to change this situation as well as providing platforms for information sharing and capacity building.

With the Kyoto Protocol's commitment period coming to a close, the **Paris Agreement** was drafted at the 21st Conference of the Parties (COP 21) of the UNFCCC which took place 30 November to 12 December 2015 in Paris, France. The agreement was adopted on December 12th 2015, and was opened for signature in New York on the 22nd of April 2016 (which, symbolically, is also Earth Day). This agreement is a consensus between 195 countries on the need to reduce global greenhouse gas emissions. The Paris Agreement entered into force on 4 November 2016.

The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs) and to strengthen these efforts in the years ahead. NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

Some of the key elements of the agreement include: a goal to keep global warming "well below 2 degrees Celsius" and to strengthen the ability to deal with the impacts of climate change, which includes provisions for developed nations to support developing nations in adapting to climate change through climate financing; and a focus on loss and damages (UNFCCC 2015).

The Paris Agreement has implications for DRR and the environment, but it does not directly mention DRR or the SFDRR. Article 8 of the Paris Agreement asks parties to "recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage" and appoints the Warsaw International Mechanism to promote implementation of approaches to address loss and damage, including giving guidance on early warning, preparedness and risk assessment and management (UNFCCC 2015). The Warsaw International Mechanism was established at the 19th COP in Warsaw in November 2013.

OTHER RELATED AGREEMENTS AND INITIATIVES

- Also related to DRR and CCA is the **UN Convention to Combat Desertification (UNCCD)**, which entered into force in 1996 with the goal to mitigate desertification and the effects of drought and drought risk through long-term strategies.

  The new **UNCCD 2018-2030 Strategic Framework** is the most comprehensive global commitment to achieve Land Degradation Neutrality (LDN) in order to restore the productivity of vast expanses of degraded land, improve the livelihoods of more than 1.3 billion people, and reduce the impacts of drought on vulnerable populations.
- **The Convention on Biological Diversity (CBD)** entered in to force in 1993 and has three main objectives: 1) the conservation of biological diversity, 2) the sustainable use of the components of biological diversity, and 3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

  In 2010, at the 10th COP to the CBD, Parties adopted a decision linking biodiversity and ecosystems to climate change adaptation and disaster risk reduction (Decision X/33. para. 8). The CBD COP 13, held in Cancun, Mexico upheld Decision X/33 and expanded on ecosystem-based approaches for CCA and DRR in decision XIII/4.

CBD, Conference of the Parties, 2016

"Encourages Parties, other Governments and relevant organizations to integrate ecosystem-based approaches to climate change adaptation and mitigation, and disaster risk reduction, into their strategic planning across sectors"

CBD, Decision XIII/4, para 4

- **The Ramsar Convention on Wetlands Protection** adopted the "Resolution on wetlands and disaster risk reduction" at its 12th Meeting of the Conference of the Parties in Punta del Este, Uruguay (from 1 to 9 of June 2015). This resolution clearly relates the way in which we use and manage water resources and wetlands is central to sustainable DRR. It recognises the role of healthy wetlands as natural buffers to hazards such as storm surges – making protection, management, and restoration of wetlands a key ecosystem-based solution to disaster risk.
- DRR and CCA have also been mentioned as part of the **United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes**. This convention is related to DRR and CCA because it aims to protect and sustainably manage cross-border water ecosystems, and in doing so, reduce risk of disasters (such as drought) and facilitate CCA. The convention entered into force in 1996, but an amendment (which went into effect 2013), made this convention a legally-binding framework for transboundary water cooperation.
- **The Sustainable Development Goals (SDGs)** are an important initiative in the global DRR and CCA policy agenda. In the outcome declaration of the 2030 Agenda for Sustainable Development, with the SDGs at its core, the Rio+20 conference called for explicit linkages between DRR, CCA and sustainable development. Of all the above international agreements, it is one of the most influential because it can be considered an umbrella agreement into which many of the above agreements are linked. The SDGs replaced the Millennium Development Goals (MDGs) in 2015 and cover a set of 17 international sustainable development goals, including aspects of DRR and CCA. The SDGs which especially relate to DRR and CCA include: Goal 1: No Poverty; Goal 6: Clean Water and Sanitation; Goal 7: Affordable and Clean Energy; Goal 9: Industry, Innovation and Infrastructure; Goal 11: Sustainable Cities and Communities; Goal 13: Climate Action; Goal 14: Life Bellow Water; and Goal 15: Life on Land.
- Finally, the **International Union for the Conservation of Nature (IUCN)** provides information and implements various projects on DRR and CCA. In 2014, its **World Parks Congress** featured a number of high-level events on the importance of protected areas for DRR and CCA. It generated the "*Promise of Sydney*, to scale up protection, especially in the oceans, and involve all of those who govern and manage the world's protected and conserved areas; to inspire all people to experience the wonder of nature through protected areas; and to invest in nature's solutions to halt biodiversity loss, mitigate and respond to climate change, reduce the risk and impact of disasters, improve food and water security, and promote human health and dignity".

RIO+20

"Rio+20" is the short name for the United Nations Conference on Sustainable Development which took place in Rio de Janeiro, Brazil in June 2012 – twenty years after the landmark 1992 Earth Summit in Rio.

The primary result of the conference was the document "The Future We Want". One of the main outcomes of the Conference was the agreement by member States to launch a process to develop a set of Sustainable Development Goals.

www.un.org/futurewewant

Figure 3.3
Environmental forum in Sudan on women's role in environmental and climate change action

GENDER IN INTERNATIONAL AGREEMENTS AND RELEVANCE FOR DRR AND CCA

The Gender and Development (GAD) approach grew out of the Women in Development (WID) and Women and Development (WAD) moving away from focusing on exclusively on women to the social construction of gender. GAD brings in an analysis of power and the use of the term 'empowerment' which is now seen as a crucial component of successful programs and policies. Empowerment refers to the "processes by which those who have been denied the ability to make choices acquire such an ability. In other words, empowerment entails a process of change" (Kabeer 1999: 2). As such, it does not view addressing gender concerns, as the WID and WAD does, as reallocating economic resources. Instead, gender concerns necessarily involve redistributing power and the current policy climate reflects this in their goals (**Figure 3.3**). With the GAD, gender minorities, such as the LGBTI (lesbian, gay, trans and intersex), can also be taken into account within the policy sphere. However, there is a lack of translation into policies and actions, as one finds more focus on women than other sexual and gender minorities (Gaillard *et al*. 2016).

The current understanding on mainstreaming gender within development is reflected both in the 2030 Agenda for Sustainable Development as well as in the SFDRR. SDG 5 is about achieving gender equality and empowering all women and girls. The SFDRR specifically calls for a gender, age, disability and cultural perspective to be integrated in all policies and practices relating to disaster risk reduction, and to promote leadership of women and youth (United Nations 2015). It has been specifically noted that "Women and their participation are critical to effectively managing disaster risk and designing, resourcing and implementing gender-sensitive disaster risk reduction policies, plans and programmes; and adequate capacity building measures need to be taken to empower women for preparedness as well as to build their capacity to secure alternate means of livelihood in post-disaster situations" (United Nations 2015 :23).

UNCCD and CBD also include mandates on women's rights and gender equality. The UNFCCC originally did not, being focused solely on emission reductions, but since 2001, it has included mandates on gender across multiple decisions and programmes (Aguilar *et al*. 2015). The need for CCA and its impact on women has driven gender issues up the agenda since perhaps the findings from a UN report (United Nations 2009) that "women have high exposure to climate-related risks exacerbated by unequal rights, and that women's empowerment and the reduction of discriminatory practices has been crucial to successful community adaptation and coping capacity". Thus in the UNFCCC, to date, decisions on adaptation have the most robust gender-sensitive language integrated.

The gender dimension of DRR and CCA is thus increasingly recognised in principle but the translation of policies into adequate practices remains scarce.

3.3 Conclusions

Reducing disasters has received broad political consensus from different policy angles, has been guided by its own UN agency, and is not restricted by a legal framework as is climate change mitigation and adaptation (Hannigan 2012). Climate change action, on the other hand, through the UNFCCC and other Multilateral Environmental Agreements is receiving more financial and political attention. Convergence between DRR and CCA is occurring although it is not embraced by all, especially among those DRR academics who consider the adaptation and resilience discourse to be something like a band-aid, rather than addressing main underlying causes of risk, rooted in poverty, poor governance and structural inequalities (Hannigan 2012). According to Pelling (2011), conventional approaches to CCA are too conservative as they rarely embrace the transformational change that DRR academics advocate in order to address underlying risks factors.

Within the climate change community, mitigation remains the priority, but since the Paris Agreement which acknowledged the necessity of adaptation, the emphasis of CCA in international development cooperation is rising. The transformational change discussion is entering CCA from various sources, such as the Green Climate Fund (GCF). The GCF was set up in 2010 as part of the UNFCCC's financial mechanism. The GCF aims to catalyze a flow of climate finance to invest in low-emission and climate-resilient development, driving a paradigm shift in the global response to climate change.

There is a significant amount of overlap between DRR and CCA, especially when it comes to working with weather-related hazards. While CCA may focus more on long-term and slow onset hazards than DRR, the distinction is clearer in the future prospective lens of CCA. However, since the impacts of climate change are being felt now, CCA and DRR could work more hand in hand. However, Doswald and Estrella (2015) conclude that although there is significant overlap between the two fields, there is an artificial division often leading to a "silo approach" and unnecessary division of budgets and actions and ecosystem-based approaches: notably, Eco-DRR/EbA can act as natural bridges to connect the two (Doswald *et al*. 2017). We will learn more about this in following chapters.

KEY INTERNATIONAL AGREEMENTS AND RELEVANT INSTITUTIONS

- Convention on Biological Diversity (**https://www.cbd.int/**)
- Ramsar Convention on Wetlands (**http://www.ramsar.org/**)
- Sendai Framework for Disaster Risk Reduction (**http://www.unisdr.org/we/coordinate/sendai-framework**)
- Sustainable Development Goals (**www.sustainabledevelopment.un.org**)
- United Nations Framework Convention on Climate Change (**www.unfccc.int**) and the Paris Agreement (**https://unfccc.int/sites/default/files/english_paris_agreement.pdf**)
- Intergovernmental Panel on Climate Change (**www.ipcc.ch**)
- United Nations Convention on Combatting Desertification (**http://www.unccd.int**).
- United Nations Office of Disaster Risk Reduction (**www.unisdr.org**)
- International Union for the Conservation of Nature (**www.iucn.org**) and World Park Congress (**www.worldparkscongress.org**).
- United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (**www.unece.org/env/water.html**)

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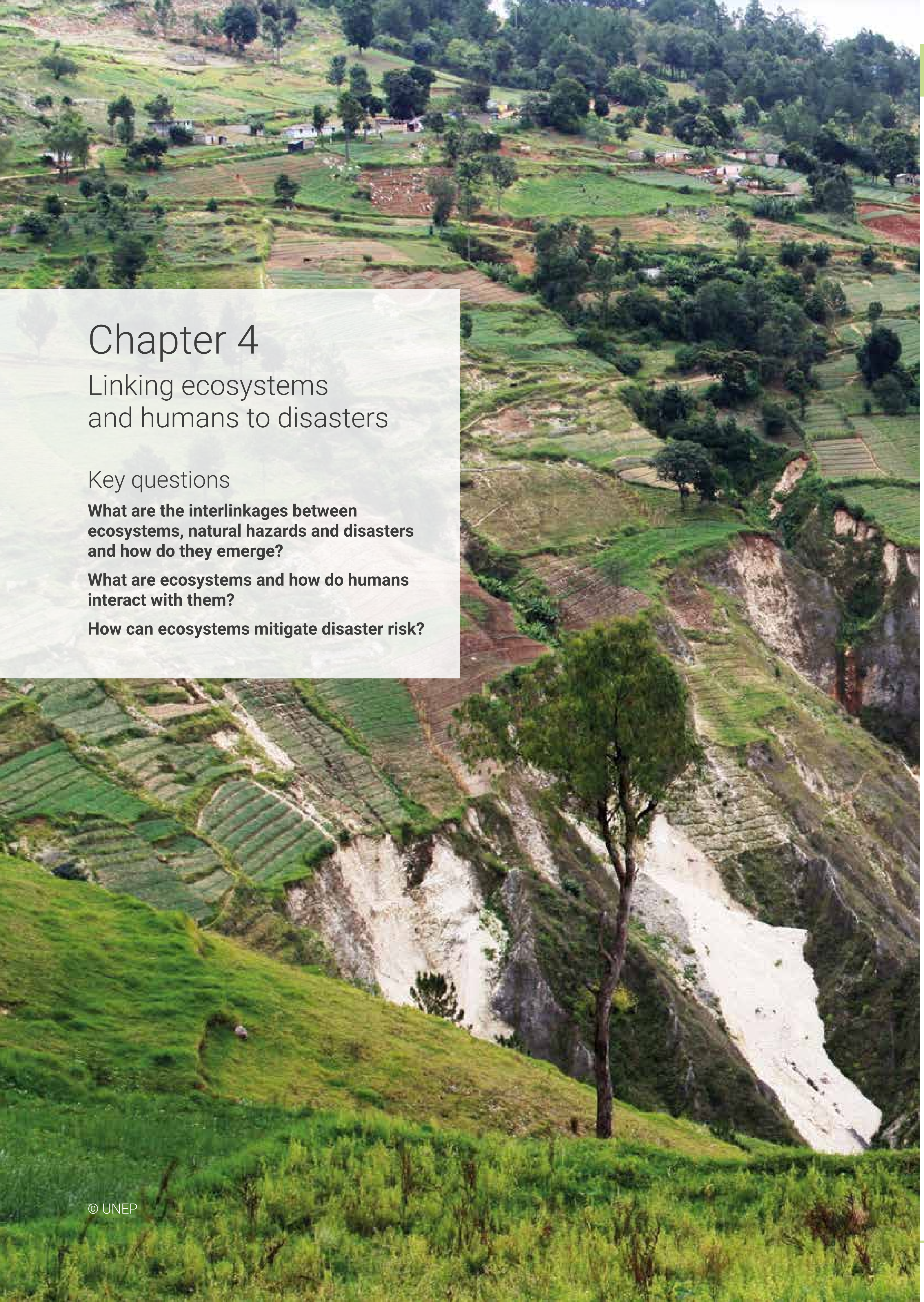


Chapter 4

Linking ecosystems and humans to disasters

Key questions

What are the interlinkages between ecosystems, natural hazards and disasters and how do they emerge?

What are ecosystems and how do humans interact with them?

How can ecosystems mitigate disaster risk?

4.1 The interlinkages between ecosystems, natural hazards and disasters

Ecosystems provide a variety of goods and services upon which people directly or indirectly depend (Christensen *et al*. 1996). The Millennium Ecosystem Assessment (2005) defines four main categories of ecosystem services: supporting (e.g. nutrient cycling, pollination), provisioning (e.g. food, timber), regulating (e.g. erosion control, carbon storage and climate regulation) and cultural services (e.g. recreation, spirituality), that support human well-being (**Figure 4.1**). Hazard mitigation is considered a regulating service, which directly contributes to human well-being by increased disaster security. Thus, healthy ecosystems serve as buffers and provide the basis for the use of provisioning, regulating and cultural services. As we know, during the past decades many efforts have been made to reduce negative impacts on the environment that have led to various global environmental problems. Nevertheless, the Earth system is moving towards an increasingly critical state.

Figure 4.1
Linkages between ecosystem services and human well-being.
Credit: Nehren 2014, modified from MA 2005. Redrawn by S. Plog

In 2009, a group of scientists led by Johan Rockström from the Stockholm Resilience Centre and Will Steffen from the Australian National University constructed a new framework to define a "safe operating space for humanity" (Rockström *et al*. 2009), known as the planetary boundaries concept. The concept is based on nine main Earth system processes: climate change, ocean acidification, stratospheric ozone depletion, biogeochemical cycles (phosphorus and nitrogen), global freshwater use, change in land use, biodiversity loss, atmospheric aerosol loading, and chemical pollution. For each of these processes a threshold is defined, which is called planetary boundary.

According to Rockström *et al*. (2009) "transgressing one or more of these planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems" (Rockström *et al*. 2009:1). In 2009, three of nine planetary boundaries were already overstepped, namely climate change, biodiversity loss, and the nitrogen cycle as part of biogeochemical cycles (phosphorus and nitrogen).

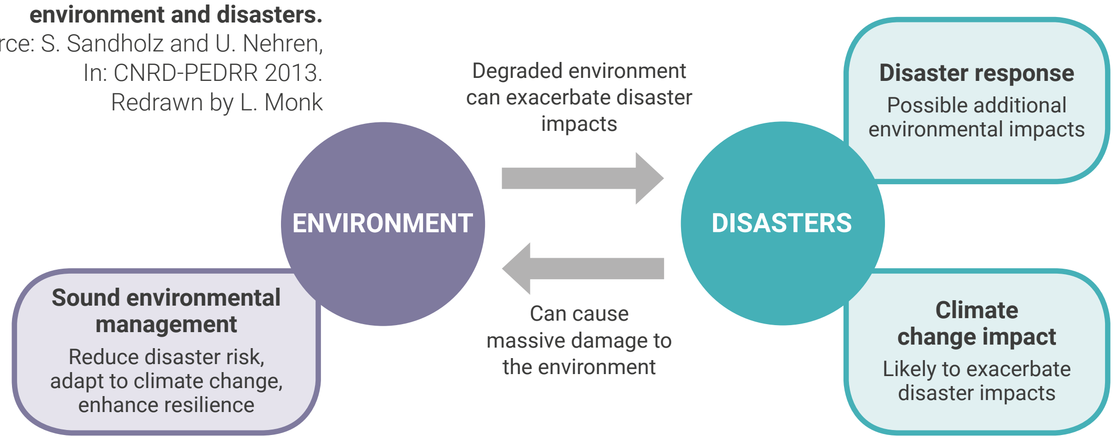
Recently, Steffen *et al*. (2015) presented a new study based on the same processes as in 2009, but with slightly modified names for two of the processes and considering a large number of recent scientific publications. Moreover, regional-level boundaries have now been developed for biosphere integrity (formerly biodiversity loss), biogeochemical flows, land-system change and freshwater use. As a main result, the authors state that in addition to the three boundaries that have already been crossed in 2009, the land-system change boundary has now been overstepped as well. According to the lead author of the study, transgressing a boundary could have nefast consequences on the Earth's state for human well-being.

When we take a closer look to the nine main Earth system processes of the planetary boundaries concept, we see close linkages to the state of ecosystems. It is for instance obvious that ecosystem loss and degradation due to land-system change affect biodiversity integrity and also reduce carbon storage and sequestration.

There are many other interlinkages, which are less obvious, such as those between ecosystems, natural hazards and disasters. The term *natural* hazards indicates that these types of hazards are *natural* occurrences, such as earthquakes, storms, floods, or droughts. However, *natural* does not mean that humans do not have any impact on the frequency and intensity of some of these hazards. SREX (IPCC 2012), for instance, states that climate change has an impact on the frequency and intensity of some types of hazards, such as heat waves, extreme coastal high water levels, and mass movements in high mountain areas. Taking into account that ecosystem loss and degradation significantly contribute to anthropogenic climate change, we see that there is an indirect link between ecosystem loss and degradation and the frequency and intensity of certain types of natural hazards. When people are exposed to these hazards and the hazard overwhelms their capacity to cope with the effects, the hazard can become a disaster.

However, there are also direct interlinkages between ecosystem loss and degradation, natural hazards and disasters (**Figure 4.2**). Environment and disasters interact with each other in a number of ways. Disasters cause massive damage to the environment, while degraded environments exacerbate disaster impacts. Climate change will likely exacerbate disaster impacts and also impacts on the environment in numerous ways (e.g. changes in seasons and changes in habitat suitability of species). Furthermore, responding to disasters often leads to additional environmental impacts, due to emergency procedures and lack of environmental contingency plans. Investments in sound environmental management, especially in disaster prevention and post-disaster recovery stages, can reduce disaster risks and thus contribute to more resilient and sustainable development. Furthermore, environmental management solutions are increasingly being applied for adaptation to climate change because of these interlinkages between society, environment and ecosystem services that can be used to help people adapt.

Figure 4.2
Interlinkages between environment and disasters.
Source: S. Sandholz and U. Nehren, In: CNRD-PEDRR 2013. Redrawn by L. Monk



These different interactions can be illustrated with two coastal ecosystems: coastal dunes and mangroves. Removing sand from coastal dunes for construction purposes or destroying dunes to build settlements and tourism infrastructure can reduce the buffer function against high waves (including tsunamis) and storms (**Figure 4.3**). Settlements and infrastructure located behind the dunes, which were previously protected due to the buffering function of the coastal dune system are now exposed to the impact of wind and waves. This means that conservation and sustainable use of the dune system would have been the appropriate way to reduced disaster risk and adapt to climate change.

Figure 4.3
***Left*: Fore dunes in Chile that serve as buffers and protect from wind and waves. These fore dunes have been partly removed to create space for coastal infrastructure. The new infrastructure will now be directly exposed to storms and waves and even tsunamis that occur along the central Chilean coast.**
***Right*: Destruction of coastal dunes in central Chile.** © U. Nehren

Mangroves are important breeding grounds and nurseries for coral reef fish and other marine animals. But apart from their numerous biological functions, mangroves also buffer against storms and waves and protect from coastal erosion. Destroying them can reduce the natural coastal protection and increase the risk of coastal erosion from cyclones and storm surges. This happened for instance in Java Island, Indonesia (**Figure 4.4**). To counteract further coastal erosion, in some affected areas mangroves have been restored with the support of researchers, NGOs, and the local communities.

Figure 4.4
***Left*: Close to the city of Semarang on the North coast of Central Java, Indonesia, mangroves have been replaced by agricultural systems and settlements, which, in combination with other factors, resulted in increased coastal erosion.**
***Right*: During the last ten years, mangroves have been restored to counteract further coastal erosion and protect the coastal zone.**
© U. Nehren

In summary, ecosystem degradation can directly and indirectly contribute to a natural hazard becoming a disaster. Or, in other words according to the 2012 World Risk Report: "Not all storms and other natural hazards need to turn into disasters" (Alliance Development Works 2012). This is a crucial point which is often not considered in decisions on DRR. Ecosystem conservation, sustainable management and restoration should therefore be taken into account as suitable measures to reduce disaster risk.

Anthropocene

"The Anthropocene is an informal geologic chronological term for the proposed epoch that began when human activities had a significant global impact on the Earth's ecosystems"

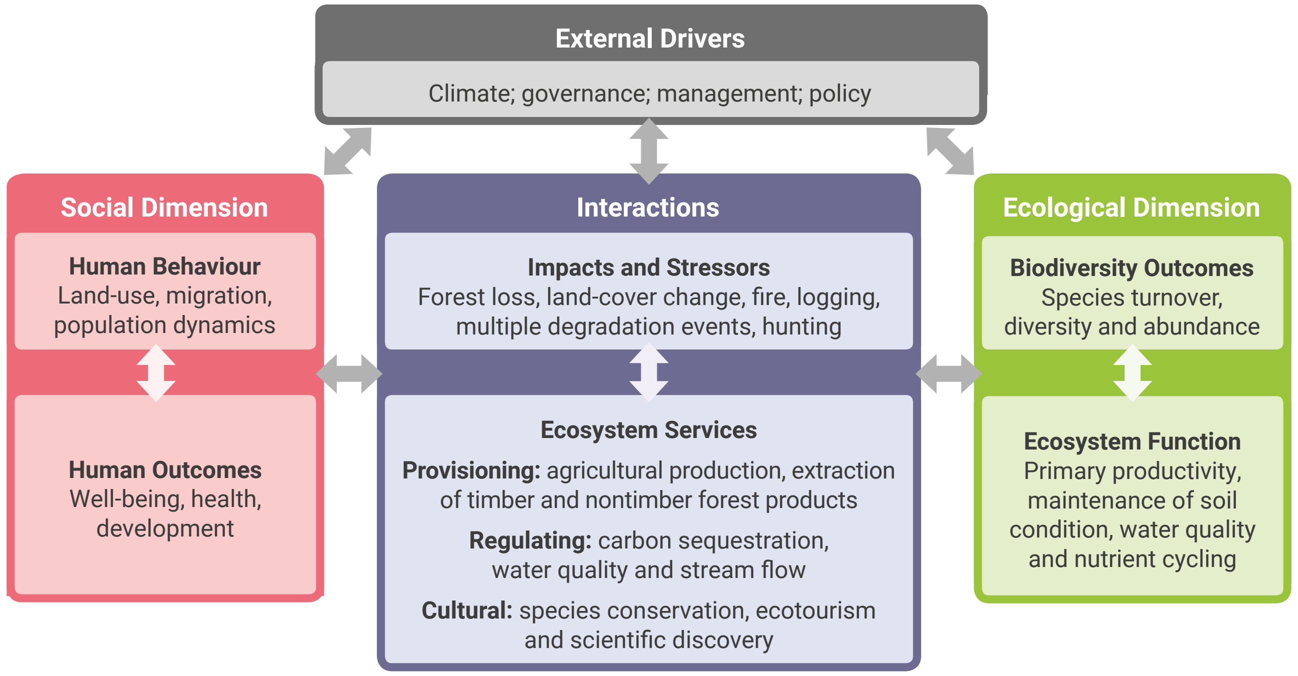
Crutzen and Stoermer 2000

4.2 Socio-ecological systems

The CBD defines an ecosystem as a "dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" (United Nations 1992). There are other definitions of ecosystems, some of which explicitly include humans as part of ecosystems. The term socio-ecological system (SES) is often used and denotes the intertwining of humans and nature into a complex, dynamic and interacting system (**Figure 4.5**). The SES can be defined as (Redman *et al.* 2004):

- A coherent system of biophysical and social factors that regularly interact in a resilient, sustained manner;
- A system that is defined at several spatial, temporal, and organisational scales, which may be hierarchically linked;
- A set of critical resources (natural, socioeconomic, and cultural) whose flow and use is regulated by a combination of ecological and social systems; and
- A perpetually dynamic, complex system with continuous adaptation.

Figure 4.5
Socio-ecological system.
Redrawn and adapted from a generic SES framework presented in Collins *et al.* 2010. Redrawn by L. Monk

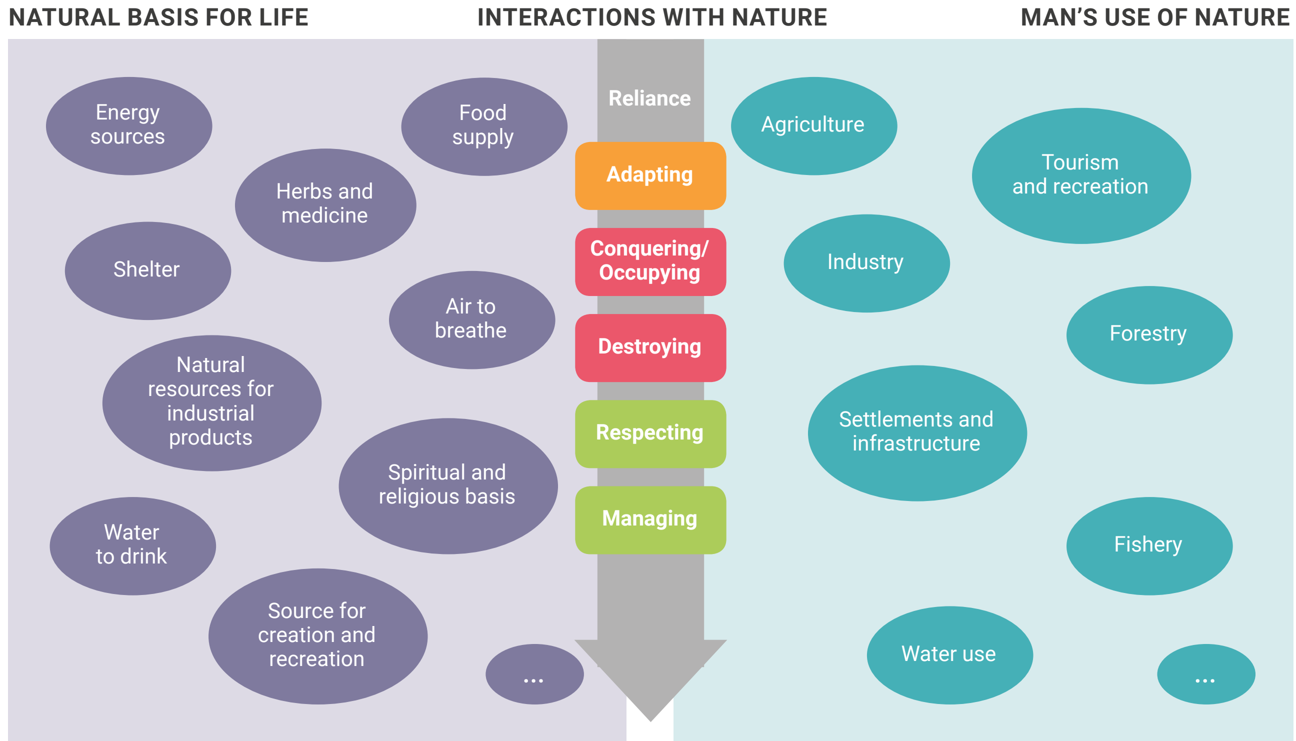


Our interactions through history with the environment have changed dramatically and thus the SES is a different landscape to what it was. Taking a look at these changes is important to understand the current SES. Such a systemic understanding of SES allows for linking human action to ecosystem change. Our impact on ecosystems has become so strong that the meteorologist Paul Crutzen and the ecologist Eugene F. Stoermer suggested to even proclaim a new geological epoch, called the **Anthropocene** (Crutzen and Stoermer 2000).

A proposal was presented to the Stratigraphy Commission of the Geological Society of London, suggesting that from the beginning of the industrial revolution in the late 18th century be taken as the starting point of this new epoch. Since that time carbon emissions to the atmosphere have increased significantly, as have plant and animal extinction rates. This means with respect to the impact on our planet, we became a geological factor. The discussion on the exact definition of the Anthropocene is still ongoing and there are also other suggestions for its delimitation ranging from the Neolithic Revolution around 12,000 years ago to the first nuclear explosion on 16th July 1945 in Alamogordo, New Mexico, United States.

If we take a closer look at human-nature interactions over the course of evolution, we see that these interactions changed dramatically (**Figure 4.6**). While our early ancestors of the genus *Australopithecus* in Africa had to rely on their environment and adapt to the natural conditions, tribes of *Homo habilis* who lived around 2.33 to 1.44 million years ago already developed tools such as choppers and hand axes (Hartwig 2004). Around 400,000 years ago *Homo erectus* then made controlled use of fire (Bowman *et al.* 2009). These inventions can be seen as initial steps for conquering, occupying and partly destroying the natural environment. However, the effects from that time must be seen as rather limited due to low population density and limited geographical expansion. This is what we can also observe when we take a look at the few hunter-gatherer tribes that survived into modern times.

Figure 4.6
Human interaction with nature. We see that nature is the basis for human life and that humans make use of nature in several ways. During human evolution human-nature interactions have changed from purely adapting to respecting and managing nature.
Design: Hoang and Nehren. Redrawn by L. Monk



With the Neolithic Revolution (also called Agricultural Revolution) that started around 12,000 years ago, humans settled down and systematically used the land for agriculture and livestock farming (Barker 2009). This led to a fundamental land cover change in many regions of the world. It was also the trigger for urbanisation and population growth. The next stage of human-nature interaction started with the industrial revolution. It is, among others, characterised by a rapid transition from hand production methods to machines, chemical manufacturing and iron production processes that affected almost all aspects of daily life. According to Lucas (2002), the impact of the Industrial Revolution was such that for the first time in history, the living standards of the masses of ordinary people began to undergo sustained growth. However, the Industrial Revolution was also a major turning point in human-nature interactions because it was accompanied by massive environmental degradation at the global scale.

Today we are experiencing the highest life expectancies and living standards in human history, at least for the majority of the world's population (UNDP 2014). At the same time we are facing severe environmental, social and economic challenges, as already stated almost 50 years ago in the highly regarded report "The Limits to Growth" by the Club of Rome (Meadows *et al*. 1972). More recent publications on global environmental challenges include among others the Millennium Ecosystem Assessment Report (MA 2005), the Fifth Assessment Report of the IPCC (IPCC 2014), the Global Assessment Report 2019 (UNDRR 2019), and the IPBES' Global Assessment Report on Biodiversity and Ecosystem Services (IPBES 2019).

The global challenges for humanity are also addressed in international development agendas, in particular in the Sustainable Development Goals (SDGs). These concepts and international agreements aim at respecting and managing nature to secure human-well-being for future generations under the guiding principle of sustainable development.

4.3 Ecosystems can mitigate disaster risk

As many ecosystems in the world are already highly degraded, we try to conserve, sustainably manage or even restore ecosystems to improve the ecological status of our planet. In so doing we can decrease the vulnerability caused by ecosystem degradation and therefore reduce disaster risk. Furthermore, ecosystems provide important services that are necessary for well-being and can also mitigate certain types of natural hazard.

Indeed, in many cases ecosystem-based approaches can reduce the impact of all three components of the disaster risk equation: exposure, vulnerability and hazard. We consider that healthy ecosystems reduce exposure in certain cases, for example along coastlines where green belts act as natural buffers. Ecosystems also reduce vulnerability because they provide many ecosystem services for supporting livelihoods and human well-being. Last, healthy ecosystems can reduce the impact of hazards by acting as natural buffers. Examples are provided in **Figure 4.7**. **Table 4.1** provides an overview of the hazard mitigation functions of different ecosystems. However, we must also say that not all hazards can be effectively mitigated by ecosystems, which is for instance the case for earthquakes, and that the magnitude of the hazard can be a limiting factor, such as in the case of the 2004 Indian Ocean Tsunami and the 2011 Tohoku earthquake and tsunami in Japan where coastal forests provided only limited protection.

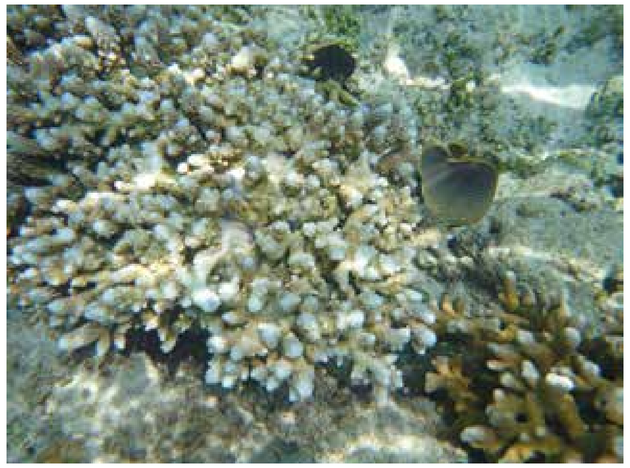
Figure 4.7
Examples of ecosystem types in reducing hazard occurrence.

Mountain forests and **vegetation on hillsides** can reduce the risk of landslides, rock fall, avalanches and soil erosion. Moreover, forests store water and can reduce the runoff after rainfall events. Thereby they can reduce the risk of floods and droughts.

Photo: Mountain forest in Brazil (Atlantic Forest of Rio de Janeiro) © U. Nehren

Wetlands and **riverine ecosystems** are important for flood control as they store water and slowly release it, reducing speed and volume of runoff. Coastal wetlands tidal flats, deltas and estuaries can reduce the height and speed of storm surges and tidal waves.

Photo: Wetland in Nicaragua © U. Nehren



Coastal ecosystems, such as **coral reefs, saltmarshes, mangroves and sand dunes**, can serve as natural buffers against tropical cyclones, storm surges, flooding, other coastal hazards and to some extent tsunamis. Moreover, coastal wetlands buffer against saltwater intrusion and adapt to sea-level rise.

Photo: Corals in Indonesia © S. Sandholz

Dryland ecosystems can reduce the risks of droughts and desertification, as trees, grasses and shrubs conserve soil and retain moisture. Shelterbelts, greenbelts and other types of living fences act as barriers against wind erosion and sand storms.

Photo: Dry forest in Kenya © U. Nehren

Table 4.1
Hazard mitigation functions of different ecosystems (adapted from Estrella and Saalismaa 2013).

ECOSYSTEMS	HAZARD MITIGATION	
Mountain forests, vegetation on hillsides	• Vegetation cover and root structures protect against erosion and increase slope stability by binding soil together, preventing landslides.[1] • Forests protect against rockfall and stabilise snow, reducing the risk of avalanches.[2]	• Catchment forests, especially primary forests, reduce risk of floods by increasing infiltration of rainfall, and delaying peak floodwater flows, except when soils are fully saturated.[3] • Forests in watersheds are important for water recharge and purification, drought mitigation and safeguarding drinking water supply.[4]
Wetlands, floodplains	• Wetlands and floodplains control floods in coastal areas, inland river basins, and mountain areas subject to glacial melt.[5] • Peatlands, wet grasslands and other wetlands store water and release it slowly, reducing the speed and volume of runoff after heavy rainfall or snowmelt in springtime.	• Coastal wetlands, tidal flats, deltas and estuaries reduce the height and speed of storm surges and tidal waves.[6] • Marshes, lakes and floodplains release wet season flows slowly during drought periods.
Coastal (Mangroves, saltmarshes, coral reefs, barrier islands, sand dunes)	• Coastal ecosystems protect against hurricanes, storm surges, flooding and other coastal hazards – a combined protection from coral reefs, seagrass beds, and sand dunes/coastal wetlands/coastal forests is particularly effective.[7] • Coral reefs and coastal wetlands, such as mangroves and saltmarshes, absorb (low-magnitude) wave energy, reduce wave heights and reduce erosion from storms and high tides.[8]	• Coastal wetlands buffer against saltwater intrusion and adapt to (slow) sea-level rise by trapping sediment and organic matter.[9] • Non-porous natural barriers, such as sand dunes (with associated plant communities) and barrier islands, dissipate wave energy and act as barriers against waves, currents, storm surges and tsunamis, depending on the magnitude.i.[10]
Drylands	• Natural vegetation management and restoration in drylands contributes to ameliorate the effects of drought and control desertification, as trees, grasses and shrubs conserve soil and retain moisture. • Shelterbelts, greenbelts and other types of living fences act as barriers against wind erosion and sand storms.	• Maintaining vegetation cover in dryland areas, and agricultural practices, such as use of shadow crops, nutrient enriching plants and vegetation litter, increases resilience to drought.[11] • Prescribed burning and creation of physical firebreaks in dry landscapes reduces fuel loads and the risk of unwanted large-scale fires.

1 Dolidon *et al*. (2009), Peduzzi (2010), Norris *et al*. (2008).
2 Bebi *et al*. (2009), Dorren *et al*. (2004).
3 Krysanova *et al*. (2008).
4 World Bank 2010.
5 Campbell *et al*. (2009).
6 Batker *et al*. (2010), Costanza *et al*. (2008), Ramsar (2010), Zhao (2005).
7 Badola *et al*. (2005), Batker *et al*. (2010), Granek and Ruttenberg (2007).
8 Mazda *et al*. (1997), Möller (2006), Vo-Luong and Massel (2008), Narayan *et al*. (2016).
9 Campbell *et al*. (2009).
10 Intergovernmental Oceanographic Commission (2009), UNEP-WCMC (2006).
11 Campbell *et al*. (2009), Krysanova *et al*. (2008).

4.4 Conclusions

There are indirect and direct linkages between ecosystems and disasters. It is known that ecosystem degradation feeds into disaster risk and interventions within the socio-ecological system can either negatively or positively influence disaster risk. Ecosystem-based approaches can be effective tools in reducing disaster and climate risks and one of the few approaches to reduce all three components of the risk equation: buffering and mitigating hazard impacts, reducing vulnerability by providing ecosystem services to reduce vulnerability and reducing exposure when natural infrastructure is established in highly exposed areas.

However, depending on the magnitude of the hazard there are limitations to how much protection ecosystems can provide, just as there are limitations to engineered structures (Vosse 2008). Exactly how much protection an ecosystem can provide may be locally specific, requiring the expertise of ecologists working together with disaster risk managers and engineers to design risk protective systems that work with nature, rather than against it to the extent possible. Furthermore, ecosystem-based solutions often require a lot of land which may not be available (Doswald and Osti 2011).

Nevertheless, working with ecosystems can reduce disaster risk and help adapt to climate change. Furthermore, they provide a number of benefits stemming from the services they provide. Due to this, ecosystem-based approaches have emerged in both the DRR and CCA community as natural solutions. The following chapter explores Eco-DRR and EbA in more detail and discusses differences and similarities between them.

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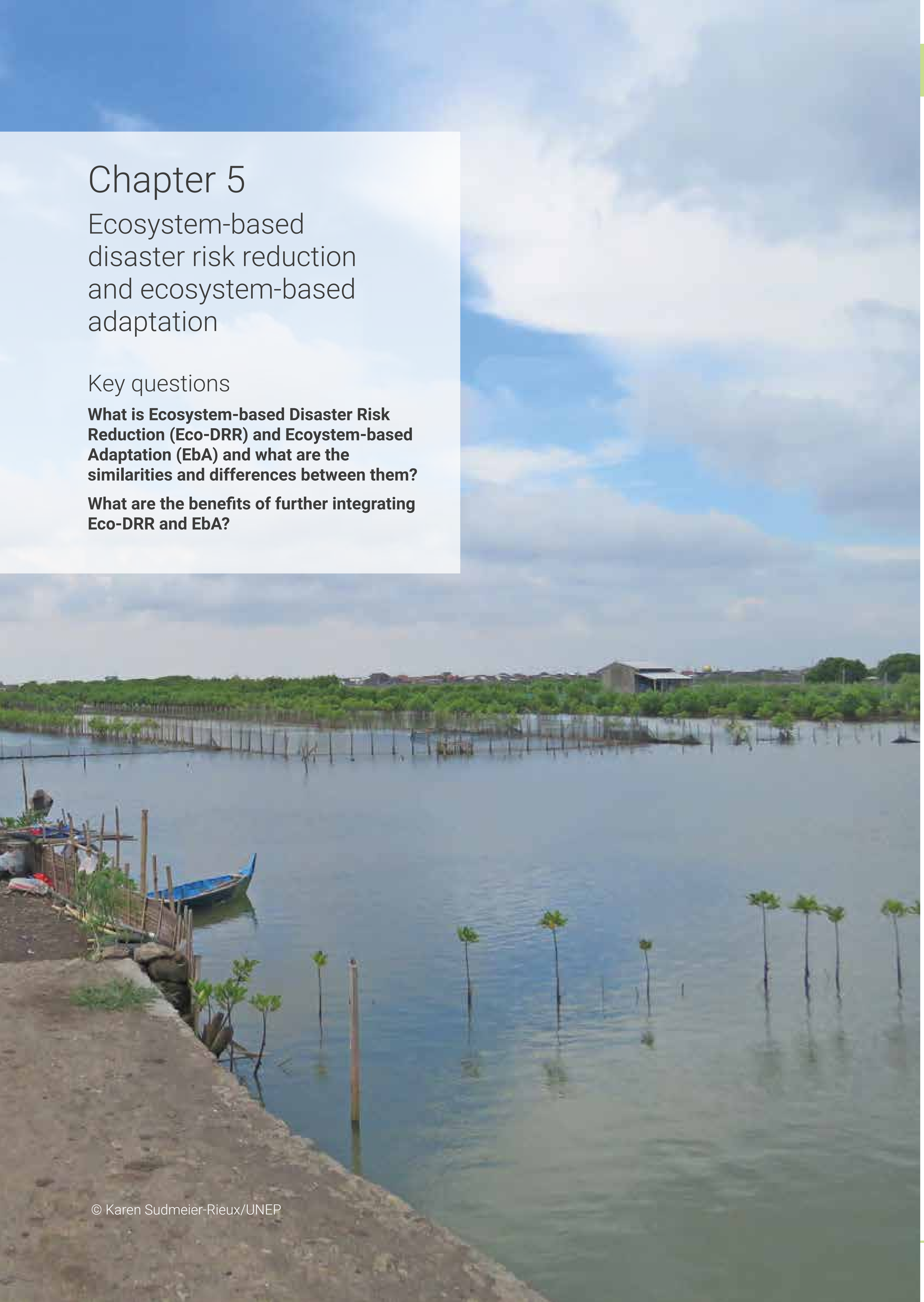

Chapter 5

Ecosystem-based disaster risk reduction and ecosystem-based adaptation

Key questions

What is Ecosystem-based Disaster Risk Reduction (Eco-DRR) and Ecoystem-based Adaptation (EbA) and what are the similarities and differences between them?

What are the benefits of further integrating Eco-DRR and EbA?

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5.1 Ecosystem-based disaster risk reduction

The idea of Eco-DRR is relatively simple. It entails combining natural resources management approaches, or the sustainable management of ecosystems, with DRR methods, such as early warning systems and emergency planning, in order to have more effective disaster prevention, reduce the impact of disasters on people and communities, and support disaster recovery.

Well-managed ecosystems, such as wetlands, forests and coastal systems, act as **natural infrastructure that reduce physical exposure** to many hazards and by **increasing socio-economic resilience** of people and communities by sustaining local livelihoods and providing essential natural resources such as food, water and building materials (Renaud *et al*. 2013, Renaud *et al*. 2016). Ecosystem management also generates a range of other social, economic and environmental benefits for multiple stakeholders, which in turn feed back into reduced risk.

DEFINITION: Eco-DRR

"Ecosystem-based disaster risk reduction (Eco-DRR) is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development".

Estrella and Saalismaa 2013

CASE STUDIES

Switzerland

In Switzerland, protection forests are a main component of its disaster risk reduction program in the Alps in order to protect critical infrastructure from frequent hazards, such as rock fall, avalanches or shallow landslides (**Figure 5.1**). The Swiss government spends over $120 million annually on the management of its protective forests to achieve a balance between young and old trees and a mix of species to keep forests healthy and strong.

The government forest office manages the protection forests even if they are owned privately. In some cases, the local government will even financially compensate private land owners in the case that they have lost income from logging. Local people prefer to have forests for protection because they also provide places for recreation, are more aesthetic and appear less threatening than avalanche barriers or rock nets.

Protection forest planning has a time span of 50-100 years and is based on public willingness to maintain their forests. There are a number of scientific studies, forest management guidelines and cost-benefit analyses that demonstrate that protection forest cost 5-10 times less than structurally engineered structures over time (Wehrli and Dorren 2013).

Figure 5.1
Protection forest, Davos, Switzerland.
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The alternative to maintaining protective forests are engineered solutions, such as avalanche barriers that are frequently found in the Alps, especially in areas where the protection forest have been cut. The past years, however, have seen a shift back to the non-engineered protective measures – wherever possible – because the public often prefers protection forests for the many additional benefits they get as compared to avalanche barriers. However in some cases, it is useful and necessary to have both.

Brazil
One of the worst weather-related disasters in Brazilian history took place in January 2011 in the municipalities of Nova Friburgo, Teresópolis, Petrópolis and São Jose do Vale do Rio Preto in the State of Rio de Janeiro. After a 24 hour rainfall event between the 11th and 12th January, the Santo Antonio River level increased dramatically and many areas around the state reported floods, land and mudslides (**Figure 5.2**). According to the Government of Brazil, more than 900 fatalities were reported, the material damage was above $1.2 billion, more than 345 persons were missing, and in the end more than 35,000 people were left homeless (SBF 2011).

Most of the areas affected by landslides were riverbanks showing some level of human intervention (for example for agricultural or residential purposes). Landslides that occurred in areas covered by natural ecosystems or with well-conserved native vegetation were of lower magnitude when compared with landslides that occurred in disturbed areas. Landslides in terrains covered with native vegetation were always located in the proximity of areas affected by human activities (SBF 2011).

Brazilian governmental authorities, like the Brazilian Ministry for Environment (MMA) and the Government of Rio de Janeiro State, are using the concept of resilient landscapes as the basis to reduce vulnerability and disaster risk and adapt to climate change.

In order to reduce risks of landslides, mudslides and flooding, different measures were implemented by a number of actors: the government of the Rio de Janeiro State, the municipalities and also by the communities. These developments and the implementation of these measures started before the 2011 event but were accelerated after the catastrophe.

Figure 5.2
Brazil landslides in 2011.
© S. Sandholz

In order to restore the areas affected by the landslides and mudslides and to mitigate hazards, the Government of Rio de Janeiro State is mainly investing in structural engineered measures. However, to a certain extent ecosystem-based approaches are considered as well, including slope stabilization measures, river parks and reforestation of riparian areas and the construction of natural channels for water infiltration. However, government reports reference several barriers in implementing DRR measures, some of which are related to institutional coordination, bureaucracy and even corruption (Sandholz *et al*. 2018).

For more detailed information on both the Swiss and Brazil example, as well as other examples from The Netherlands, Guatemala/Mexico, Burkina Faso/Niger and the USA, please refer to the "Eco-DRR Case Study Source Book" (Nehren *et al*. 2014).

DEFINITION:
EbA
"Ecosystem-based Adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change "
CBD 2009

5.2 Ecosystem-based adaptation

EbA has emerged in international climate policy for a as a "new" approach and is "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change" (CBD 2009). The EbA concept stems from a long history of using environmental management to adapt to climatic variations, for example changing planting dates, as well as reducing risks from natural hazards as stated above for Eco-DRR. EbA is currently growing with interest in policy arenas with inclusion in the IPCC AR5 and with the production of catalogues of case studies, research, and development of guidelines and tools (IPCC 2014). A number of institutions have produced criteria and guidelines for EbA (IUCN 2016, FEBA 2017).

CASE STUDIES

Mali
A World Bank funded project "Natural Resources Management in a Changing Climate in Mali" states its aim to expand the adoption of sustainable land and water management practices in targeted communes in Mali. This objective is achieved through the implementation of capacity building, biodiversity conservation and support to poverty reduction activities through an ecosystem-based adaptation approach. It is an integrated approach to conservation, restoration and sustainable management of territories to enable people adapting to climate change, and ultimately increase their resilience (World Bank 2013).

Mountain EbA Programme
The UNEP/UNDP/IUCN "Mountain EbA" projects in Uganda, Peru and Nepal aimed to reduce vulnerability and increase resilience to climate change through EbA (UNDP 2015). Methodologies for assessing the vulnerability to climate change and decision tools for EbA were developed and implemented at the ecosystem level. In pilot sites in each country, EbA measures were implemented contributing towards ecosystem resilience and reduction of livelihood vulnerability in the face of climate change impacts (**Figure 5.3**).

Figure 5.3
The Nor Yauyos-Cochas Landscape Reserve in Peru.
© UNDP

Recent IPCC studies (2012, 2014) have highlighted the importance of ecosystem-based measures as part of necessary adaptation and lists protection of ecosystems as one of several elements providing significant co-benefits and synergies between mitigation and adaptation.

The IPCC (2014) in fact lists some ecosystem-based measures being undertaken around the world, including:

- **"Adaptation planning integrated into coastal and water management, into environmental protection and land planning, and into disaster risk management;**
- **Mainstreaming climate adaptation action into subnational development planning, early warning systems, integrated water resources management, agroforestry, and coastal reforestation of mangroves;**
- **Ecosystem-based adaptation including protected areas, conservation agreements, and community management of natural areas is occurring. Resilient crop varieties, climate forecasts, and integrated water resources management are being adopted within the agricultural sector in some areas".**

(excerpted from IPCC 2014: 8-9)

5.3 Similarities and differences between ecosystem-based disaster risk reduction and ecosystem-based adaptation

While environmental management undertaken to tackle climate variability and climatic hazards is not new and much evidence exists as to the effective use thereof (Doswald *et al*. 2014), many EbA, Eco-DRR and hybrid EBA/Eco-DRR projects are either embryonic or currently underway. Thus, complete information on these is lacking. Therefore, juxtaposing theory with practice will be useful to highlight differences and commonalities between the fields of practice. Understanding the two is important for project development and integration.

In a UNEP discussion paper (Doswald and Estrella 2015), 34 ecosystem-based projects/initiatives were reviewed and analyzed. They were classified into EbA, Eco-DRR and hybrid Eco-DRR/EbA projects to understand how EbA and Eco-DRR projects are undertaken in practice and to find key integration points. The following similarities and differences between EbA and Eco-DRR are drawn from this discussion paper.

OBJECTIVES OF ECOSYSTEM-BASED DISASTER RISK REDUCTION AND ECOSYSTEM-BASED ADAPTATION

EbA and Eco-DRR both aim to achieve their goals using similar measures: sustainable management, conservation and restoration of ecosystems. EbA, however, because of its connection to the CBD (see CBD 2009) perhaps, has more emphasis on ecosystem services and biodiversity than Eco-DRR. Indeed, some EbA projects primarily focus on maintaining and increasing the resilience of biodiversity and ecosystem services as a way to help people adapt.

Eco-DRR projects usually do not have such a focus (at least in the stated aims) to protect biodiversity *per se.* Instead, the focus is on increasing resilience of people or reducing risks from hazards using environmental management or utilizing ecosystem services. UNEP's Eco-DRR project in The Democratic Republic of Congo, for example, aims to strengthen community capacity to maximise the ecosystem service benefits provided by the Lukaya river catchment, including its potential to regulate floods and for water pollution mitigation (UNEP 2016). Proper terrace management is another way of reducing erosion issues and can contribute to Integrated Water Resource Management (IWRM) (**Figure 5.4**).

Figure 5.4
Terracing in DR Congo.
© UNEP

Hybrid EbA/Eco-DRR projects often aim to reduce risk or increase resilience and apply adaptive measures often in broad terms. For example, the Partnership for Resilience's project in Ethiopia aims "to reduce vulnerability of the community to current hazards, but also incorporate measures that help people prepare for the future and adapt to climate change".

However, differences between EbA and Eco-DRR project objectives are not always clear. The difference often depends on the implementing institution. When biodiversity conservation organizations are involved, a more ecosystem-focus is applied. This is not to say that one approach is necessarily right or wrong because ultimately the focus is on helping people to adapt or reduce risk through the use of biodiversity and ecosystems.

In **Figure 5.5**, we give the example of watershed management, which is a way of managing water resources on the scale of a watershed. The main goal is to manage water, whether too much - to prevent flooding, or too little - to prevent the likelihood of future drought. It meets both the goal of CCA and DRR.

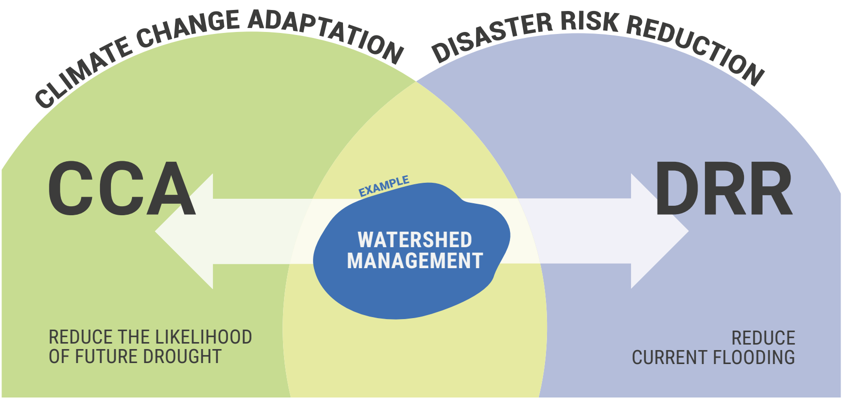

Figure 5.5
Ecosystem-based management approaches, such as watershed management can be used to manage flooding and drought.
© W. Lange and S. Sandholz, redrawn by S. Plog

POLICY AND INSTITUTIONAL CONTEXTS

At the policy level, the importance of including ecosystem management for CCA and DRR is recognized. The UNFCCC's Paris Agreement invites parties to engage in adaptation action, which may include "building resilience of socioeconomic and ecological systems" (UNFCCC 2015), while the SFDRR recognizes environmental degradation as a major contributing factor to disaster risk. Environment will thus underpin achievement of outcomes across the SFDRR's seven global targets (see chapter 3). In parallel to EbA, Eco-DRR is emerging as a field of practice as well as in the policy arena. In Chapter 3, we discussed the various policies where Eco-DRR has been mentioned. These include the SFDRR (2015); the UNFCCC Paris Agreement (2015); a number of SDG targets and several CBD decisions (e.g. decision X/33).

Figure 5.6 illustrates the major international framework agreements passed in 2014 and 2015, which include priorities and decisions on Eco-DRR/EbA.

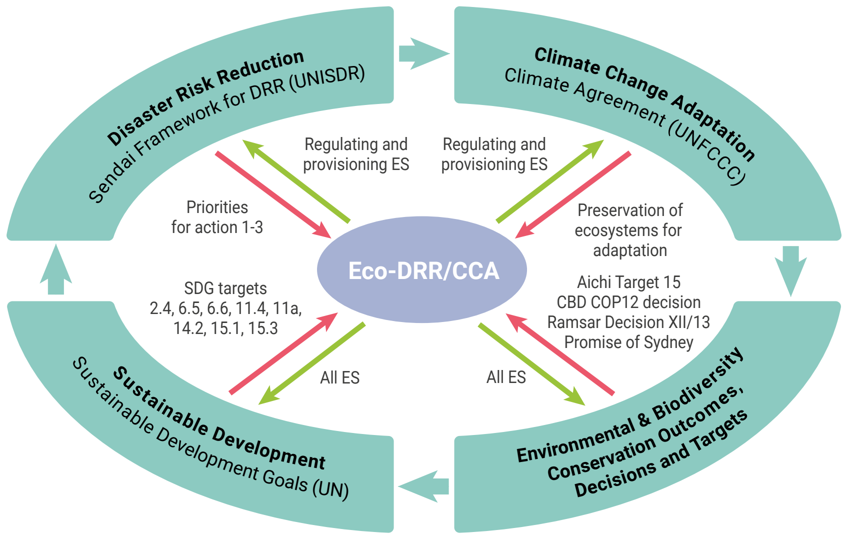

Figure 5.6
Eco-DRR/EbA major priorities and decisions with regards to major international framework agreements. Green arrows illustrate various levels of ecosystem services (ES), red arrows highlight the main provisions of each agreement related to Eco-DRR/EbA. Source: Renaud et al. 2016, Copyright permission granted.
Source: Renaud *et al.* 2016.
Redrawn by L. Monk

Both Eco-DRR and EbA projects almost always involve implementation by environmental agencies or environmental/conservation NGOs, given their clear emphasis on the environment. One special case is the Partnership for Resilience whose Eco-DRR/EbA projects involve working with humanitarian and disaster management organisations, such as the International Federation of Red Cross and Red Crescent Societies (IFRC), Cordaid and CARE.

Eco-DRR and EbA projects would also generally partner with environmental ministries as well as with actors from key development sectors, such as agriculture, water, and urban development. Both recognise the importance of mainstreaming Eco-DRR and EbA into national and local development policies, programmes and plans. Hence, Eco-DRR, EbA and hybrid Eco-DRR/EbA projects all recognize the importance of bringing together and working with different government ministries and other stakeholders, including civil society, universities, and businesses and the private sector.

EbA projects also work within specific policies. For example, in Europe, some EbA projects are undertaken under the EU water framework directive. EbA projects are also working to develop guidelines/policies for land management and population (e.g. CI's EbA project in South Africa and the GEF-funded project in Colombia). An exception is perhaps the case of CI's EbA project in South Africa, which includes EbA as an integral part of the DRR strategy locally and is working nationally to influence policy (Bourne 2013). Aside from the South African example, there is not enough information on the projects to know whether EbA projects generally try to work with national DRR policies.

Eco-DRR projects, on the other hand, aim to work and influence both DRR and environmental policies. The UNEP Eco-DRR project in the Democratic Republic of Congo aimed to work with the Ministry of Social and Humanitarian Affairs to ensure that environment was part of their disaster management framework and strategies (**Figure 5.7**). However, this remains challenging given the marginal roles played by environmental ministries within DRR.

Figure 5.7
Creating national mechanisms to mainstream Eco-DRR, Lukaya, Democratic Republic of Congo.
© H. Partow/UNEP

Just as CCA and DRR overlap, so do EbA and Eco-DRR, and perhaps even more so given their common focus on ecosystem-based approaches. Furthermore, there are "hybrid projects" that integrate CCA and DRR using an ecosystem-based approach. Yet, due to the largely different policy and institutional contexts of CCA and DRR, EbA and Eco-DRR tend to operate in separate silos. Moreover, hybrid projects tend to have either an EbA or Eco-DRR "slant" depending on the experts involved in the project (**Figure 5.8**).

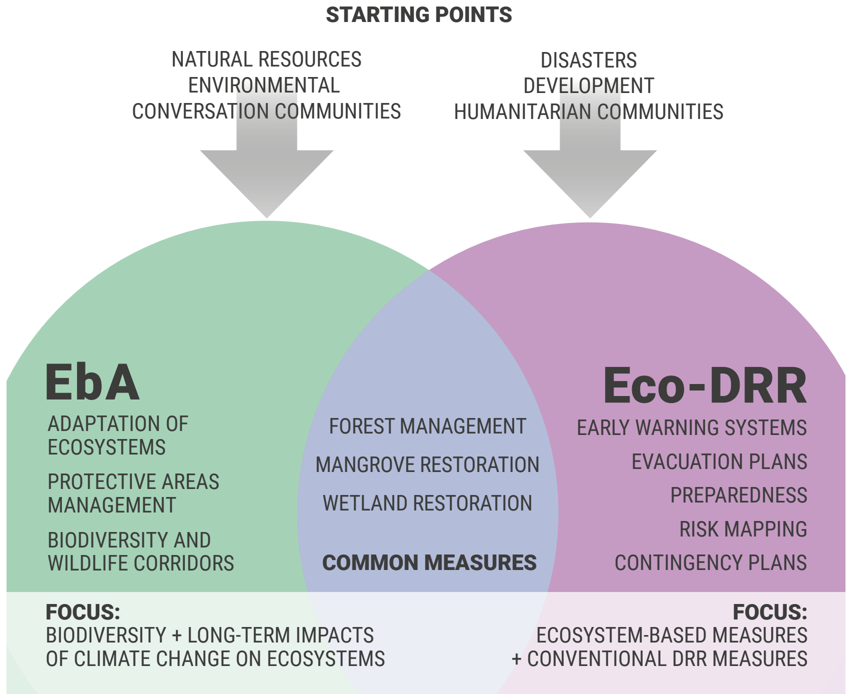

Figure 5.8
Starting points for EbA versus Eco-DRR with a large zone of overlapping common measures.
© S. Sandholz, W. Lange, redrawn by S. Plog

TYPES OF HAZARDS AND ECOSYSTEMS COVERED IN PROJECTS

Droughts, floods, storms, landslides, erosion and fires were the hazards addressed by both EbA and Eco-DRR projects. Eco-DRR also dealt with hazards, such as tsunamis, earthquakes, dust storms and avalanches, while EbA also dealt specifically with sea-level rise and broad (potential) changes to temperature and rainfall patterns. Hybrid Eco-DRR/EbA projects also included glacial lake outburst floods (GLOF) (see **Figures 5.9**).

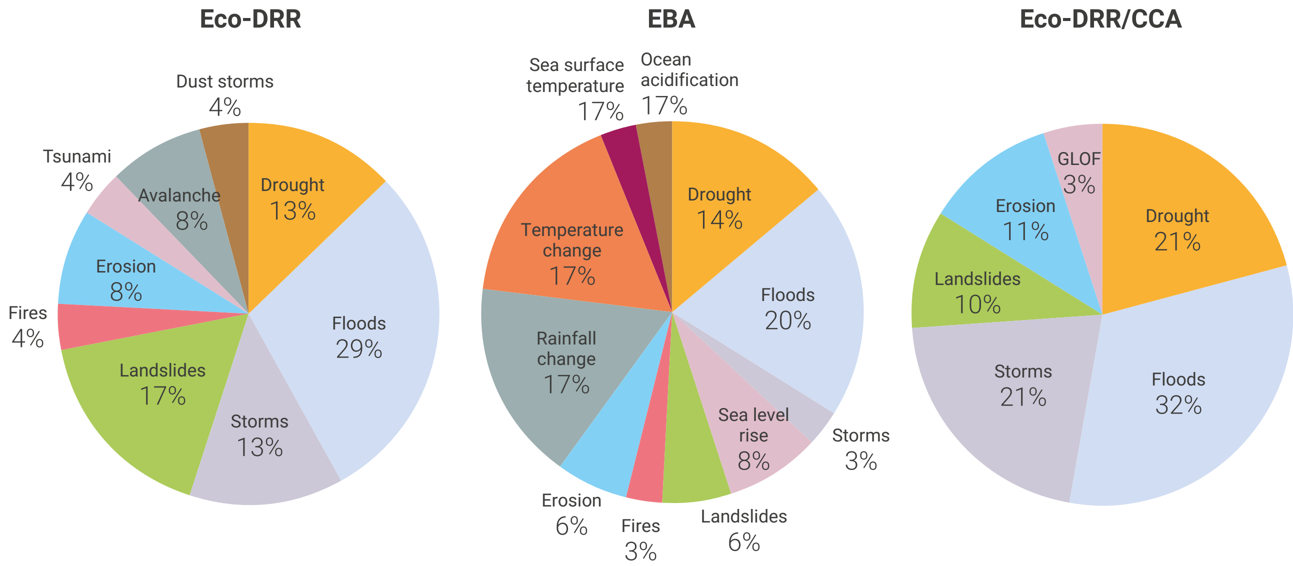

Figure 5.9
EbA, Eco-DRR and Hybrid Eco-DRR/EbA projects and hazard types addressed.
Source: Doswald and Estrella 2015. Redrawn by L. Monk

More differences could be observed in the types of impacts addressed by both approaches. While Eco-DRR mainly addressed impacts in terms of loss of livelihoods, lives, food security, water security and health, EbA also addresses long-term impacts such as biodiversity loss, changes within ecosystems (e.g. coral bleaching and habitat suitability changes) and potential increase in disease/pest outbreaks, alongside issues dealt by Eco-DRR such as livelihoods, food and water security.

Projects equally covered drylands, marine, mountain, forest, inland waters, as well as marine and urban ecosystems. Urban projects tend to label their actions more as adaptation (i.e. EbA[2]) than disaster risk reduction (Eco-DRR). However, this is more likely due to the current political prominence of climate change (Mercer 2010) than a real difference.

TYPES OF ACTIVITIES UNDERTAKEN BY ECOSYSTEM-BASED ADAPTATION AND ECOSYSTEM-BASED DISASTER RISK REDUCTION PROJECTS

Both Eco-DRR and EbA will undertake a risk/vulnerability assessment and decide on what measures to undertake. Vulnerability assessments for EbA will try to incorporate future climate change scenarios/maps to determine future vulnerabilities; however, local climate models are not often finescale enough for detailed planning and therefore general trends on climate will be taken into account. Eco-DRR tends to focus more on past and current hazards in their risk assessments. These are often also taken into account in EbA but the depth of analysis may not always be the same.

EbA projects often address how to restore ecosystems or assist communities to better adapt to changing climate conditions, including protected area management (PAM), or strengthening biodiversity and wildlife corridors. Often the focus may be on biodiversity issues and the long-term impacts of climate change on ecosystems and people. Eco-DRR projects may include typical aspects of DRR: early warning, evacuation plans, etc. in combination with ecosystem-based measures. Common measures include forest management, mangrove restoration, wetland restoration or using an Integrated Water Resource Management (IWRM) approach, which takes into account natural watershed boundaries and a more holistic approach to addressing water and climate issues.

2 The term "ecosystem-based adaptation" is not used by these projects. They mostly refer to CCA in conjunction with green infrastructure or solutions.

5.4 The benefits of integrating ecosystem-based disaster risk reduction and ecosystem-based adaptation

As we have seen, ecosystems and their services are central, though not primary, to the discussion of CCA and DRR. Indeed, the environment is at the same time the context, the problem and the solution to many hazards facing society. Environmental conditions can either increase or reduce vulnerability and risk to disasters.

As we know, ecosystems are vulnerable to current anthropogenic pressures and are being degraded, as outlined in the Millennium Ecosystem Assessment (MA 2005). The capacity of ecosystems to provide these services may be further undermined by climate change or hazard impacts, as well as by the unsustainable measures undertaken under CCA or DRR.

Strategic management of ecosystems, therefore, is necessary to ensure provision of services that are important to society in the face of climate change and natural hazards. However, it is important to state that solely ecosystem-based solutions may not always be effective and practicable (**Figure 5.10**).

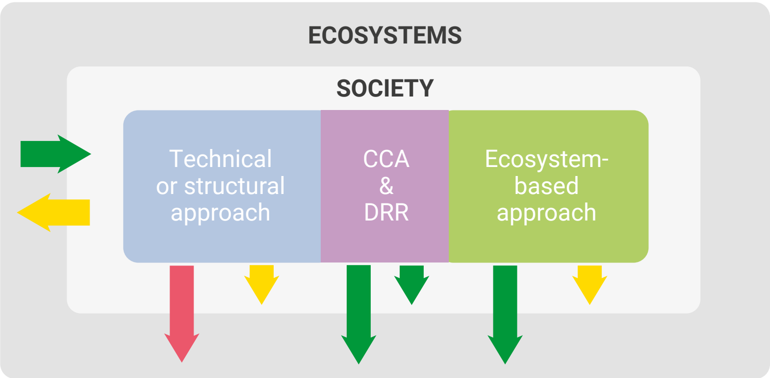

Figure 5.10
The relationship between ecosystems, society and climate change adaptation (CCA) and disaster risk reduction (DRR). The figure shows the impact (in terms of damage and cost versus benefits) on ecosystems and society from different scenarios of planned adaptation strategies: solely technical or structural (blue), solely ecosystem-based (green), and an integrated framework containing both strategies (purple). The green arrows indicate positive impacts; the red arrows negative impacts; and the yellow arrows both positive and negative impacts. The impact on society from the two measures in isolation is positive and negative; negative in this instance is due to cost and feasibility.
Source: Doswald and Estrella 2015. Redrawn by L. Monk

One of the additional arguments to using ecosystem-based approaches within CCA and DRR, aside from their capacity to decrease hazard impacts, is the fact that they provide multiple social, economic and cultural benefits for local communities.

There are numerous case studies and scientific publications that show the benefits of ecosystem-based approaches, especially with respect to CCA (i.e. EbA). Furthermore, studies show that its use is mainstreamed within many sectors (e.g. coastal protection, agriculture and forestry, urban areas) albeit the term EbA is not explicitly used (Doswald and Osti 2011). It is worth pointing out, however, that there is a cross-over in terms of case studies that have been used to advocate for EbA and Eco-DRR (ProAct Network 2008, Doswald and Osti 2011, Renaud *et al*. 2013, Renaud *et al*. 2016). Interest from the international arena is one of the reasons that these case studies have been subsequently "labelled" as EbA rather than Eco-DRR.

In many of the available case studies, there is a focus on ecosystems in relation to addressing climate-related hazards as well as other climate change impacts, such as sea-level rise and salinization in coastal zones. This is so because ecosystem-based approaches are not widely applied for non-climatic hazards, such as earthquakes or volcanic eruptions, although several studies have shown how re-vegetation and forest management can reduce risk of rock falls or landslides triggered by earthquakes (e.g. in the case of protection forests in Switzerland; see Peduzzi 2010).

Figure 5.11
Bamyan Province, Afghanistan.
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There are important opportunities for bringing together different actors and sectors at sub-national or local levels, for instance working with provincial or municipal governments, as illustrated in the case of UNEP's Eco-DRR project in Bamyan Province, Afghanistan (**Figure 5.11**), in the case of PfR's Eco-DRR/EbA project in Orissa, India or in CI's EBA project in South Africa.

Some of the national mechanisms for bringing together different stakeholders around Eco-DRR/EbA issues may include: National Platforms or Committees on Disaster Risk Reduction or Climate Change Adaptation (where they exist and/or are functional), humanitarian clusters, working groups, devolved municipal or local-level adaptation planning committees, etc. The challenge remains in ensuring that such national mechanisms or platforms integrate ecosystem-based considerations in their DRR or CCA agendas.

Despite clear efforts within Eco-DRR, EbA and Eco-DRR/EbA projects to bring together different stakeholders across different sectors, there remains a general tendency to work in parallel but separate tracks at the policy level, depending on whether the project is more oriented towards DRR or CCA. Nonetheless, significant opportunities exist in focusing advocacy efforts towards more integrated Eco-DRR/EbA policies and overcome the policy divide between DRR and climate change communities. In this regard, the role of environmental ministries in government as well as environmental/conservation national NGOs become all the more critical in promoting ecosystem-based approaches to bridge the gap between DRR and CCA. Moreover, national coordination and planning mechanisms for DRR or CCA also provide key entry points for promoting and mainstreaming integrated Eco-DRR/EbA approaches.

While efforts towards collaboration at the national level is crucial, at the local level, the formation of informal/formal groups or networks to either work collaboratively and/or to share knowledge is important not only for the long-term viability of projects but also for increasing resilience to climate change and hazards. Moreover, it has been found that community involvement from the outset in projects is important for their success (e.g. one of the lessons learned from Columbia's integrated national adaptation project).

5.5 Conclusions

We have examined the differences and similarities between Eco-DRR and EbA. While there are key differences in overall approach and implementation especially at the theoretical level, practice shows that often it is a question of differences in discourse than a real difference. Indeed, in many cases one can substitute "risk reduction" by "adaptation" and vice-versa (though not always). This is seen especially at the level of project implementation, where for all intent and purposes EbA and Eco-DRR activities are virtually indistinguishable from one another.

Nevertheless, EbA and Eco-DRR are generally undertaken by very separate communities due to different policy and funding tracks. Hybrid Eco-DRR/EbA projects are emerging as communities converge due to mutual needs for integration. However, hybrid projects tend to be still more recognisable as either Eco-DRR or EbA depending on who is involved in the project as well as factors such as data availability and outcomes sought (i.e. weather-related hazards or extreme events play more of a role than general climatic change).

Reducing disasters has received broad political consensus and is guided by an internationally endorsed global framework on DRR (i.e. SFDRR) but is not restricted by a legal framework, as is the case in CCA (i.e. Paris Agreement) (Hannigan 2012). CCA, on the other hand, receives much more financial and political attention. Convergence between DRR and CCA is occurring although it is not embraced by all, especially among DRR academics who consider the adaptation and resilience discourse to be more like a band-aid solution instead of a real remedy for addressing the main underlying causes of disaster risk that are rooted in poverty, poor governance and structural inequalities (Hannigan 2012). According to Pelling (2011), conventional approaches to CCA are too conservative as they rarely embrace the transformational changes needed to truly reduce underlying vulnerabilities and address climate risks. In a similar context, resilience has also been regarded as a band-aid approach by many (academics and practitioners); nonetheless, wide acceptance of the concept of resilience is providing clear opportunities for DRR and CCA integration.

Synergies between both DRR and CCA communities should be maximized in order to avoid mal-adaptation and/or increase risk, as well as avoid duplication in efforts. The EbA discipline is still growing and could benefit from Eco-DRR knowledge. Potentially, Eco-DRR could help EbA in decision-making in the face of uncertainty of climate change impacts through its focus on reducing disaster risk. EbA in turn could help provide more adaptive management that is sensitive to climatic and environmental changes and thus ensure long-term sustainability of Eco-DRR projects. Given that policy, institutional and funding tracks are likely to stay separate, integration is more likely to be achievable at the project level.

Fostering collaboration at the project level would provide good lessons for future practice and facilitate the integration of CCA and DRR through ecosystem-based approaches. This would then promote the development of much needed integrated multi-level governance tools for CCA and DRR, integrated multi-hazard and climate change assessments, as well as community-based approaches for both strategies. Gaps in knowledge in both communities should be filled through dedicated research and appropriate monitoring and evaluation frameworks that support learning and knowledge.

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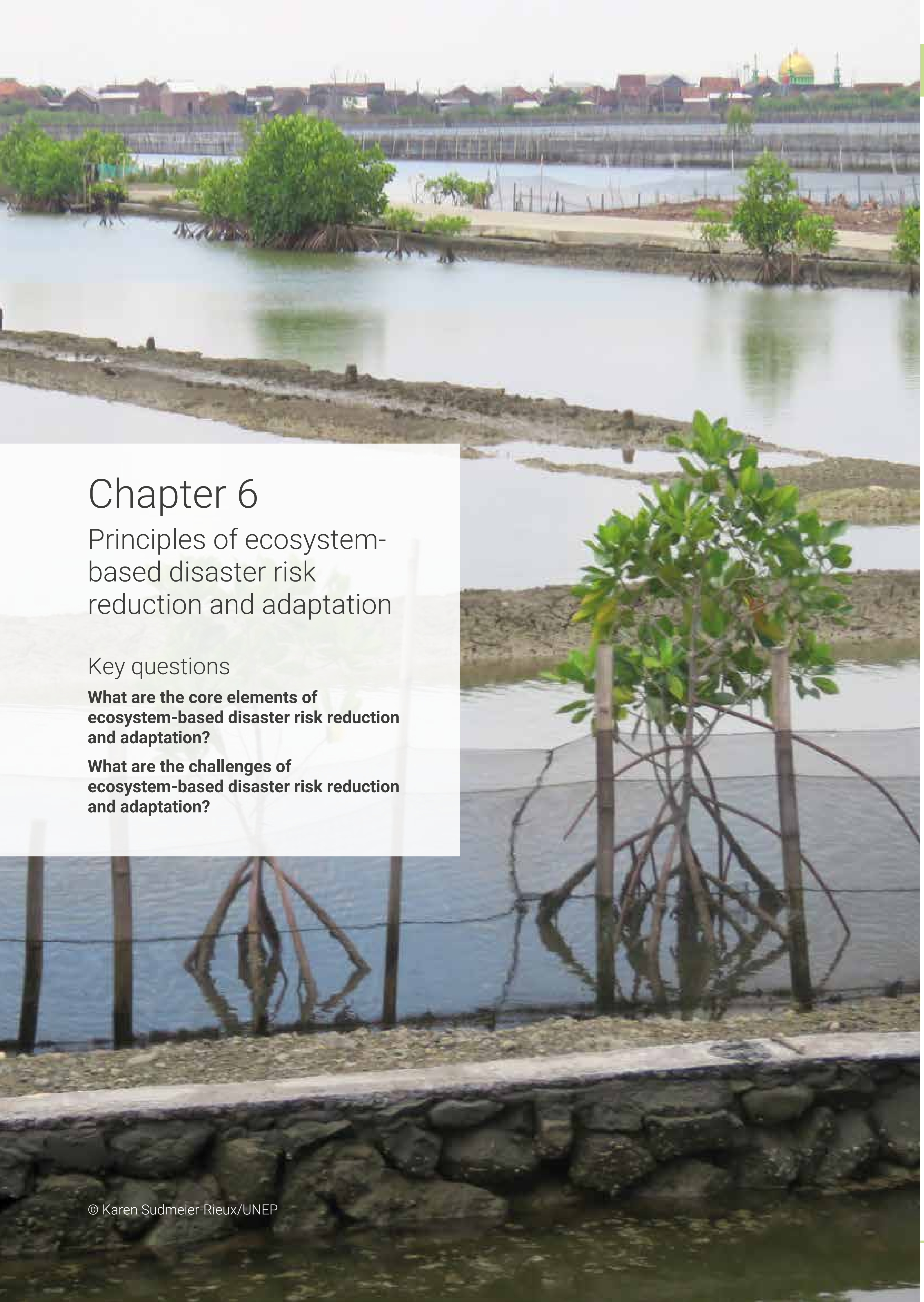

Chapter 6

Principles of ecosystem-based disaster risk reduction and adaptation

Key questions

What are the core elements of ecosystem-based disaster risk reduction and adaptation?

What are the challenges of ecosystem-based disaster risk reduction and adaptation?

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6.1 Ecosystem-based disaster risk reduction and adaptation

As seen in the previous chapter, integrating Eco-DRR and EbA or hybrid projects into DRR and CCA strategies and projects can be very beneficial. It is also possible to mix structural measures, i.e. grey measures, such as dykes, seawalls, etc. with these green measures (Eco-DRR/EbA). Indeed, such green-grey (hybrid) measures are usually very helpful since ecosystem-based approaches may not always be applicable nor enough.

There exists much literature on EbA that has been generated via different organisations such as IUCN, WWF, CI, UNEP, just to name a few. Handbooks, guidelines and guides for various aspects of EbA exist. The *AdaptationCommunity.net* is a useful resource for those interested in EbA. Not as much exists for Eco-DRR and in the following section and chapters the focus will be on Eco-DRR but much can also be applicable for EbA or hybrid projects.

6.2 Core elements of ecosystem-based disaster risk reduction and adaptation

The following principles constitute the core elements of Eco-DRR/EbA and guidance to better the understanding the role of ecosystems in DRR and CCA.

1. **Ecosystems provide multiple functions and services, including protection from hazard events.**
2. **Eco-DRR/EbA is a "no-regrets" strategy.**
3. **Green infrastructure is often more cost-effective over time than grey infrastructure for DRR/CCA.**

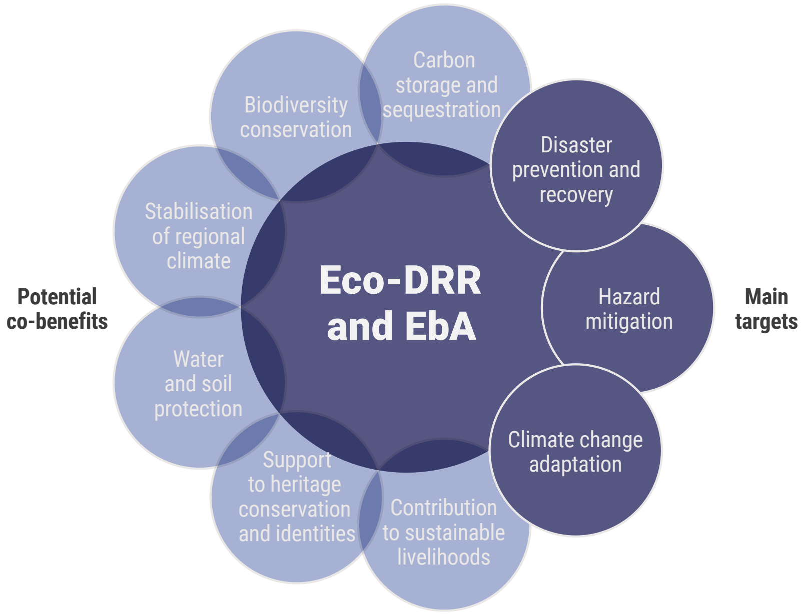
Additionally:

4. **Eco-DRR and EbA is anchored in sustainable livelihoods and development.**
5. **Proper environmental management is critical to addressing the risks associated with climate change and hazard events.**
6. **Integrating environmental approaches into disaster risk management and CCA requires multi-sectoral and multi-disciplinary collaboration, all while involving local stakeholders in decision-making.**
7. **Eco-DRR/EbA has limitations and might have to be combined with other strategies.**

1. ECOSYSTEMS PROVIDE MULTIPLE FUNCTIONS AND SERVICES, INCLUDING PROTECTION FROM HAZARD EVENTS

One of the main components of Eco-DRR/EbA that distinguishes it from structural engineering measures is the multiple benefits ecosystems provide (**Figure 6.1**). In addition to the **main targets of disaster prevention and recovery, hazard mitigation, and CCA, ecosystems contribute to sustainable livelihoods** by providing goods such as clean water, food and fibre. This way ecosystems support poverty reduction in developing countries as they are often the strongest base for livelihoods. Often ecosystems also **support heritage conservation and local identities**, e.g. when attaching spiritial values to mountains, forests or springs (Sandholz 2016). Services related to **water and soil protection** are closely linked to hazard mitigation, as for instance reforestation in upper watersheds reduces the risk of landslides and flooding.

Figure 6.1
Multiple benefits of Eco-DRR/EbA.
U. Nehren 2014, modified from Estrella and Saalisamaa 2013



However, there are several other services such as erosion control, soil fertility maintenance and water purification. Healthy ecosystems also **stabilise the regional climate** and, depending on the type of vegetation, contribute to climate change mitigation by **storing and sequestering carbon** (Lal 2004, Grenier *et al*. 2013). Finally, certain ecosystems can have high **biodiversity** value, providing greater robustness during periods of stress (Thompson *et al*. 2009, Willis *et al*. 2010).

The physical risk reduction capacity of ecosystems depends on their health and structure, and the intensity of the hazard event. Ecosystems can reduce physical exposure to common natural hazards, namely landslides, flooding, avalanches, storm surges, wildfires and droughts, by serving as natural infrastructure, protective barriers or buffers (Renaud *et al*. 2013, 2016) (**Figure 6.2**, **Figure 6.3**).

Several studies of coastal forests along Japan's coasts determined that during the 2011 tsunami, coastal vegetation provided some natural protection by catching large debris (e.g. boats) as tsunami waves retreated inland (Tanaka 2012). As a result, the Japanese government is expanding its national park system along Japan's coast with strict land use guidelines for moving critical infrastructure inland (Onishi and Ishiwatari 2012).

Also in Chile the protective role of coastal dunes against tsunami impacts has been recognized (Nehren *et al*. 2016), and restoration of dune vegetation for tsunami mitigation has been included for instance in Puerto Saavedra in the province of Araukaria, which suffered from the largest earthquake ever measured (magnitude 9.5) and a tsunami in 1960 (Acevedo 2013).

Several countries in Europe, such as Germany, the Netherlands, the UK, Switzerland, and cross-border initiatives from the countries bordering the Danube River aim to mitigate floods through "making space for water" by removing built infrastructure, like concrete river channels, and restoring wetlands and rivers to improve their water retention capacity. For example, The Netherlands invested €2.3 billion to re-establish floodplains, resulting in reduced flood risk for 4 million people along its main rivers (Deltacommisie 2008) (**Figure 6.4**). In addition to risk reduction, these initiatives consistently pursue integrated landscape and ecosystem approaches which consider values of the wetlands in particular for biodiversity conservation, tourism, and recreation.

Another good example are mangroves, which can significantly reduce the impact of tropical cyclones and storms surges (Das and Vincent 2009). It is, however, controversial to what extent they can mitigate the impact of tsunamis (Danielsen *et al*. 2005; Kerr and Baird 2007; Alongi 2008; Cochard 2008). At the same time, mangroves provide various other services, such as supporting fisheries and tourism activities, providing important wildlife habitats, storing high amounts of carbon, and improving coastal water quality (Saenger 2002, Wicaksono *et al*. 2016, Nehren and Wicaksono 2018).

Figure 6.2
Coastal dunes in Valparaíso Region, Central Chile, are an effective natural coastal barrier.
© U. Nehren

Figure 6.3
Mangrove forest, Semarang, Indonesia.
© U. Nehren

Figure 6.4
Nederrijn River Rhenen, Netherlands.
© M. van Staveren

ECO-DRR and EBA benefits

Ecosystems can prevent or mitigate **hazards**

Ecosystems can reduce **exposure** by functioning as natural buffers

Ecosystems can reduce **vulnerability** by supporting livelihoods – before, during and after disasters

...but all solutions have limits...

2. ECO-DRR/EBA IS A "NO-REGRETS" STRATEGY

The "no-regrets" refers to the multiple benefits that investment in ecosystem approaches bring. Interestingly, the IPCC SREX (IPCC 2012) also refers to "no-regrets" and actions for improving adaptation and reducing disaster risks, including investing in ecosystem management. In other words, investing in a green belt, for example, is a "no-regrets" strategy because it may provide not only protection from hazards, with or without combined structural barriers, while also providing many other benefits, especially livelihoods support, carbon sequestration, biodiversity, etc.

UNEP in its address to the UN General Assembly on DRR highlighted the role of ecosystem management as one of the few approaches that addresses all three components of the risk equation (see box on the left and **Figure 6.5**).

A variety of tools, instruments and approaches that are already used in ecosystem management, such as IWRM, Protected Area Management (PAM), Integrated Coastal Zone Management (ICZM), and Integrated Fire Management (IFM) can be readily adopted and applied as part of risk reduction strategies (see chapter 13). Risk reduction can also be part of spatial and land-use planning. Improved and routine use of risk information (e.g. types of hazards over time and space, socio-economic vulnerability profiles of communities, elements at risk, etc.) needs to feed into the design of integrated ecosystem management interventions to enhance their added value for DRR. For instance, rehabilitation of upland watersheds can be harnessed for flood mitigation by improved understanding of the local hazards, hydrology, topography as well as socio-economic demands on forest products and the types of indigenous tree species that are best suited for reforestation activities.

3. GREEN INFRASTRUCTURE IS OFTEN MORE COST-EFFECTIVE OVER TIME THAN GREY INFRASTRUCTURE FOR DISASTER RISK REDUCTION/CLIMATE CHANGE ADAPTATION

One of the main opportunities linked to ecosystem-based approaches to DRR and CCA is its potential cost-effectiveness. However, measuring cost-effectiveness is not without challenge.

Indeed, there are only a few well quoted examples comparing natural versus engineering approaches, such as the study conducted by New York City which compared green versus grey infrastructure investments for improving its ageing sewer system and reducing flooding. The green infrastructure plan was estimated to cost tax payers US $5.3 billion, while the grey infrastructure renewal would have cost US $6.8 billion. In addition, over time the benefits of green infrastructure accrue while grey infrastructure requires renewed investment after 10-15 years (**Figure 6.6**) (NYC 2010).

Another study, conducted by Conservation International (CI), Secretariat of the Pacific Regional Environment Programme (SPREP), UNEP and UN Habitat for the city of Lami, Fiji, carried out a cost-benefit analysis to assess adaptation options for the city. It compared green solutions, such as planting mangroves and replanting stream buffers, with engineering measures, such as building seawalls and increased drainage (Rao *et al*. 2013). The study concluded ecosystem-based measures yielded a US $19.50 benefit to cost ratio, as compared to engineering actions estimated at US $9. Nonetheless, the study also revealed that in terms of avoided (flood) damage, engineered measures provided 15-25% greater protection than ecosystem-based measures, thus recommending that hybrid green-grey infrastructure be used as part of the city's coastal defence and adaptation strategy (Rao *et al*. 2013).

Figure 6.6
Benefits over time of green versus grey infrastructure in New York City.
Source: NYC 2010. Modified by S. Sandholz. Redrawn by L. Monk

Figure 6.5
Dunes for mitigating sea waves in Sri Lanka.
© B. McAdoo

Green belts can stabilize slopes and also reduce exposure of settlements.
© UNEP

Healthy ecosystems support livelihoods before, during and after disasters.
© UNEP

DEFINITION: LIVELIHOOD

"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base."

Chambers and Conway, 1991, quoted after UNISDR 2010

4. ECOSYSTEM-BASED DISASTER RISK REDUCTION IS ANCHORED IN SUSTAINABLE LIVELIHOODS AND DEVELOPMENT

DRR is essentially about promoting sustainable development in hazard-prone areas. As land and ecosystem degradation are accompanied by increasing risks, costs, and poverty for some population groups, sound land and ecosystem management is essential to sustain livelihoods for present and future generations. Against this background, the Eco-DRR/EbA approach comprises much more than just punctually preserving or restoring ecosystems or implementing ecological infrastructure to reduce disaster risks. Rather, the approach can be an essential component of integrated land management with the overall goal to reduce disaster risk and support sustainable development.

Eco-DRR strategies need to align with long-term development challenges, such as poverty reduction and addressing unsustainable use of natural resources through sustainable livelihoods development. Demonstrating short-term tangible benefits especially to local communities is critical to win and maintain necessary engagement for sound environmental management.

Nehren *et al*. (2016) identified several services from three coastal dune systems in Chile, Java, Indonesia, and Vietnam, which, while serving as a buffer against coastal hazards such as storms, storm surges and tsunamis, directly contribute to local livelihoods through freshwater provision, providing areas for tourism, recreation and leisure, plants and animals, and several cultural services. These services depend on healthy ecosystems. Therefore, the overexploitation of provisioning services by mining and use of sand for construction as well as sealing of dune areas for settlements and tourism facilities hamper sustainable development, reduce the resilience of coastal communities, and increase disaster risk.

5. ENVIRONMENTAL MANAGEMENT IS CRITICAL TO ADDRESSING THE RISKS ASSOCIATED WITH CLIMATE CHANGE AND HAZARD EVENTS

There is overwhelming evidence that climate change has caused impacts on natural and human systems and is expected to exacerbate certain hazard occurrences (IPCC 2012). The linkages between environmental management, climate change and hazards are two-pronged:

- **Hazard events and climate change impact ecosystems**
  Many terrestrial, marine and freshwater species have shifted their geographic ranges and there is high "risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods" (IPCC 2014: 12).
- **Poor ecosystem health impacts the magnitude of a hazard event and adaptability to climate change**
  Well-managed highly biodiverse ecosystems are more resilient to climate-related risks and help people to maintain more assets needed to make livelihoods sustainable and less vulnerable to climate change (Elmqvist *et al*. 2003).

Thus, restoring and conserving ecosystems can increase their resilience and provide people with essential services as well as help people adapt to climate change. Climate change may also make it necessary to manage ecosystems to help them adapt to climate change, such as relocating species or planting species that are suited to the new climate, especially in ecosystems that are highly fragmented due to the current land use.

6. INTEGRATING ENVIRONMENTAL APPROACHES INTO DISASTER RISK MANAGEMENT REQUIRES MULTI-SECTORAL AND MULTI-DISCIPLINARY COLLABORATION, WHILE ALSO INVOLVING LOCAL STAKEHOLDERS IN DECISION-MAKING

Successful implementation of Eco-DRR/EbA needs multi-sectoral cooperation and multi-disciplinary approaches and teams. It requires involving people with different technical expertise and knowledge, for instance city engineers and land developers working together with ecologists and disaster management experts, as well as including those with local or traditional/indigenous knowledge.

Establishing cross-sectoral, multi-disciplinary collaboration and building on existing platforms facilitates sharing of available data, helps ensure scientific and technical rigor in designing and implementing Eco-DRR/EbA initiatives and obtaining the political support necessary to integrate ecosystem-based approaches into national, regional, and local development plans, while gaining stakeholder buy-in.

Understanding different local livelihoods needs and priorities, utilizing local or traditional knowledge, and involving local stakeholders in decision-making are critical for promoting risk reduction through sustainable ecosystems management. Local communities are direct users of the natural resources in their area and their knowledge of local ecosystems should be used for planning of Eco-DRR/EbA initiatives. Raising the awareness of local men and women by demonstrating the combined livelihoods and risk reduction benefits of ecosystem management is equally important in winning and sustaining local support.

Initiatives often fail when there is limited or lack of participation by local stakeholders, which may include local government authorities, informal leaders, women's groups, community-based organizations and residents. Identifying community actors, such as disaster management committees, forest user associations, and farmers' associations, who can become advocates for Eco-DRR/EbA is essential. At the same time the cooperation among local level and higher-level authorities (regional or national) is also essential for long-term planning and implementation of measures.

7. ECO-DRR/EBA HAS LIMITATIONS AND NEEDS TO BE COMBINED WITH OTHER RISK REDUCTION/ADAPTATION STRATEGIES

Investing in ecosystems is not a single solution to risk reduction but should be used in combination with other risk management measures. In order to be effective, ecosystem-based approaches need to be based on rigorous understanding of local ecological conditions, socio-cultural and economic circumstances and livelihoods, existing hazards, and technical requirements of the intervention. In some cases, ecosystem thresholds may be surpassed depending on the type and intensity of the hazard event and/or health status of the ecosystem, which may therefore be insufficient to provide adequate buffer against hazard impacts. For instance, mangroves may not provide as much protection against tsunamis as they would for storm surges (Spalding *et al.* 2014). Thus promoting ecosystems management as the main risk reduction strategy could provide a false sense of security. On the other hand, many structural engineering works may also provide a sense of false security and there are many examples of where populations have settled immediately behind river dykes or sea walls and they have not sufficed to protect against unpredictable extreme events. Moreover, ecosystem-based approaches often require a lot of space/land which may not be available or practical as for within a city landscape for example.

Sometimes combining ecosystems-based approaches with human-built infrastructure (e.g. embankments) in a hybrid approach may be a good way to provide protection of critical assets.

Strengthening early warning systems and disaster preparedness measures remain paramount in saving lives and major assets and not to be forgotten when there is a focus on ecosystem-based measures.

8. CHALLENGES

We also need to be aware of some of the challenges in implementing Eco-DRR/EbA:

8.1 The protection capacity of ecosystems to hazard events can be locally specific

The protection capacity of ecosystems is difficult to quantify and will depend on an ecosystem's health and local parameters to resist hazard events. For example, in general, vegetation on steep slopes will be beneficial to reducing erosion rates and many shallow landslides (Papathoma-Köhle and Glade 2013). However, trees that are too old and heavy may actually even trigger landslides.

Mangroves may be useful for absorbing wave energy during a "10 year" coastal storm event but depending on its width and health may not be resistant to a "100 year" storm – while it has to be acknowledged that "100 year" storms could become future "10 year" storms due to climate change impacts. Therefore, the use of green belts or other natural infrastructure requires a more detailed study of local conditions to ensure the same protection as engineered structures. Furthermore, engineered solutions can often be more easily quantifiable. In the past decade, fortunately more scientific studies have been undertaken to quantify protective ecosystem services but more is needed.

8.2 Ecosystem benefits can be difficult to quantify and compare with structural engineering measures

Just as the protection capacity of ecosystems is difficult to measure and compare with structural engineering measures, so is the overall economic value of ecosystems. This makes it more difficult to conduct the classic cost-benefit analyses most decision-makers use for making decisions about which investments to make toward DRR or CCA. Therefore, more similar economic valuation and cost-benefit studies and tools are required which provide decision-makers with more readily available information.

8.3 Investing in Eco-DRR/EbA requires political will, long-term strategies and inter-agency cooperation

As Eco-DRR/EbA strategies are often only more cost effective over the long term, they require considerable political will and long-term planning. Such is the case in Switzerland, where investing in the management of its protection forests is a national strategy that includes management plans for the next fifty years and has with significant public support. Such long-term planning or political will is not always easily obtained. Furthermore, it requires intercommunal or even transboundary approaches. The forest which protects some village in the Swiss Alps might belong to another municipality, so long-term cooperation based on negotiations will be part of the strategy.

6.3 Conclusions

This chapter provided core principles of Eco-DRR/EbA. Ecosystem-based approaches are aligned with sustainable development, but it requires a paradigm shift to start implementing these approaches more fully, especially as they often demand an interdisciplinary, landscape and multisectoral approach. Although these approaches are gaining momentum and recognition, there is still a lack of knowledge and willingness to invest in long-term prevention, including risk sensitive land use management, ICZM, IWRM and other ecosystem-based approaches. This is often due to a preference for immediate, structural engineering approaches – which may be the most appropriate depending on the situation – but may be costlier and offer fewer multiple benefits for livelihoods over the long term. The following chapters will provide more details and tools that can guide planning and implementation of Eco-DRR/EbA. There has been much written on EbA and its planning and implementation and we refer the reader to those sources.

ADDITIONAL RESOURCES

- **A landscape approach for disaster risk reduction in 7 steps:** https://www.wetlands.org/publications/landscape-approach-disaster-risk-reduction-7-steps/
- **Mangrove restoration: to plant or not to plant' has been translated in 6 languages and there are more versions in development:** https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/
- **Adaptation community:** https://www.adaptationcommunity.net/ecosystem-based-adaptation/international-eba-community-of-practice/

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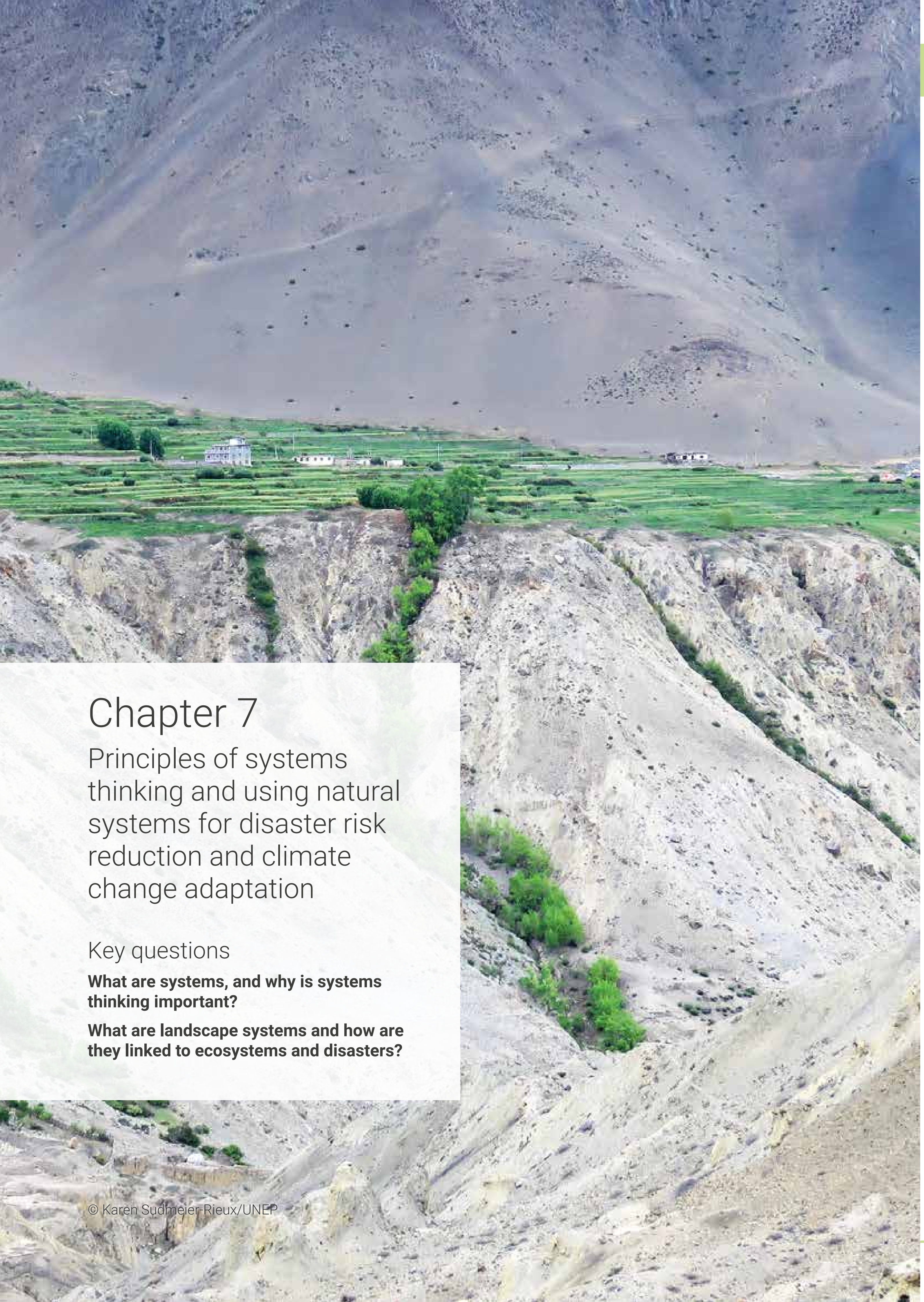


Chapter 7

Principles of systems thinking and using natural systems for disaster risk reduction and climate change adaptation

Key questions

What are systems, and why is systems thinking important?

What are landscape systems and how are they linked to ecosystems and disasters?

7.1 Principles of systems thinking

Systems thinking emanated with the Greek philosopher and scientist Aristotle (384-322 BC). He noticed that any kind of system, which can be for instance biological, physical or economic, cannot be determined or explained only by the sum of its components. Based on this observation he defined the general principle of holism, which he published in his classic work Metaphysics (original title: τὰ μετὰ τὰ φυσικά): "The whole is more than the sum of its parts." From the early works of Aristotle and other philosophers and scientists a whole discipline evolved: Systems science, which studies the nature of systems. Today, systems thinking has become increasingly important in many scientific fields, but also in almost every area of daily life. We talk for instance about urban systems, traffic systems, sanitation systems, agricultural systems, computer systems, virtual systems, or ecosystems. But how can we define systems and the principles of systems thinking? As usual there are numerous definitions that slightly differ from each other.

Widely used is the one by Churchman (1968), according to who "a system is a set of interacting or interdependent entities. These can be real or abstract and form an integrated whole." Systems are moreover defined by elements and processes within a defined boundary and an exchange of matter, energy, and information. And finally, systems have in common that the behavior of elements at the micro level determines the characteristics of the system as a whole. This is what we call emergence. Systems thinking can be defined as the process of understanding how things, regarded as systems, influence one another within a whole.

In thermodynamics we distinguish between three types of systems (**Figure 7.1**):

1. An isolated system is one that does not have interactions beyond its boundary layer. Such a system does not exist in nature but is used in controlled laboratory experiments.
2. A closed system is a system that transfers energy across its boundary, but no matter.
3. And finally an open system transfers both matter and energy across its boundary to and from the surrounding environment.

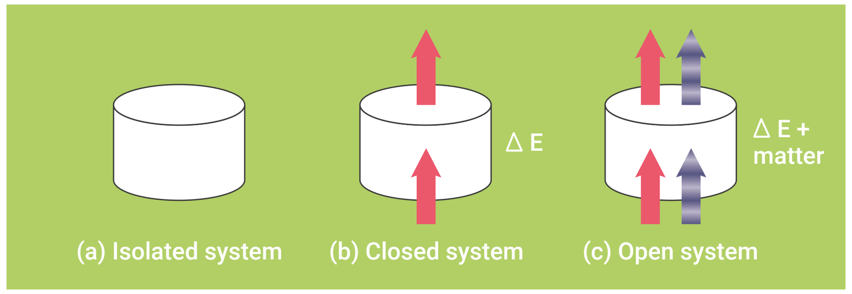


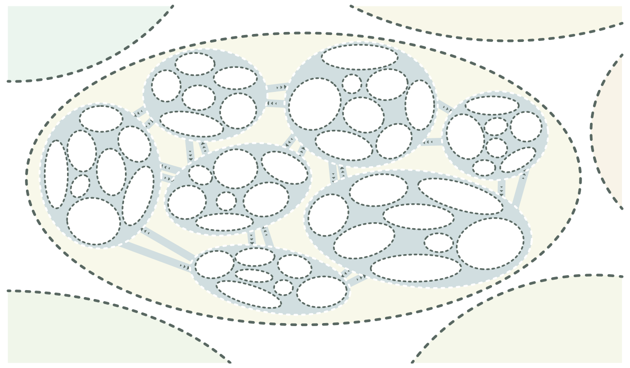
Figure 7.1
Different types of systems.
Design: U.Nehren

Figure 7.2
Ecosystem hierarchies. The photo on the left shows a tropical lowland rainforest in the central Amazon basin of Brazil. Within the floodplains of these lowland rainforests we find seasonally flooded riverine forests with distinct characteristics, such as the Igapó forest in the Rio Negro shown on the photo in the middle. The water-filled rosette of the bromeliad on the right photo is a micro-ecosystem; these bromeliads grow as so called epiphytes on rainforest trees.
© D. Sattler

Ecosystems are open systems because communities of organisms interact with each other and with their environment outside ecosystem boundaries. Within ecosystems, we find that there are hierarchies, or smaller systems within larger systems, linked to each other within complex functional networks. An example is the Amazon rainforest, which is considered a huge ecosystem (**Figure 7.2**). However, within the Amazon rainforest we find various types of smaller ecosystems that are determined by climatic, topographic, geological and other factors, such as riverine forests or mountain forests.

At the very small scale, even some flowering species like bromeliads can be considered an ecosystem, as they provide self-containing microhabitats for aquatic insects, amphibians and even reptiles. Therefore, ecosystems are also nested systems (**Figure 7.3**). This means that different subsystems interact within the boundary of a larger system, such as different smaller forest ecosystems within the Amazon rainforest.

Figure 7.3
Nested Systems.
Design: S. Plog



Why is system thinking important?

Earlier in this book, we pointed out that we need to manage nature sustainably in order to support human well-being, and in the long-term to even assure our survival. But sound ecosystem management requires an understanding of the complex nature–human interactions to make the right decisions.

Thus thinking in terms of systems and developing models to explain reality and consider dynamic processes is important. In 1845, the famous naturalist and geographer Alexander von Humboldt published his five-volume work "Kosmos" (Humboldt 1862), in which he tried to unify the knowledge of various branches of scientific disciplines of his time, such as geography, botany, anthropology, geology, and astronomy. His holistic studies, which aimed at a very full explanation of the "unity of all nature", were based on observations and comprehensive measurements and resulted in outstanding scientific works. His quantitative methodology with modern instruments and techniques became known as "Humboldtian science."

While naturalists, like Alexander von Humboldt and Charles Darwin, had a very comprehensive knowledge on various areas of natural sciences of their epoch, today's scientists often work on very specific questions within highly specialized disciplines. However, holistic approaches in sciences are not outdated. The integration of specialized scientific knowledge into comprehensive scientific models is one of the challenges of modern research on natural resources management. But unlike in Humboldt's time, today multidisciplinary teams of researchers work together and share their knowledge and computers help them to integrate the growing volume of data into more and more complex models. However, not only researchers but also practitioners are facing the challenge of system complexity. Here is an example.

As a result of historical deforestation and land use intensification, today the Atlantic Forest biome is a highly fragmented landscape dominated by pastures and agricultural lands (Nehren *et al*. 2013; **Figure 7.4**), where forest remnants make up only 11.4-16.0% of the original forest cover (Ribeiro 2009). Despite the very high forest losses and degradation of the Atlantic Forest biome, the remaining forest patches are characterized by outstandingly high biological diversity and rates of endemism (Galindo Leal and Gusmão-Câmara 2003). Due to this biological richness and at the same time ongoing threats from humans, the Atlantic Forest biome is considered a so-called 'biodiversity hotspot' (Myers *et al*. 2000).

Figure 7.4
The photo on the left shows an intact mountain rainforest ecosystem in the Atlantic Forest of Rio de Janeiro. Rainforests have been widely replaced by agricultural and pasture systems and forest are reduced to small patches (*photo in the middle*). Deforestation in slope positions has led to accelerated soil erosion processes (*photo on the right*).
© U. Nehren

In the Brazilian state of Rio de Janeiro various initiatives have been taken to protect the remaining rainforest areas. However, at the same time ongoing urban sprawl and infrastructural development leads to further forest fragmentation. This phenomenon occurs in many developing and emerging countries in particular close to economically growing metropolitan regions.

In terms of impact on ecosystem services, the undertaken forest conservation and reforestation measures to establish larger biological corridors would have many benefits, such as improving regulating services (e.g. slope stabilization, erosion control, flood control as well carbon storage and sequestration). Also, biodiversity conservation would be supported by establishing larger wildlife corridors and better habitat networks. On the other hand, the areas of Rio de Janeiro state where such forest conservation and reforestation measures could be implemented are close/in rural areas which are dominated by livestock and agricultural production systems. Furthermore, closer to the metropolitan region (about 1-2 hours driving distance) we find intensive vegetable production systems. As a result, in some regions ecosystem conservation goals compete with food production. This is a challenge and also an opportunity (Martinelli and Filoso 2009, Nehren *et al*. 2019).

Indeed, replacing larger areas of agricultural and pasture land by natural forests would affect the provisioning service of food production the region needs. As a consequence, the following scenario is conceivable: Farmers lose their main income source from intensive agricultural production and without sufficient alternative income opportunities their livelihoods would be negatively affected. Most probably some families would move to nearby cities to find employment. In the cities they would have to find living space and socialize in the new environment. At the same time, they would lose part of their rural cultural identity.

Situations like this can be complex. Coming back to the systems perspective, in this example, there are several interacting systems: forest ecosystems, agricultural systems, social systems, economic systems and cultural systems. These systems are highly interlinked, competing and working together as well as being related to many other systems (e.g. weather system, etc.) which are not explicitly mentioned. Even though it is not possible to capture all systematic relationships, we should be aware of the complexity and try to identify main cause-effect chains.

Thus, in thinking about undertaking reforestation in a specific context, it is important to be aware of the possible impacts on agricultural systems and rural livelihoods – with potential impacts even on larger scales – and therefore carefully plan reforestation schemes, involve local stakeholders and communities, balance with agricultural needs and choose the right tree species. Furthermore, biodiversity and ecosystem processes need to be thought through and thus avoid reforesting with monocultures at a large scale, which may make the forest more susceptible to disease and negatively affect local livelihoods.

Furthermore, there could be opportunities to combine ecosystem conservation and restoration with sustaining or ideally improving livelihood and reducing disaster risk. Alternative income possibilities could be provided by the reforestation and ecosystem restoration and agroforestry systems could be suitable to create livelihood opportunities while providing protective services. Further considerations could be Payment for Ecosystem Services (PES) schemes that could serve as incentive systems offered to farmers or landowners for sustainably managing their land and thereby contribute to improving watershed services and mitigating climate change (Rodrigues Osuna *et al*. 2014). Overall it is important to take care to not only protect the forest ecosystems as a natural system, but also the socio-ecological system as a whole. If we ignore the systemic relationships between the natural and human systems, the situation could worsen.

Even small ecosystem features, such as in coastal dunes, mangroves, seagrass beds, coral reefs, wetlands and protection forests, in a landscape need to be considered and managed within the landscape as a whole – including agricultural, forestry, urban, industrial and other strongly human-impacted areas.

7.2 Landscape systems, ecosystems and disasters

In geography and landscape ecology, the concept of landscape systems is used as a theoretical framework to describe, analyze and manage the environment. Landscape systems consist of natural subsystems. According to Leser (1997) these are the so called "geoecofactors" climate, relief, rock and water as well as the "bioecofactors" vegetation and fauna. Soil represents an intermediate category, as soils are made of biotic and abiotic compounds. Human systems interact with these natural subsystems and have a fundamental impact on landscape development (**Figure 7.5**).

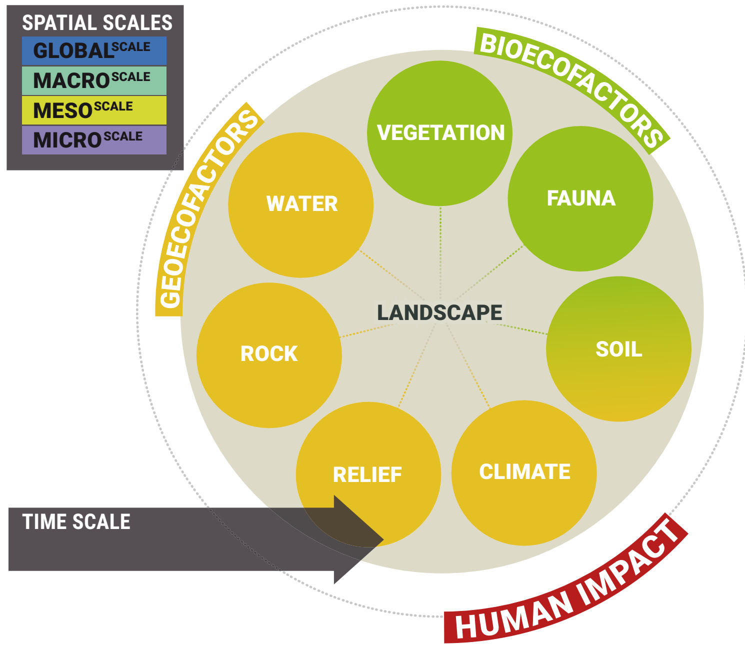


Figure 7.5
Conceptual model of a landscape system (based on Leser 1997, modified by Nehren 2008; Design: S. Plog)

Time scales and spatial scales are important for these landscape features. Thus, when we take land management decisions, for instance to reduce disaster risk, time scales and spatial scales need to be taken into account. Spatial scales can be categorized as global, macro, meso and micro scales. Climate change, for instance, is a phenomenon at global scale, while transboundary flood risk management in a large watershed such as the Nile River belongs to the macro scale. Examples of the meso scale are the management of mangroves and coastal dunes in a district or community, while the stabilization of a slope represents the micro scale. However, be aware that a clear distinction between the scales is not always possible. Time scale is very important to think about, especially when considering management for the provision of certain services. It can take time for a newly planted forest to mature enough to be a protective feature in a landscape and to provide other ecosystem services.

7.3 Conclusions

Both the ecosystem and the landscape approach are very useful for Eco-DRR and EbA. Ecologists or biologists tend to use ecosystems because they focus on the biological components of the system. Their conceptual models are around these ecosystemic integrations and thus talk about "agro-ecosystems" or "urban ecosystems" and their emphasis is on ecological patterns and processes. In contrast, the landscape approach puts stronger emphasis on the abiotic components and the human-nature interactions within the systems. Therefore, the landscape approach is very helpful for spatial planning. Moreover, it is very useful when we for instance plan a slope stabilization measure. Here we have to consider the geological subsurface, soils, water, topographical conditions, and affected settlements and infrastructure, in addition to the type of forest cover.

Moreover, it is important to remember that landscapes are open systems, which usually do not have clearly defined boundaries. Therefore, often other physical units are used when it comes to management decisions. For water management issues for instance, watersheds or catchment areas are used as clearly definable geo-hydrological units. But if we consider managing a mountain forest for conservation purposes, we would rather consider the forest cover and elevation to define a landscape boundary. However, political decisions related to natural resources management are mainly taken based on administrative units, usually defined by national, federal state, province, district, and community boundaries. To manage watersheds or conservation corridors for DRR, it is sometimes therefore necessary to cooperate across administrative borders.

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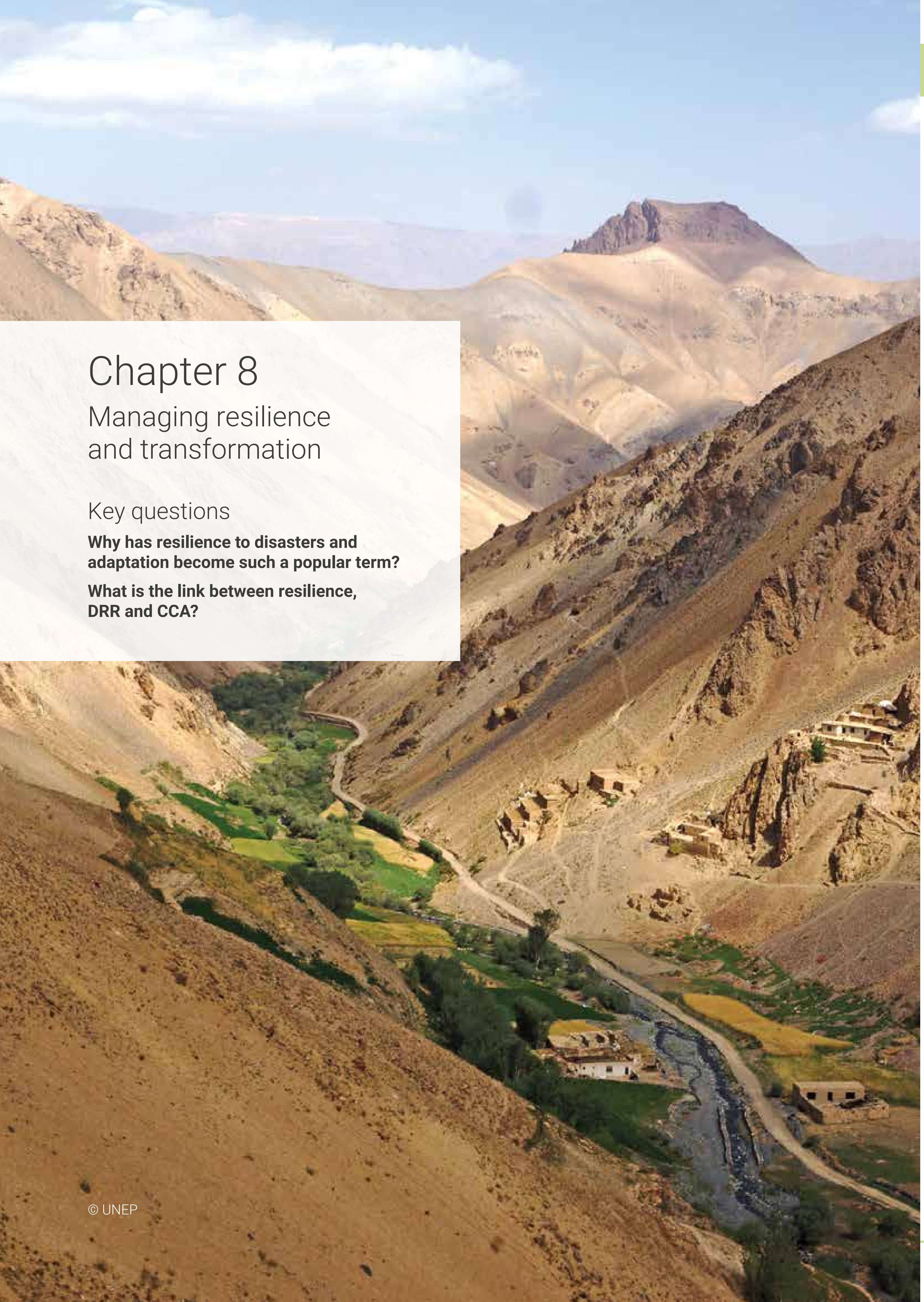

Chapter 8

Managing resilience and transformation

Key questions

Why has resilience to disasters and adaptation become such a popular term?

What is the link between resilience, DRR and CCA?

8.1 Resilience a key concept

Resilience is a central term in the post-2015 Sustainable Development Agenda and the SFDRR. Resilience is at the heart of a debate about how best to encourage governments, civil society and the private sector to invest in DRR measures. Humanitarian and development agencies are finding their mandates further blurred: should humanitarian agencies focus mainly on the post-disaster phase and should development agencies focus mainly on prevention? In parallel, there is considerable debate about how to integrate DRR with CCA and more effectively mainstream these into development activities. The concept of resilience presents an opportunity to strengthen coherence between the humanitarian, climate change, DRR and sustainable development agendas. Moreover, resilience has become an attractive concept because of its more positive connotations that focus on enhancing local capacities and adaptation potential than the negative connotations attributed to vulnerability and risk reduction.

However, despite its increased popularity in international discourse, there is limited theoretical understanding and multiple, often contradictory definitions of resilience – for example even IPCC and UNDRR use different definitions. Taking a more detailed look at the different documents of the post-2015 Agenda it is surprising that despite using the term all over, only the SFDRR gives a definition for resilience, while neither the Paris Agreement nor the SDGs do. In operational terms, due to the complexity of the concept of resilience, a main challenge is determining which indicators should be used, and how to measure them in order to inform DRR policies. Nonetheless, resilience has become the new goal of many international and national development policies, with little guidance or benchmarks that describe what resilience is, how to increase it, or when resilience has been achieved (Sudmeier-Rieux, 2014). This chapter explores 'resilience' and its inputs to the international discourse in the fields of DRR and CCA and what are the links between resilience, DRR and ecosystem-based approaches.

Originating in engineering sciences in the 19th century, the term was later popularized by ecological sciences and child psychology before becoming popular in literature on climate change and disaster management, with UNDRR including it in its mandate since 2005: "to increase the resilience of nations and communities to disaster risk".

As can be seen by the definitions of UNDRR and IPCC, quite a few elements are thought to compose resilience: "bounce-back", "resourcefulness", "absorb", "retain function, identity and structure" and "adaptation, learning and transformation". Some of these elements, such as the last two mentioned can seem at first glance contradictory.

In systems sciences, resilience is: "the *ability of a system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable time and composite costs and risks*" (Haimes 2009). According to systems thinking, other characteristics of resilience include **robustness**, which refers to the degree of insensitivity of a system to perturbations, and **redundancy**, which refers to the ability of certain components of a system to assume the functions of failed components without adversely affecting the performance of the system itself (Haimes 2009).

DEFINITION: RESILIENCE

"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, building from the definition used in Arctic Council, 2013

"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

In building engineering, seismic resilience of buildings is part of a system which has:

1. Reduced failure probabilities;
2. Reduced consequences from failures in terms of lives lost, damage, and negative economic and social consequences;
3. Reduced time to recovery.

(Bruneau and Reinhorn 2006, as quoted by Bahadur *et al.* 2010).

Tierney and Bruneau (2007) use the "R4 Framework", which describes resilience as:

Robustness
The ability of systems and other units of analysis to withstand disaster forces without significant degradation or loss of performance.

Redundancy
The extent to which systems or other units are substitutable if significant degradation or loss of functionality occurs.

Resourcefulness
The ability to diagnose and prioritize problems and initiate solutions by mobilizing material: monetary, informational, technological and human resources.

Rapidity
The capacity to restore functionality in a timely way, containing losses and avoiding disruptions. (Modified from Tierney and Bruneau 2007)

Figure 8.1 illustrates the resilience triangle (Tierney and Bruneau 2007). It depicts a disturbance at t0 followed by a certain time of recovery (t). One example can be a bridge which fails during an earthquake. In this illustration, resilience can thus be the time and cost for reconstructing the bridge.

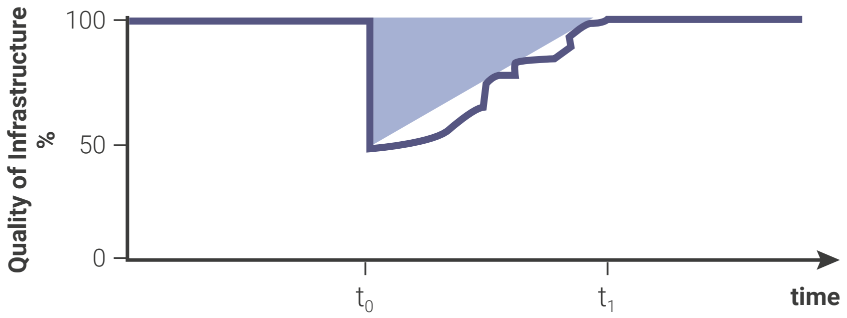

Figure 8.1
The Resilience triangle as a function of quality of infrastructure and time.
Modified from Tierney and Bruneau 2007. Redrawn by L. Monk

In economics, resilience refers to the inherent ability and adaptive responses of systems that enable them to avoid potential losses (Rose 2007). Increasingly, also social aspects of resilience are emphasized.

Thus, the concept of resilience can be seen as having different facets to it, while incorporating timeframes of during and after a disturbance.

8.2 Resilience, disaster risk and climate change adaptation

When defined in the narrower sense of "returning to a normal state", resilience parallels coping capacities or recovery strategies for dealing with shock and adversity, rather than favouring long-term capacity building and reducing underlying vulnerabilities. Adaptation can be seen as a longer-term process of slowing adjusting and changing to the conditions, while coping is usually considered a short-term strategy for dealing with stress or a shock. Both require making adjustments to systems, (i.e. livelihoods), based on decisions and choices following an appraisal of events and possible outcomes or consequences.

Thus resilience, when thought only as coping, is similar to adaptation but also different. In this conceptual framing, it is also possible to be resilient to change in a harmful way; i.e. coping with shocks and stressors but ultimately staying stuck in a way of doing things. Adaptation requires learning and change, or at least adjusting to a certain extent.

There are many examples this harmful state of "resilience", of highly "resilient" populations around the world, living in harsh environments and often subjected to small and large shocks, such as flooding as well as from everyday economic and health issues. These populations often have a high capacity to "bounce back". Consider the example given in chapter 2 from Nepal. Here the people built very simple houses in the floodplain, which floods every year (**Figure 8.2**, **8.3**).

These people can be considered highly resilient because they are used to rebuilding their houses and recover after frequent small flooding. However, they remain highly at risk of a large and dangerous flooding as well as other risks, such as epidemics.

Figure 8.2
Vulnerable house in Nepal.
© K. Sudmeier-Rieux

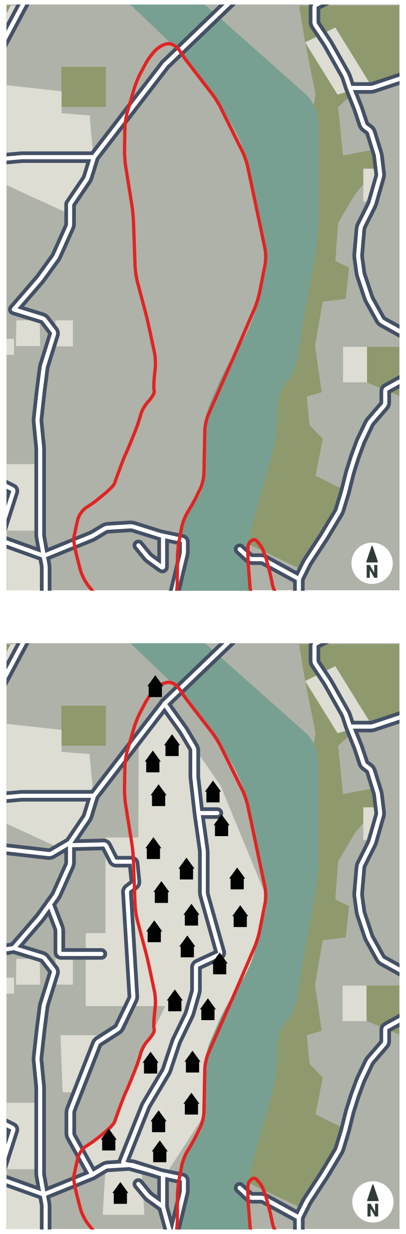

Figure 8.3
Redrawn figure from Google maps.
***Above*: Seuti Khola River, Dharan Nepal in 2004;**
***Below*: Seuti Khola River, Dharan Nepal in 2009.**
Credit S. Plog

Figure 8.4
Bamiyan, Afghanistan.

Let's take another example from Bamiyan Province in Afghanistan (**Figure 8.4**). People have lived in the valleys of these high mountains for centuries and have developed strategies for coping with extreme winters and flash floods during springtime. If we follow the most common definition of resilience, "bouncing back", we can say that these populations are highly resilient. But these people continue to live in places at high risk from mountain hazards, with everyday economic and health challenges. As a result, their high capacity to rebounce to the "normal state" does not necessarily mean they are able to lower their risks.

The bottom-line issue and main criticism of the concept of resilience to disasters is that communities at subsistence level have very low marginal capacities to deal with shocks, and their thresholds leading to a non-functioning state may be easily transgressed. For marginalized populations, the "normal state" is thus not necessarily the desired state and cannot be addressed through emergency measures but rather through long-term development interventions. Thus, resilience as defined as the capacity to recover to the normal state does not suffice to reduce underlying risk factors, or vulnerabilities to disasters or climate change impacts (Sudmeier-Rieux, 2014).

FROM BOUNCING BACK TO BOUNCING FORWARD: TRANSFORMATIONAL RESILIENCE

In recognizing that "bouncing back" does not take into account that disasters are accompanied by change, Manyena *et al.* (2011) offer an alternative definition: "the ability to bounce forward following a disaster", which could also be described as "positive transformation" of a community, or system. If mainstream resilience definitions represent more conservative notions of maintaining stability or the status quo, then "transformability" is a more appropriate notion for addressing underlying risk factors and engaging in new development pathways, which include disaster prevention and vulnerability reduction measures. The IPCC definition of resilience, which is influenced by the CCA process, also aims to reflect partially this need to "bounce forward", by recognising the processes of "adaptation, learning and transformation".

Nevertheless, resilience as a conceptual "bouncing forward" changes the original meaning of resilience but it provides the promise of a framework against which disaster prevention and post-disaster measures should be undertaken. Seeing resilience in this light is a paradigm shift, which mirrors the process required of addressing the underlying causes of vulnerability as well as improving capacities to recover after a disaster.

Figure 8.5 illustrates different types of resilience along a time scale. During this time scale, there are various shocks or levels of stress with different responses and types of resilience: recovery (or passive resilience), adaptation and transformation. The figure uses a simple ball and curve figure to illustrate differences between these different types. In recovery the ball bounces back, in adaptation the curve moves outward, in transformation, the ball moves to a higher state. Chelleri *et al.* (2015) assign recovery to the engineering definition of resilience, adaptation and transformation to a socio-ecological definition of resilience.

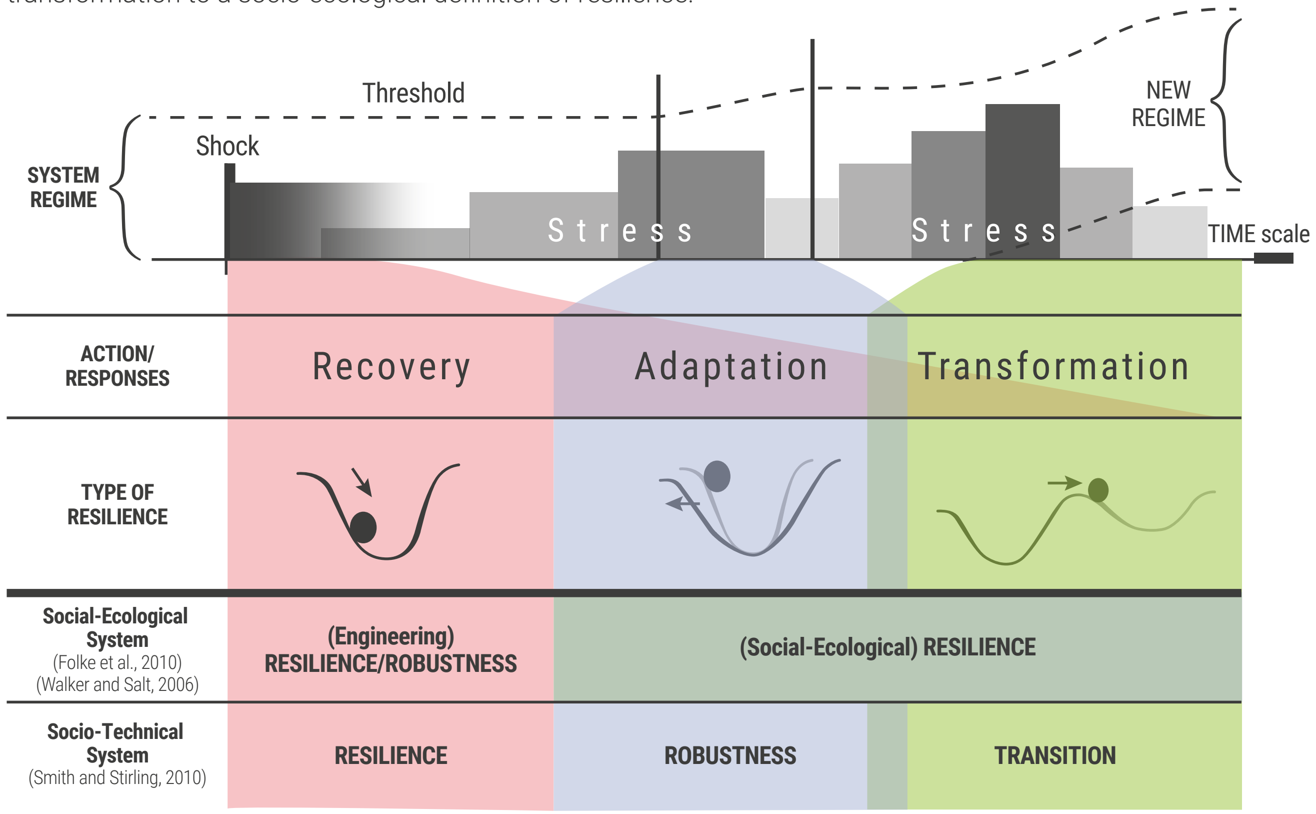

Figure 8.5
Types of resilience according to different schools of thought and in various stages.
© Chelleri *et al.* 2015. Redrawn by L. Monk

In this light, proponents of transformative resilience argue that it can provide a common platform for addressing DRR, adaptation and poverty reduction, moving away from hazard-oriented, technology-driven DRR that is the current norm. According to this viewpoint, it has the potential to bring about more systemic approaches to DRR and understanding of complex systems while offering a stronger entry point for critical long-term but neglected aspects of DRR and CCA, such as ecosystem-based approaches.

8.3 Conclusions

Resilience in its traditional definition as "returning to a normal state" (or passive resilience) may be a useful concept to describe a more efficient recovery process after a crisis as one step in the disaster management cycle, but will not necessarily change population's everyday risks, well-being, and sustainability or reduce vulnerability in the long run. In other words, a population can be vulnerable and at risk, while simultaneously resilient. Looking towards a concept of transformative resilience can aid move towards the needed paradigm shift required to deal with the challenges of climate change and disaster risk. Thus, in spite of several caveats of how it is understood and depending on whether it is considered as passive or transformative, the concept of resilience can be a useful bridge between DRR and CCA. Furthermore, resilience is a key concept for ecosystem-based approaches because ecosystems and socio-ecological systems operate along these scales of recovery, adaptation and transformation. Understanding these complex processes is difficult but necessary when working on a system level.

One main challenge is the operationalisation of the resilience concept for DRR and CCA. Notwithstanding the choice of definitions, assessing and measuring resilience remains a difficulty. If one sees resilience as a capacity rather than an outcome, then the picture might become slightly easier (FSIN Resilience Measurement Technical Working Group 2014) but nevertheless, multiple indicators at different levels will be required. These issues will be further considered in Chapter 17.

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Chapter 9

Ecosystems management contributions pre- and post-disasters

Key questions

How can ecosystem management support different disaster phases?

How can gender considerations be taken into account pre- to post-disaster?

9.1 Ecosystem management and the disaster management phases

We start by questioning the dominant view of disaster management (**Figure 9.1**), where the hazard event is the trigger for the post-disaster emergency responses, the recovery and reconstruction phase. The disaster management phase then returns to the pre-disaster phase which includes disaster mitigation and disaster preparedness activities.

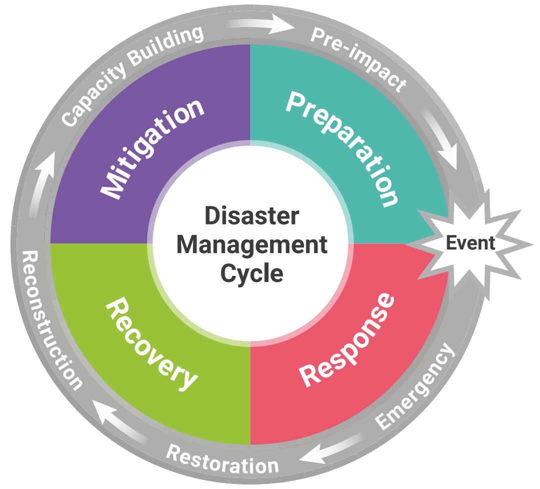

Figure 9.1
Disaster management cycle

In this predominant situation, the emphasis and most budgets are placed in the post-disaster phase and on pre-disaster preparedness activities, such as early warning systems or emergency preparedness. This is how disasters have been most commonly managed. Over the past decade this notion has been challenged by NGOs, development- and UN agencies, such as UNDRR, which are advocating for a paradigm shift towards disaster prevention through long-term planning and investments in reducing underlying risk factors in order to reduce hazard impacts (**Figure 9.2**). Here the emphasis is on reducing disaster risks through investments in poverty reduction, risk-sensitive land-use planning, and sustainable development, rather than just managing risks as in the old paradigm.

Figure 9.2
Disaster risk reduction spiral.
Source: Modified from Tony Lloyd-Jones (editor), Max Lock Centre, University of Westminster, 2009.
Redrawing by: S. Plog

Ecosystem-based activities can be implemented at all stages of the DRR spiral from the early stages after a hazard event, through reconstruction, mitigation and especially in the prevention phases. **Table 9.1** shows the four main phases of the DRR spiral along with the main ecosystem management component.

This chapter will go through the different phases of the DRR spiral and will explore different options for including ecosystem-based activities as part of a more comprehensive DRR portfolio of activities alongside more "classical" DRR activities.

In addition, the gender lense will be included because experience and data from around the world have shown that women can play a critical role in protecting the environment as they find source of sustenance – such as water, firewood, fodder, medicinal plants, forest products and nature-friendly agricultural practices – in a healthy environment. Often women have been called 'stewards of natural environment conservation' because they have a wealth of knowledge to protect, conserve, and regenerate natural resources. Thus, examples of women's activities that are invaluable for DRR will be given. We will examine at the roles women can and do play in the disaster risk reduction cycle – including during an emergency, recovery, reconstruction, and preparedness and prevention. This will help inform future strategies for including women in all stages of Eco-DRR.

9.2 Ecosystem management and post-disaster recovery

PHASE I. RELIEF

The main objective of the relief phase, which takes place during and immediately after a hazard event, is to save lives (Figure 9.3). Main actors are usually neighbours, community members and, when available, local fire brigades, search and rescue teams, or national armies.

The relief phase is most effective when there are existing contingency plans, frequent rescue and emergency drills and well established evacuation plans. Since the main focus is on saving lives, there may be little time to include environmental considerations, other than basic considerations to avoid pollution of water sources or dumping waste materials in waterways. Environmental contingency plans may be part of relief training. Services of ecosystems, such as provision of construction material, fire wood, food, etc., can be used. Green open spaces can be used for temporary shelters (camps).

When hazardous materials are released during a disaster, such as oil spills or ground water pollution, we call this an environmental emergency. Such emergencies must be dealt with proper techniques that go beyond the scope of Eco-DRR/EbA.

Rather than being people who need to be helped, women can become helpers when emergency strikes. This shift can happen through long-term activities that empower women and training to respond to disasters. This can be more effective than top-down approaches where women do not have information and cannot take decisions to respond appropriately to disasters. Research conducted in Papua New Guinea by Mercer *et al*. (2008) highlights the need for more participatory approaches. They discuss response of the Singas villagers who were asked by disaster officials to move from river banks to higher grounds to solve their problem

TIME FRAME AFTER HAZARD EVENT	OBJECTIVES	MAIN ACTIONS	ECOSYSTEM-MANAGEMENT COMPONENT
PHASE I. RELIEF			
Hours to days after	Save lives	Search and rescue, emergency skills	Avoiding dumping of hazardous materials in environmentally-sensitive areas or habitats; possible use of provisioning services from ecosystems (food, wood, shelter, etc.)
PHASE II. EARLY RECOVERY/TRANSITION			
Days to months after	Secure livelihoods	Temporary shelters, provision of basic services e.g. water, food	Rapid environmental assessments, sourcing of sustainable materials for recovery, waste management
PHASE III. RECONSTRUCTION			
Months to years after	Reconstruct livelihoods	Reconstruction/ provision of housing and infrastructure, job creation	Environmentally sensitive reconstruction, sustainable materials sourcing, improved waste management, ecosystem restoration, green infrastructure and improved ecosystem management for DRR
PHASE IV. PREVENTION a) Risk and vulnerability assessments			
Continuously updated	Analyse and assess risk	Hazard and exposure mapping, vulnerability assessments, risk mapping	Combined ecosystem mapping with risk/ hazard mapping
PHASE IV. PREVENTION b) Development planning and risk reduction			
Continuous process, on regular intervals	Hazard, vulnerability and exposure reduction	Risk sensitive land use planning, based on assessments	Ecosystem and land management plans, ecosystem protection and restoration included in planning and zoning
PHASE IV. PREVENTION c) Preparedness			
Continuously updated	Increase readiness for future hazard events	Creation and maintenance of early warning systems, evacuation plans	Including ecosystems in environmental emergency preparedness programmes

Table 9.1
The four main phases of the DRR spiral. Credit: Authors

Figure 9.3
Collapsed supermarket in Haiti during earthquake of 12 January 2010.
© UNEP

of flooding. While the villagers did not contest this, they had no intention of complying with these top-down instructions because their livelihood depended on the river ecosystem. Participatory approaches enable those at the are directly affected by the hazard concerned to be involved at all points, including arriving at emergency strategies (Mercer *et al*. 2008).

PHASE II. EARLY RECOVERY

The main objective of the early recovery stage is to secure livelihoods, return to «normal life», find missing persons and belongings, clean debris and establish temporary shelters, secure food and water supplies (**Figure 9.4**). This phase takes place days to weeks or months after a hazard event. Main actors involved are usually neighbours, community members, civil protection, humanitarian agencies and NGOs. This phase is most effective when there are already existing contingency recovery plans.

Figure 9.4. Looking for valuables after 2010 Haiti earthquake.
© UNEP Haiti

Some of the biggest challenges of the early recovery stage include:

- **Location** of temporary settlements
- **Pollution of drinking water** by human waste
- **Waste management** and sanitation issues

Environmental considerations are possible and should be taken into account during the early recovery phase. They should include the basic principle "do no harm", which means avoiding actions that may be damaging to lives and livelihoods in the long run.

Inappropriate location of temporary settlements and lack of sanitation can easily lead to water pollution and thus to long-term environmental and human-social problems. Location of temporary shelters near animal pathways can lead to dangerous human-animal conflicts.

Other environmental recommendations include:

- Keeping sources of contamination away from water sources
- Avoid dumping debris in waterways that may cause flooding/pollution
- Careful management of water and sanitation are key to preventing diseases

Women's leadership often emerges when communities struggle to recover after a disaster. Enarson and Morrow (1998) document how a *Women will Rebuild* coalition was formed in Miami after being hit by Hurricane Andrew in 1992, which was successful in "achieving visibility for women's needs in disaster, influencing the distribution of relief funds, and challenging male power structures, including control over post-disaster reconstruction" (Enarson and Morrow 1998: 178). Examples from Nepal in the aftermath of the 2015 Earthquake also show how women's organizations have been instrumental in the recovery process and reaffirm that disaster recovery efforts can also be a time for challenging and resetting gender relations. In Nepal, restrictive social norms limited the access of single/widowed women to post-disaster recovery efforts. The period of mourning for 13 days after death of the husband when women were restricted from touching anyone or eating anything restricted their ability to meet their needs (Mawby and Applebaum 2018: 17). In many instances, Nepali men were absent in the communities because they were outside the country for work, had been participating in the civil war, or killed in the conflict. This meant women had to take responsibility for recovery efforts. This was the context that Nepali women's civil society organisations (CSOs) stepped in, and in doing so, "the work of women's CSOs helped create a stronger recovery that more thoroughly addressed the needs of Nepali communities. A more robust societal recovery helps reduce future instability and advancing the status of women and enabling their full participation can yield a stronger response to multi-layered instability." (Mawby and Applebaum 2018:19).

Indeed, as UNDP *et al*. (2010) note, it is important to address gender inequalities in recovery efforts and long-term development strategies so that they are not perpetuated leading to the same vulnerabilities in the future too. This requires a "holistic approach that engages all recovery actors and embeds gender in all disaster recovery planning activities, from reviewing national policies to post-disaster evaluations" (UNDP *et al*. 2010: 10).

PHASE III. RECONSTRUCTION

This phase usually takes place months to years after a hazard event and involves returning livelihoods to «normal» or better than before, rebuilding houses, infrastructure, and businesses. Main actors are neighbours and communities, government, humanitarian and development agencies and the private sector. This phase is much more effective where there are reconstruction plans and guidelines for building back better and greener (**Figure 9.5**).

Figure 9.5 Haiti post hurricane Matthew 2016.
© UNEP

Challenges during the reconstruction phase:

- Location and proper planning of reconstructed housing
- Unsustainable sourcing of construction materials
- Proper infrastructure planning, e.g. water supply or road access
- Waste and debris management
- Cleaning up in sustainable way
- Including ecosystems in reconstruction plans to reduce future risks

Environmental considerations should be carefully included in this phase as building back better and greener is possible in most cases. The potential of ecosystem restoration and creating green infrastructure for DRR should be considered as well. In many cases, it may be necessary to relocate settlements if they were constructed in inappropriate locations away from hazard-prone areas. It is necessary to avoid sourcing building materials from unsustainable sources, for instance excavating sand from dunes on coasts or taking down forests on steep slopes, which could degrade natural protection functions and thus increase vulnerability of already affected populations to future hazard events.

Also, production processes for building materials that might harm the environment should be avoided or improved. Sustainable waste and debris management continue to offer challenges as well as ensuring that the clean-up process does not cause long-term damage. For example, in Sri Lanka, following the 2004 South Asian Tsunami, the beach clean-up created more damage than the hazard event itself, because the clean-up led to the spread of invasive species (Sudmeier-Rieux *et al*. 2013).

Post-disaster efforts may also reinforce social and gender inequalities in many ways "by distributing resources to male head of households, by provisioning traditional male occupations, ignoring women's small enterprises, by seeking support and decision making only from make leaders" (Drolet *et al*. 2015: 438). Most Post Disaster Needs Assessment would include chapters on gender in recovery and reconstruction, usually gender would be considered a cross-cutting topic affecting any other sector investigated (Hinzpeter and Sandholz 2018).

Women and men's contribution in the reconstruction phase may be different depending on the social context. Women may do more work relating to water and food provision and care jobs within the household. They may also be actively involved in rebuilding efforts and agricultural work that were considered 'men's work'. For example, in Pakistan, although many women in affected communities abided by strict laws regarding social interaction outside the household, the post-disaster recovery efforts saw them involving in labour outside home, alongside men (Drolet *et al*. 2015). They also note that "Living in poverty as part of a marginalised group creates few opportunities to build up the resources needed to fall back on at a time of disaster. Social protection initiatives that provide access to essential services and income, including protection from the risks of disasters, is a universal human right and contributes to building resilience by improving economic security, health, and well-being" (Drolet *et al*. 2015:445). Therefore, it is important that women and all affected people and groups are involved in decision-making in the post-disaster reconstruction planning. The long-term challenge is to build sustainable livelihoods. Example of a similar intervention by an NGO called Pattan drawing from a UN study is included below.

Gender-sensitive reconstruction efforts in Pakistan

Pattan, an NGO with a long history in development and disaster assistance, began work with flood-affected communities in 40 Pakistani villages in 1992. Pattan staff identified weaknesses in flood mitigation and preparedness programs, including an inadequate warning system, absence of community organizations, lack of community participation in flood response, and failure to recognize how disasters affect women and men differently. Pattan set out to improve community flood response by integrating disaster reduction strategies into development policies and projects and incorporating a carefully thought-out gender perspective into its disaster response program. Pattan began by organizing forums to encourage community participation in projects addressing disaster preparedness, response, and recovery. However, the practice of sex segregation prevented women from joining the forums in most villages. Women asked that Pattan organize parallel women's forums. These forums soon became the primary vehicle for women's representation and participation in disaster assistance projects. Male staff could not interact with women in the community, so Pattan recruited and trained female staff to ensure women's needs were assessed and addressed. The forums also offered gender training for its staff and analyzed the gender impact of all of its programs. Women were responsible for distributing food, and households were registered in women's names during distributions to ensure female-headed households and women in polygamous households received assistance. Pattan also involved women in housing reconstruction. Traditionally, the house of a married couple was owned by the husband. However, Pattan persuaded communities to register houses constructed with project funds in the names of both wives and husbands. Before construction began, couples signed a contract stipulating that, in the event of divorce or separation, whoever remained in the house had to pay half its value to the former spouse. Interviews with the women revealed that home ownership had dramatically increased women's status in their families and communities and increased their participation in decision-making processes.

Adapted from Swoebel (2000) *Unsung Heroines: Women and Natural Disasters* Gender Matters, Information Bulletin No. 8, US Agency for International Development.

9.3 Ecosystem management and disaster prevention

The previous stages described belong to various states of the post-disaster management cycle. The pre-disaster, prevention phase should be a continuous process throughout disaster management, which unfortunately often only receives higher priority once a disaster has struck, causing governments and NGOs to take up disaster prevention with more urgency.

PHASE IV. PREVENTION

Prevention is multi-faceted, involves several elements and can include both structural and non-structural measures. This section will consider the following elements in disaster prevention:

Preparedness
Early warning, emergency drills and evacuation

Risk and vulnerability assessment
Analyze and assess risk for prevention

Development and long-term risk reduction
Planning procedures and ecosystem management to reduce vulnerability and exposure and increase resilience

Although gender is often not seen as important to factor in while making disaster plans, the recognition of specific conditions that make women vulnerable necessitates that gender be especially considered in disaster prevention and preparedness strategies. Myers (1994: 15–16) elaborates on how gender can be incorporated into the components of disaster prevention and preparedness (see **Table 9.2**).

Table 9.2
Gender concerns to be addressed at various stages of disaster preparedness activities.
Adapted from Myers 1994

DISASTER PREPAREDNESS ACTIVITIES	GENDER CONCERNS SPECIFIC TO THE ACTIVITY
Public awareness raising	Including and appropriately targeting women in educational campaigns designed to prepare populations for disasters Tapping women's talents as informal educators Taking into account women's heavy domestic workloads when designing training schemes
Assessing vulnerabilities	Considering how women might be vulnerable within the high-risk communities identified
Hazard mapping	Taking into account indicators based on women's needs and coping strategies Listening to women at the grassroots level
Provision of baseline information	Disaggregating vulnerable population at the minimum by sex
Establishment of early warning systems	Using appropriate media to ensure you are reaching all sectors of the population, especially women and children Ensuring women can take part in rehearsals
Practice of emergency drills	Ensuring women can take part in rehearsals Planning drills keeping women's domestic time tables in mind Realistically simulating cultural norms in the society
Stockpiling food and materials	Stockpiling materials with women's needs in mind Including obstetric/gynecological medicines/ equipment in medical supplies Ensuring that supplementary food items correspond with local cooking customs
Training emergency response teams	Ensuring that 'in the heat of the moment' women will not be side-lined and rendered even more vulnerable Planning to encourage women survivors in the disaster relief process Being careful to not have the relief plans overburden women as careers and thereby create unforeseen problems further down the line Anticipating the gender dynamics/conflicts that will inevitably be brought on by trauma
Development of a community-based approach to DRR	Consulting women at every stage Wording the plan such that it does not assume that women are victims and disaster planners and responders are only men Building on women's strengths in the plans

PREPAREDNESS

Disaster preparedness is one of the objectives of the HFA and SFDRR and one of the areas where governments have made most progress as self-reported, between 2007 and 2011 (**Figure 9.6**).

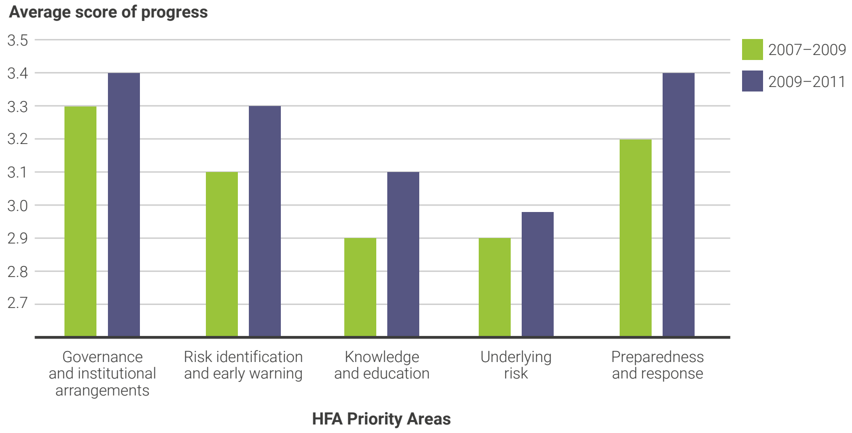

Figure 9.6
HFA progress reports, 2007-2011.
Source: UNISDR 2011 Redrawn by L. Monk

Disaster preparedness is often one of the first elements that is prioritized in DRR. Preparedness is often a highly effective way of saving lives by reducing people's exposure temporarily during a hazard event through evacuation. Preparedness can make use of highly sophisticated early warning systems or be based on local knowledge and observations of pending hazard events (**Figures 9.7**, **9.8**).

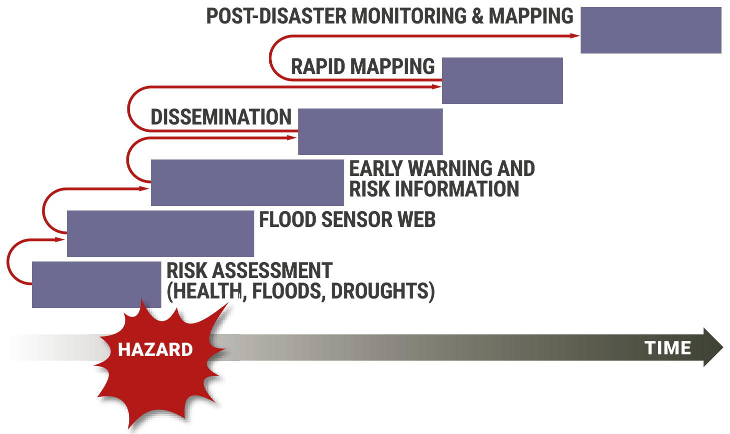

Figure 9.7
An example of the Indonesian tsunami early warning system, from the German Aerospace Center.
Credit: DLR, Szarzynski. Redrawing by S. Plog

Disaster preparedness is intended as a response to potential hazards but it does not necessarily address underlying causes of risk, which require more development-oriented solutions. For example, a flood early-warning system will enhance the disaster preparedness of a coastal community by prompting early evacuation, but in order to effectively reduce disaster risk over the long-term, their relocation to a less flood-prone area would be necessary. Relocation is, however, a very difficult social and cultural issue, which is not always easily acceptable by communities.

Figure 9.8
A local tsunami warning system in American Samoa
© B. McAdoo

RISK AND VULNERABILITY ASSESSMENTS

In a perfect world, any area at risk from a hazard event would have a **risk map** or at least a **hazard map** that provide the basis for land use or urban planning in order to reduce risks (Zimmermann *et al*. 2005). Such maps provide guidance to municipalities and homeowners about which areas should be avoided for future constructions. In some countries, risk and/or hazard maps may be mandatory and form an important basis for land use or urban planning. We will discuss this important aspect in more detail in Chapters 10 and 11.

Maps can establish non-construction zones or provide information to insurance companies which may reduce the likelihood of obtaining insurance for homeowners in high risk areas. However, in practice, many risk/hazard maps are only developed after a disaster has occurred.

In recognition of the linkages between ecosystem services and disaster risk, there are a few but increasing number of risk / hazard maps that also incorporate ecosystem services. One example is from West Africa where the entire coast of 11 countries has been mapped illustrating ecosystem services and coastal risks.

DEVELOPMENT AND LONG-TERM RISK REDUCTION

Addressing the drivers of vulnerability, such as poverty, environmental degradation, governance issues, etc. is the goal of sustainable development, which when well thought out to include DRR and CCA has the potential to reduce risk in the long-term. Ecosystem-based approaches are of major importance here because, as seen throughout this book, well-managed and conserved ecosystems provide services to enhance protection against hazards, avoid or reduce the magnitude of hazards, while providing vital services to communities that can also help CCA.

ADDITIONAL RESOURCES FOR THIS CHAPTER

SPHERE Project provides minimum standards in humanitarian response and includes environmental considerations:
www.sphereproject.org

UNEP's Training toolkit: Integrating the environment into humanitarian action and early recovery:
http://postconflict.UNEP.ch/humanitarianaction/training.html

WWF's Greening the Recovery Training Toolkit for Humanitarian Aid:
www.green-recovery.org

For more information on environmental emergencies:
http://www.unocha.org/what-we-do/coordination-tools/environmental-emergencies

9.4 Conclusions

Disaster risk reduction can be seen as a spiral consisting of four phases: Relief, Recovery, Reconstruction and Prevention. Ecosystem and gender considerations can and need to be taken into account through each phase of the DRR spiral. Within the first two phases of relief and recovery, the main importance is to protect vital ecosystems and their services and to minimize any further damage. Ensuring environmental contingency plans and rapid environmental assessment procedures are in place is important to help in this stage where environmental considerations often take the back seat compared to saving lives. The period of reconstruction provides the opportunity to "build back better" and include an ecosystem approach. The prevention phase is often where the majority of the work on incorporating Eco-DRR/EbA can be undertaken. The next chapters will detail tools for Eco-DRR/EbA.

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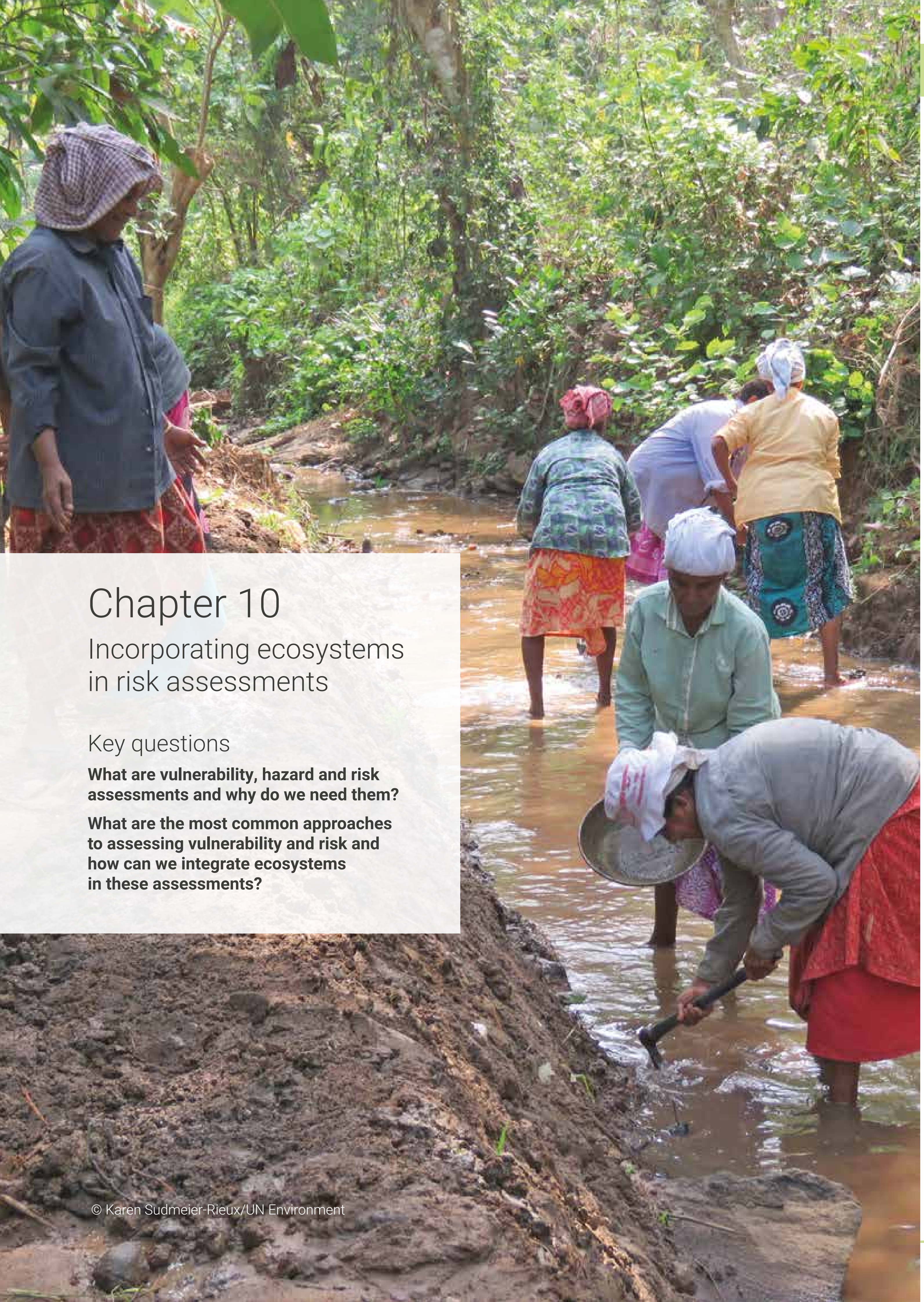

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Chapter 10

Incorporating ecosystems in risk assessments

Key questions

What are vulnerability, hazard and risk assessments and why do we need them?

What are the most common approaches to assessing vulnerability and risk and how can we integrate ecosystems in these assessments?

10.1 Vulnerability, hazard and risk assessments

Let's first quickly revise the concept of "risk". Risk refers to potential losses and is composed of three main elements: hazard, vulnerability and exposure. This is the most commonly used definition given by UNDRR. If there are no potential losses, (i.e. if a hazard event takes place in a remote area with no population, infrastructure or other resources of value), then there is no risk, even if there is a hazard.

Risk = Hazard * Exposure * Vulnerability

The basic idea behind establishing a risk assessment is to reduce the likelihood of future damages and human suffering due to hazard events. This is why one of the first steps in establishing an integrated risk management plan is to assess the risks, or potential of loss to a population over time. The next step is to communicate these risks and take the appropriate measures to reduce them. We often communicate risk through maps, whether they are simple hand drawn representations or more data dependent Geographic Information System (GIS) maps. However, there may be many other ways of communicating about immediate or pending risks, depending on cultural norms, such as through oral history, songs, or street theatre (**Figure 10.1**).

In some countries, risk assessments are mandatory and an important part of land use planning. For example, in France, "risk prevention plans" are stipulated by law and contribute to managing risk by defining areas on which construction is allowed.

The local French State representative, "*the préfet*", enforces this law, which usually goes through a public participation process where citizens can give advice on the zonings and contest them. However, in the end the "*préfet*" must enforce the law, which indicates for example that no construction is allowed in "red" or high risk zones (Pigeon 2017). Usually, risk maps are an important part of this process.

In Switzerland, federal laws since the 19th century provided the basis for protection works by local governments. In 1991 and 1994, new laws required local governments (*cantons*) to perform hazard assessments as part of land use planning, emergency management, and to determine the cost efficiency of structural and non-structural measures (Zimmermann *et al*. 2005). The Swiss have two binding instruments to implement these laws: "hazard indication maps" and "danger maps", which have been established for most municipalities that are affected by some type of natural hazard. Whereas the Swiss hazard map only depicts the type of hazard on a map, the danger map is the most commonly used instrument. It is particular as it illustrates not only the type of hazard and where it may occur but also the intensity and probability of occurrence as established by various return periods (0-30 years, 30-100 years, 100-300 years) represented by red, yellow and blue. The use of these colors is quite specific to the Swiss method for depicting hazard occurrence. Other countries may use red, orange and yellow to illustrate high, medium and low hazard zones (or to illustrate risk). However, it is very important to understand which return periods are represented for each category of hazards. It is interesting to note the cost for producing such maps: estimated at around 500 USD (2005 values) per km^2 for the Swiss hazard map and for the danger map, it can take around one year to develop for one municipality (Zimmermann *et al*. 2005).

DEFINITION

The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.

Comment: The definition of disaster risk reflects the concept of 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.

UNISDR 2017

Figure 10.1
Tsunami early warning communications
© B. McAdoo

Once we have such maps, it is up to society, i.e. decision-makers and civil society, to decide on the most cost-effective measures for reducing risk. It may actually be physically impossible to consider a zero-risk situation, and depending on the situation, it can be very expensive and economically unfeasible to completely reduce risk. Often decision-makers have to consider the lowest possible risk considering the economic costs of certain measures and may decide to accept a certain level of risk. For deciding on the extent to which a society can afford to reduce risk, decision makers may use the so-called ALARP principle, "As Low As Reasonably Practicable" (**Figure 10.2**). For example, as a society, we may be willing to spend a lot on making sure that schools, hospitals and retirement homes are made as safe as possible.

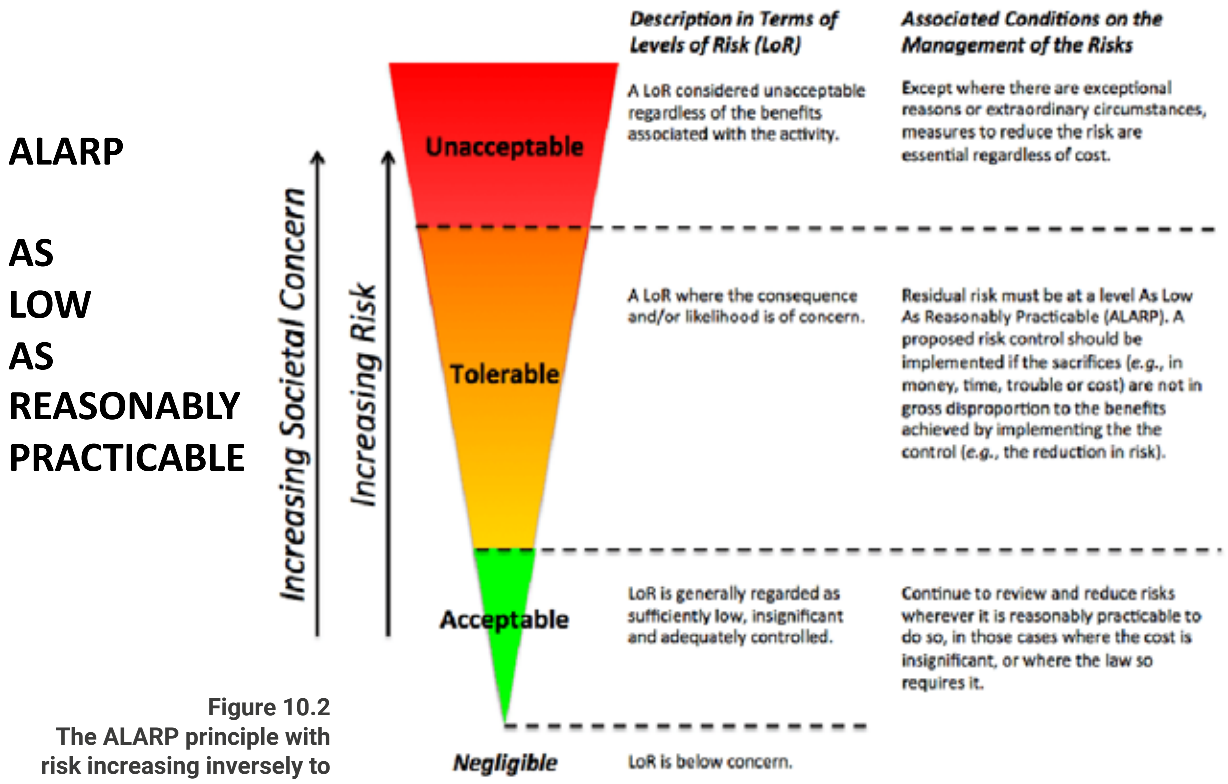

Figure 10.2
The ALARP principle with risk increasing inversely to increasing costs.
Design: L. Rharade, UNEP. Modified from Talbot and Jakeman (2015)

10.2 Common approaches to assessing vulnerability and risk

Depending on your purpose, scope, budget, time and availability of data, there are many ways of developing a risk assessment. There are several assessment methods depending on the study scale, availability of data and aims of the analysis and whether the assessment is to be undertaken through participatory means or is expert-led (Van Westen *et al*. 2006). These can be grouped into qualitative, semi-quantitative and quantitative methods.

We present a simplified overview which provides the basics to understand the difference between vulnerability, hazard and risk assessments and how to integrate data on ecosystems.

Although risk is generally accepted as a function of vulnerability, exposure and hazard, there is no universally accepted equation for calculating risk and the equation will differ depending on the purpose of the risk calculation. Often, risk assessments involve assessing the different parts of the equation, focusing on vulnerability and hazards and finally risk. We can think of a risk assessment in terms of various layers.

VULNERABILITY ASSESSMENTS

Vulnerability is the element of risk that is perhaps the most challenging to assess. To start with, natural or physical scientists assess it in very different ways from social scientists. Natural or physical scientists might consider vulnerability to be the physical damage of a house or of a landscape to a certain hazard. They may calculate vulnerability as the degree of damage to a building quantitatively.

Social scientists or professionals working with NGOs usually combine the assessment of social vulnerability with capacities or so-called **Vulnerability and Capacity Assessments (VCAs)**. The data collected are often very rich and qualitative yet not always easy (but possible) to translate into the kind of quantitative data needed for a risk assessment. For this, we tend to use socio-economic data on income, education levels, and household status, among some of the indicators.

Many types of vulnerabilities arise from conditions linked to ecosystems degradation, including competition or conflict over scarce natural resources in specific ecosystems. So considering the aspects of vulnerability that arise from poor access to or degraded ecosystem services can improve our understanding of the local populations' vulnerability.

HAZARD ASSESSMENTS

Hazard assessments are usually more standardised and less subject to interpretation. Usually, two types of data for hazards are identified: the probability of an event reoccurring, or its return period, and the intensity of the hazard. For these data, historical records, such as well as climate forecasts, to the extent they exist for the area being studied, are used. Where several hazards are present, it is useful to develop a multi-hazard map which provides a more comprehensive overview of all hazards that can occur. The data used for this can be high quality GIS data or can be drawn from local knowledge using drawn or 3-D maps to capture information where no digital information exists (**Figure 10.3**).

Figure 10.3
Participatory 3D mapping in the Democratic Republic of Congo.
© UNEP

RISK ASSESSMENTS

Since risk assessments often require quite involved data collection and expertise, we often find that many NGOs and local governments focus on vulnerability and hazard assessments. But in order to develop the complete risk assessment, the final piece of data we need is on exposure. Data on exposure can be collected from satellite images, household surveys or other population statistics.

The risk assessment usually takes the form of a risk map (**Figure 10.4**)

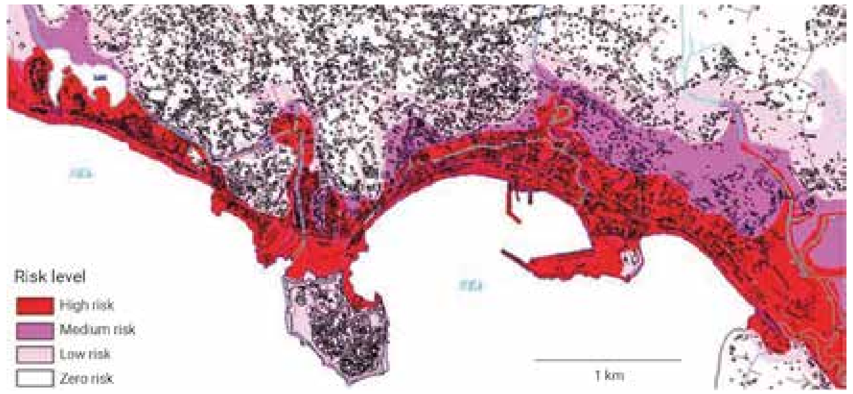

Figure 10.4
Tsunami risk map for City of Galle, Sri Lanka.
© Hettiarachchi/UNDP 2011

A well-developed risk map will show areas at high, medium to low risk and will qualify what this means in terms of expected return periods of the hazard. The scale can be a neighbourhood, a district or even global depending on the scope. Thus, quite a lot of data and expertise are required to develop risk maps.

Risk can also be represented as risk curves. For example, societal risk represented in Frequency and Number of Fatalities Curves (F-N Curves) F-N curves or annualized risk total in probabilities and losses. F-N curves relate the probability per year of causing N or more fatalities (F) to N. Such curves can be used to express social risk criteria and safety levels of facilities. **Figure 10.5** illustrates the Hong Kong Government Risk Guidelines (HKGRG), which were developed for a hazardous installation but also provides a good example for natural hazards using a F-N curve.

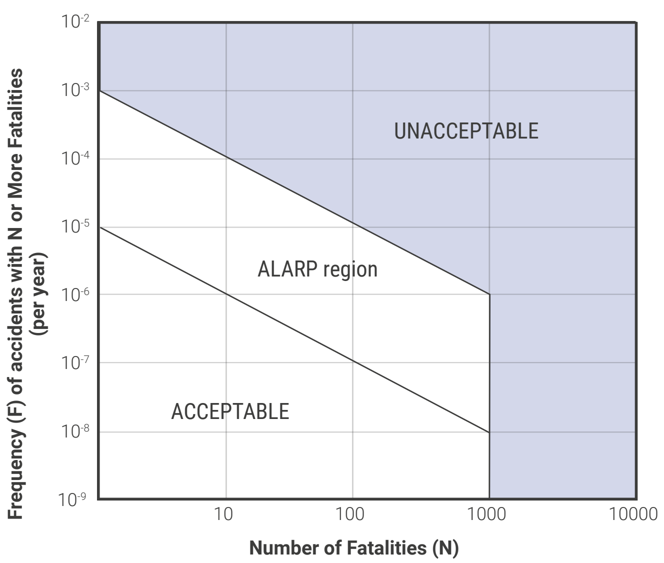

Figure 10.5
Hong Kong Government Risk Guidelines for hazardous installations and example of F-N curve.
UNEP, modified from HKGRG

"Individual risk is the predicted increase in the chance of fatality per year to an individual due to a potential hazard. The individual risk guidelines require that the maximum level of individual risk should not exceed 1 in 100,000 per year i.e. 1 x 10-5 per year. Societal risk expresses the risks to the whole population. The HKRG is presented graphically in Figure 10.5 in terms of lines plotting the frequency (F) of N or more deaths in the population from incidents at the installation. Two F-N risk lines are used in the HKRG that demark "acceptable" or "unacceptable" societal risks. The intermediate region indicates the acceptability of societal risk is borderline and should be reduced to a level which is "as low as is reasonably practicable" (ALARP). It seeks to ensure that all practicable and cost effective measures that can reduce risk will be considered."[3]

Various community risk assessment tools are available, ranging from participatory mapping of risks and resources to a social or institutional network analysis. Especially for the development context, various handbooks on participatory assessments have been developed by international institutions such as CARE or UNEP to address both CCA and DRR in the context of better environmental management (see box below).

EXAMPLES FOR COMMUNITY RISK AND VULNERABILITY ASSESSMENT TOOLS

CRiSTAL– Community-Based Risk Screening Tool – Adaptation and Livelihoods is a tool designed to help project planners and managers integrate climate change adaptation and risk reduction into community-level projects. Developed by IISD, SEI and IUCN. *(https://www.iisd.org/cristaltool/)*

Climate Vulnerability and Capacity Analysis Handbook, developed by CARE, which assesses hazard impacts on each of the five categories of livelihood resources and provides a framework for community-based adaptation. (*http://www.careclimatechange.org/index.php?option=com_contentandview=articleandid=25andItemid=30*)

The Vulnerability and Impact Assessments for Adaptation to Climate Change – VIA Module (UNEP), which assesses climate change impacts on ecosystems and human well-being. (*http://www.UNEP.org/ieacp/climate/*)

CEDRA – The Climate Change and Environmental Degradation Risk and Adaptation assessment
(by Tearfund) analyses risks posed by climate change and environmental degradation and supports NGOs in understanding communities' experiences of environmental change. (*http://tilz.tearfund.org/en/themes/environment_and_climate/cedra/*)

3 Source:http://www.epd.gov.hk/eia/register/report/eiareport/eia_1252006/html/eiareport/Part2/Section13/Sec2_13.htm

CLIMATE CHANGE VULNERABILITY ASSESSMENTS

For CCA purposes, assessments undertaken are generally Vulnerability and Impact Assessments (VIA). They involve similar steps to those described above but additionally focus on future climate change scenarios to assess vulnerability to and impact from climate change. There exist different climate models at global and regional scales as well as different scenarios for future change (IPCC 2013) that can be used to predict future vulnerability. These are often also analysed and presented in map form or a matrix form. Depending on the scale of the assessment, however, the use of global or regional models is not possible because they are too coarse. Another option is creating future scenarios with stakeholders and deriving future risk that way (see WWF 2013 for steps for a VIA for EbA).

10.3 Integrating ecosystems in risk assessment and mapping

Each step of the risk assessment process can be related to ecosystem conditions and ecosystem mapping. Adding one more layer of data on ecosystems can improve vulnerability, hazard and risk assessments by providing additional information on the interface between the risk components and ecosystem properties. Depending on the level of the assessment, you can use qualitative data from communities on how well their ecosystems protect them from hazards or you can include more formal data on ecosystem services, either through natural resources or habitat surveys. You could also include not just the location of key habitats but also information on their level of health or degradation which affects their protection or buffering functions against a certain hazard. This may require working across disciplines, i.e. with biologists or ecosystem experts in order to integrate such information.

There are various open source models that can be used for modelling the relationship between natural capital, or ecosystem services and hazards, such as InVEST by the Natural Capital Project (see Chapter 11).

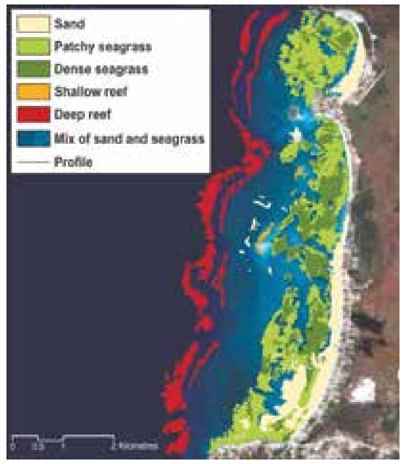

Figure 10.6
Habitats of Negril, Jamaica.
© UNEP 2010

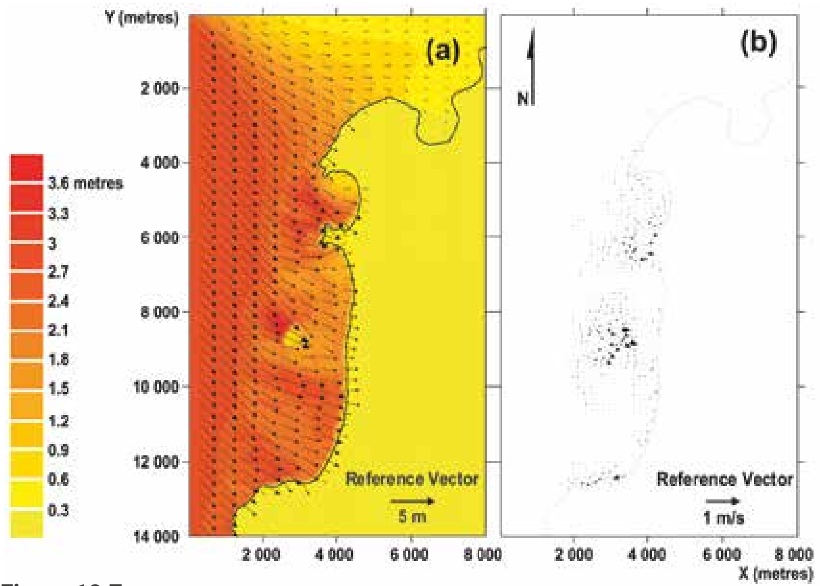

Figure 10.7
Modeling waves and currents. Numerical model results for wave heights (a) and wave-induced currents (b) at the Negril coast. Conditions: Offshore wave height (Hrms) = 2.8m, Tp= 8.7s. Waves approach from the northwest. Note the diminishing wave heights and changed nearshore flow patterns at the lee of the shallow coral reefs. © UNEP 2010.

THE RISK AND VULNERABILITY ASSESSMENT METHODOLOGY DEVELOPMENT PROJECT (RiVAMP)

RiVAMP (UNEP 2010) was conceived to develop an assessment tool that takes into account ecosystems and climate change factors in the analysis of disaster risk and vulnerability. Implemented in 2009, the project aimed to assist national and local government decision makers in evaluating their development options effectively by recognizing the role of ecosystems in reducing risk and adapting to climate change impacts. It involved a scientific assessment, which undertook remote sensing to identify ecosystem functions, modelling of exposure to storms and statistical analysis, and stakeholder consultations to identify the main drivers of ecosystem degradation and assess awareness of environmental and disaster linkages.

It specifically targeted Small Island Development States (SIDS) and other coastal areas that are highly vulnerable and exposed to tropical cyclones and related hazards (storm surges, landslides, flooding) and to accelerated sea level rise. The RiVAMP methodology was pilot tested in Jamaica. It uses information such as location of key ecosystems (**Figure 10.6**), waves and currents and modelling how corals reduce wave height (**Figure 10.7**) in order to map the exposure of population and assets to storms with different return cycles (**Figure 10.8**).

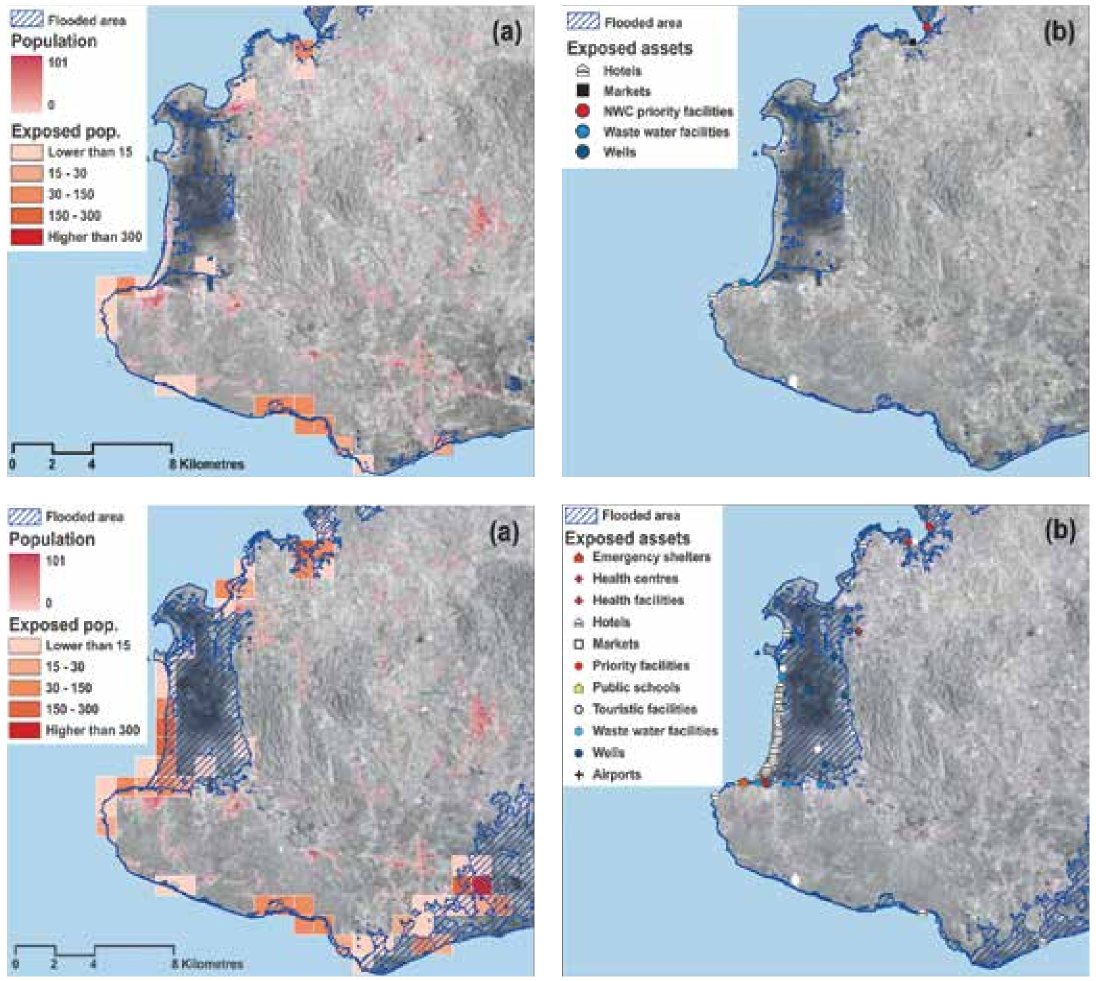

Figure 10.8. Exposure of population and assets to ten-year return period storms (*top*) and fifty-year periods storms (*bottom*). Return period exposure for a) population, b) asset
© UNEP 2010.

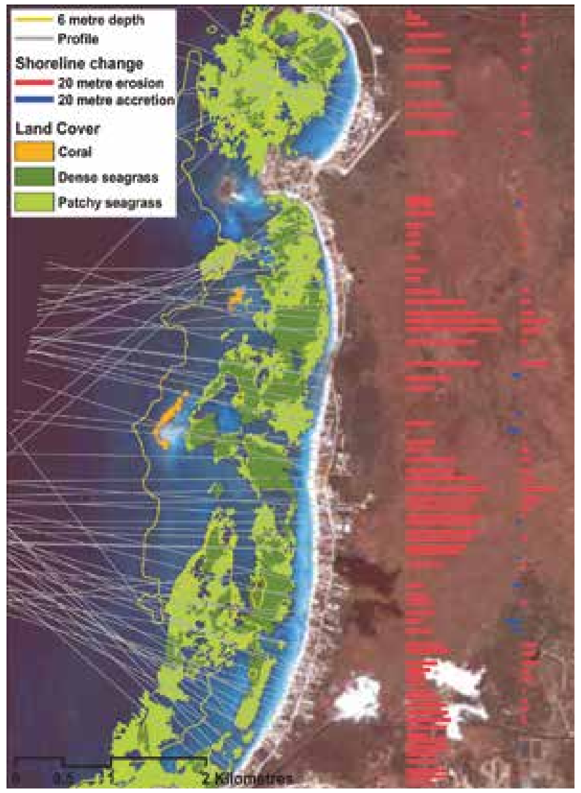

Figure 10.9
Shoreline erosion over time as compared to ecosystem services.
© UNEP 2010

The RiVAMP project conducted by UNEP in Negril, Jamaica, also developed a methodology for assessing the relation between ecosystem services, in this case coral reefs, and seagrasses in relation to coastal erosion (**Figure 10.9**). This hazard map shows how degradation of the coastal ecosystem services led to increased coastal erosion of one of Jamaica's most famous beaches, Negril. It also compares coastal erosion over two time periods 1968-2006 and 2006-2008.

The project involved community consultations and mapping to document environmental changes that have led to increased vulnerability of the community in Negril. By doing so, it helped raise awareness among local stakeholders about the importance of protecting its natural infrastructure.

UNEP OPPORTUNITY MAPPING FOR ECOSYSTEM-BASED DISASTER RISK REDUCTION INITIATIVE

This initiative has developed global datasets to visually compare on a global-scale map, ecosystem cover and population exposure to hazards in order to find opportunity areas where ecosystem management (restoration or conservation) can be used to protect the highest number of people (**Figure 10.10**).

Datasets on different types of ecosystems and physical exposure to various natural hazards are aggregated globally on a 10 x 10 kilometre resolution grid. The area covered by each ecosystem type is measured, and the physical exposure of the population calculated for each grid cell.

A given hazard exposure is then combined with a given type of ecosystem coverage. As each ecosystem type is only effective for exposure reduction of specific types of hazards (e.g. corals can reduce cyclone surge and tsunamis but have no influence on landslide hazards), cross-mapping between ecosystem coverage and hazard exposure was performed only with a selection of ecosystem-hazard combination (**Table 10.1**).

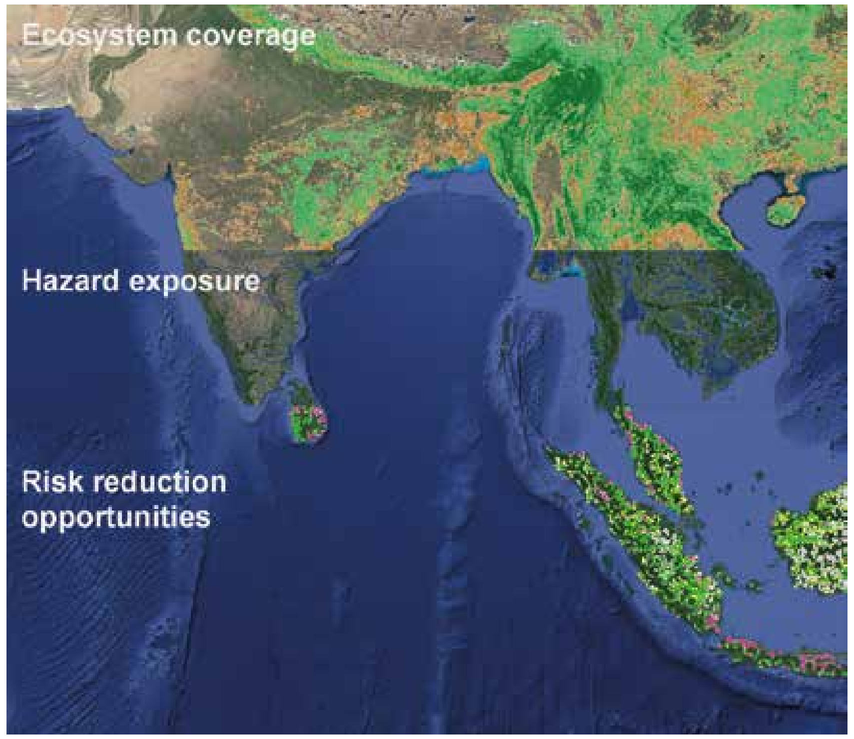

Figure 10.10
Example of input (ecosystem coverage, hazard exposure) and output (risk reduction. opportunity at global and national level).
© UNEP 2019

Table 10.1
Selected hazard-ecosystem combinations
(✓ = applies, ✗ = does not apply)
Source: UNEP/GRID-Geneva, 2016

	Tsunami	Cyclone wind	Cyclone surge	Landslide	Flood
Forest	✓	✓	✓	✓	✓
Mangrove	✓	✗	✓	✗	✗
Sea grass	✓	✗	✓	✗	✗
Coral reef	✓	✗	✓	✗	✗

Each ecosystem-hazard combination is split into six categories which represent the potential of the ecosystem type in reducing exposure to that specific hazard and the recommended Eco-DRR action (**Figure 10.11**).

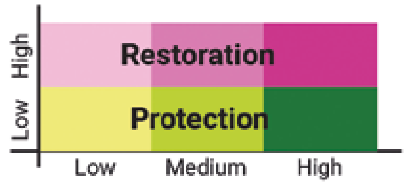

Figure 10.11
Eco-DRR opportunity categories.
© UNEP 2019

Using six categories allows the user to easily differentiate colours on maps and figures and identify:

- the level of exposure for a given hazard;
- the level of coverage by a given ecosystem;
- the type of priority action to be undertaken.

By comparing the categories on the map, the user can identify areas where ecosystem-based solutions can be applied to reduce exposure, and the type of action required (ecosystem protection or restoration).

Two types of products are available:

- A "Global" product which allows comparison between countries. In this product, the Eco-DRR opportunity categories are relative to all other countries in the world and the resolution is coarse (10x10 km grid).
- "National" products which allows analysis for certain countries. In this product, Eco-DRR opportunity categories are only relative to other grid cells within the same country and the spatial resolution is higher, depending on data availability.

10.4 Conclusions

According to OECD (2012), there is a need to develop and share best practices, methodologies and standards to ensure data harmonization and standardization initiatives for calculating risk. There are a few initiatives for harmonization such as the Integrated Research on Disaster Risk (IRDR), the International Disaster Database (EM-DAT), DesInventar, UNEP's PREVIEW and the Global Earthquake Model (GEM) (see "data sources" below). However, with few exceptions there has been little attempt to incorporate data on ecosystem degradation or ecosystem services as part of risk assessments. The few exceptions include the RiVAMP project, the UNU World Risk Report (2013) and the PREVIEW Global Risk Data Platform. There are also very few examples of risk assessments that consider green infrastructure as alternative scenarios to grey infrastructure for reducing risk, where appropriate. This is thus a new area of research and innovation that is still in its infancy.

ADDITIONAL RESOURCES FOR THIS CHAPTER

Opportunity mapping
http://EcoDRRmapping.grid.UNEP.ch.

Coastal Restoration and Superstorm Sandy
http://cdnapi.kaltura.com/index.php/extwidget/preview/partner_id/1012331/uiconf_id/24075381/entry_id/0_s8hef17v/embed/dynamic

Information on RiVamp
https://www.unenvironment.org/resources/report/risk-and-vulnerability-assessment-methodology-development-project-rivamp-linking

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DATA SOURCES

DESINVENTAR website:
http://www.desinventar.org/

EM-DAT website:
http://www.emdat.be/

GRID (Global Resource Information Database).
https://unepgrid.ch/en

NatCatSERVICE – Munich Re website:
http://www.munichre.com/natcatservice

PREVIEW Global Risk Data Platform – UNEP/ GRID website:
https://preview.grid.unep.ch/

Chapter 11

Planning tools for ecoystem-based disaster risk reduction and adaptation

Key questions

What planning tools exist to inform Eco-DRR/EbA?

How can spatial data, GIS and remote sensing be used for Eco-DRR/EbA?

What is an environmental impact assessment and how can it contribute to Eco-DRR/EbA?

© Karen Sudmeier-Rieux/ UNEP

11.1 Spatial planning to reduce risks from disasters

First of all, it is important to differentiate between planning and management tools and formal processes (**Figure 11.1**). Planning can be described as a future-oriented approach to allocate land to certain purposes while management aims to achieve or maintaining a certain ecosystem status. Formal process such as environmental impact assessments are also important to consider. Chapter 13 will follow up on the management tools in more detail.

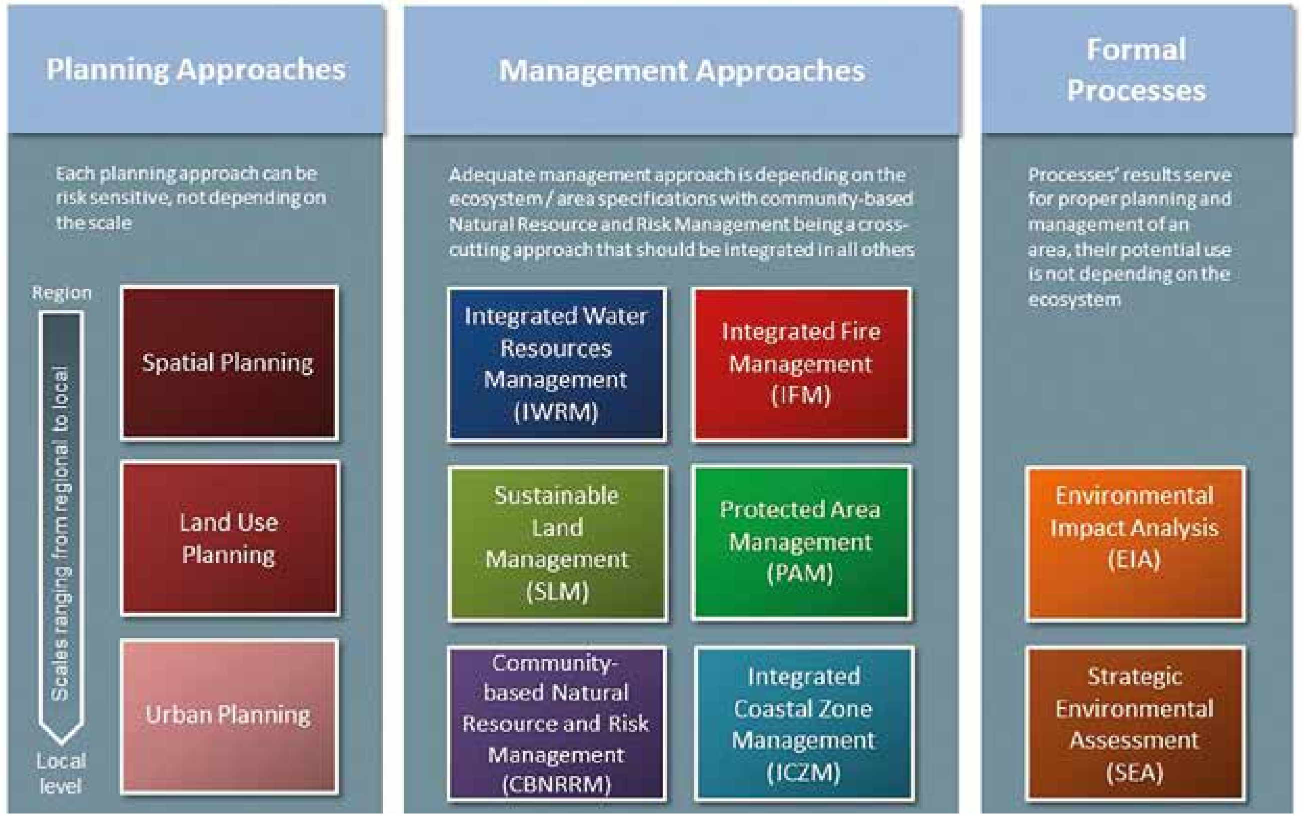

Figure 11.1
Planning and Management Approaches appropriate for reducing disaster risks
© S. Sandholz

Planning can involve both non-spatial and spatial elements. Non-spatial elements can be the enumeration of the resources required, the time-frame the plan will cover, the strategies and actions, the actors involved, etc. The spatial element is of vital importance when planning to reduce risks from disasters because disasters strike areas or regions. Thus, making a spatial plan, whether local, regional or global, helps to prescribe, regulate and determine land utilization for various purposes, such as agriculture, industrial sites, human settlements or protected areas. This is increasingly difficult due to the growing population around the globe.

A spatial plan made on a large scale serves as a basis upon which more detailed plans for urban or rural areas are formulated or upon which sector plans for agriculture or infrastructure development are made. Spatial plans play a significant and influential role in preventing or mitigating losses from hazards and managing environmental risks, because they determine the physical location of activities and investments. In addition, they are increasingly important for CCA – including EbA – to determine areas for action.

GOALS OF SPATIAL PLANNING

- **Organize land uses and the basis for subsequent urban planning or land use planning in rural/semi-rural areas (which is then more detailed);**
- **Promote sustainable development (social, environmental, economic);**
- **Develop access to information and knowledge;**
- **Enhance and protect natural resources and cultural heritage;**
- **Find a balance among multiple demands and competing interests;**
- **Reduce the impacts of hazard events by: restricting development in hazard prone areas; accommodating and planning land use according to levels of risk; zoning and coding; designing infrastructures for hazard reduction.**

Case Study

The Netherlands "Room for the River" programme aims to reduce flood risks while improving quality of life for people living near rivers. It is based on spatial planning and allocating space for different purposes (**Figure 11.2**). The main goal is to increase the safety and improve the overall environmental quality of Dutch river regions by allocating extra room for its rivers. Many of the contentious issues involved in spatial planning revolve around the fact that different sectors value land differently and these values are often in conflict. Land-use planning occurs within a political context and oftentimes, short-term gains take priority over what is sustainable and what will be safe in the future. Such conflicts are logically aggravated by land scarcity, for example in the Netherlands, where limited land resources have to be allocated wisely while allowing for future development and to adapt to climate change impacts. Here the exposed areas along the rivers are no longer considered as constructible zones, in order to reduce flood risks.

The Room for River programme illustrates that spatial planning is always a compromise: if the river banks and retention areas are no longer designated for human use land resources need to be allocated elsewhere for development. This is where involving communities in the decision-making process is critical in order to navigate the trade-offs and forge sustainable solutions.

Figure 11.2
River restoration in Netherlands.
© M. van Staveren

11.2 Participatory rural appraisals for ecosystem-based disaster risk reduction and adaptation

Participatory rural appraisals (PRA), also called Participatory Learning for Action (PLA), are an important planning tool used in development projects because they aim to incorporate and use the knowledge and opinions of the local people (Chambers 1994). They are also non-technology dependant like some mapping or modelling methods often used for planning, which can therefore be more accessible as well as more inclusive. PRA's aim to be as inclusive as possible and thus often use methods of communication and information gathering that does not require writing. Symbols, drawings and oral communications are used such as participatory mapping (**Figure 11.3**).

Some of the main tools used in PRA are:

- Focus groups and (semi-structured) interviews, consultations
- Community mapping, matrix scoring, ranking, timelines, seasonal calendars
- Participatory maps, transect walks, diagrams

Figure 11.3
Participatory risk mapping using coconut leaves in Solomon Island.
© J.C. Gaillard

11.3 Geographic information systems and remote sensing for ecosystem-based disaster risk reduction and adaptation

Spatial data refers to any geographically referenced data (do Carmo Dias Bueno 2011). It means that data are connected to a place on the Earth. GIS, which is short for Geographic Information Systems, is an information or computer system to input, retrieve, process, analyze and output multiple layers of spatial data. A GIS is composed of hardware, software, data and brainware (or the user). Within a GIS, different information layers can be overlaid due to its spatial reference. One of the most important uses of GIS and its capabilities for spatial analysis is to support decision making on land use planning. It can be a great tool for decisions about risk reduction and adaptation. Input data can range from cartographic maps, to field data and satellite images. The most common outputs from GIS software are maps, statistics and tables, charts or databases (**Figure 11.4**).

GIS was for example used to support Eco-DRR/EbA in a small municipality in the South of Haiti (**Figures 11.5**, **Figure 11.6**). The south of Haiti is frequently hit by storms, which cause storm surges and flooding. As discussed in earlier chapters, coastal ecosystems, such as coral reefs, sand dunes, seagrass beds and mangroves, can reduce the impact of storms and subsequent flooding. But like many areas of Haiti, the degradation of ecosystems has resulted in higher risk in this municipality. Since 2013, UNEP has been working with the community and the municipal government to protect the coastal habitats and reduce disaster risk. As a large portion of the population relies directly on coastal ecosystems for livelihoods, protection of ecosystems can also reduce population vulnerability.

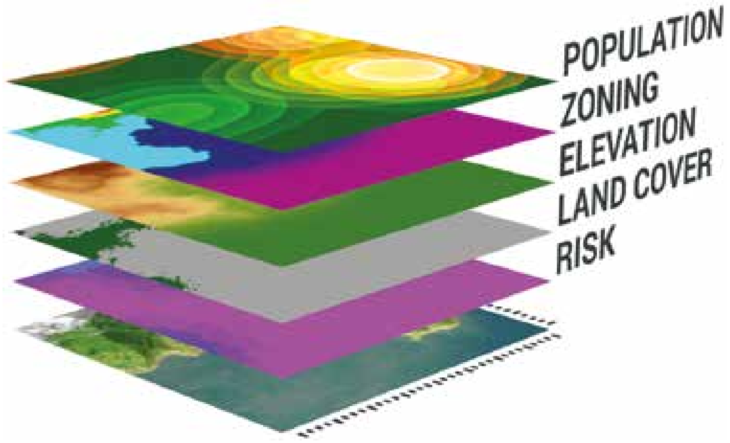

Figure 11.4
Geographic information for spatial planning and risk assessments.
Design: S. Plog

Figure 11.5
Port Salut (South Department) where fishing provides vital income.
© UNEP

Figure 11.6
Map of Port Salut, Haiti.
© UNEP

To use GIS to support this Eco-DRR/EbA project, first baseline data on demographics and geo-physical data such as elevation, water depth and type of shoreline were gathered to better understand the area (**Figure 11.7** and **11.8**). These maps were also complemented by information provided by the local community regarding historical records of storms and changes in ecosystems.

Figure 11.7
Satellite images of the shoreline in Port Salut over the years suggest that the sandy beach is experiencing erosion.
© UNEP 2016

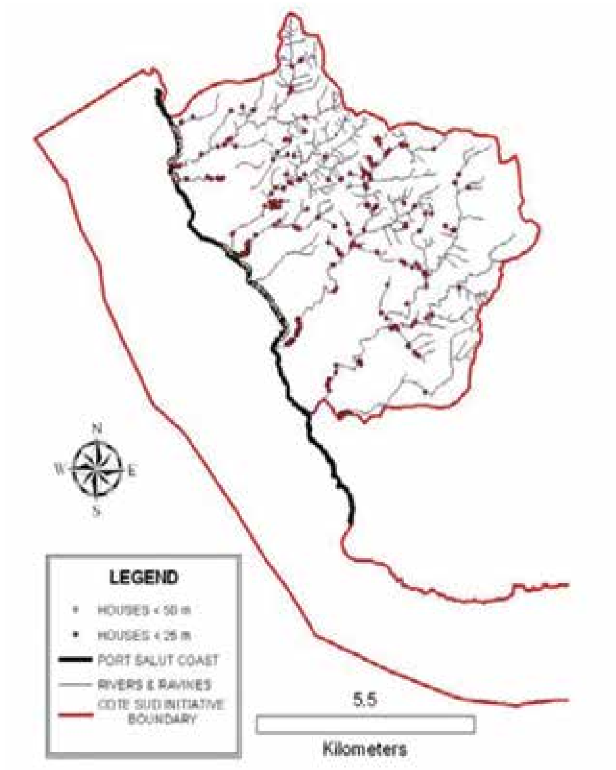

Figure 11.8
Location of exposed buildings to river flooding (within 25 m of water channels) and coastal flooding (within 50 m of the coastline).
© UNEP 2016

Then remote sensing was used to map the existing ecosystems. Remote sensing can be used to monitor ecosystems or land use. For example, satellite images can show changes in the extent of forests or wetlands over time. It can also be used to assess hazards and exposure, for example to track hurricanes or model floods. Remote sensing can provide information that can be used in land use planning for example to reduce impact of urban growth on the environment or prevent sprawl into hazard-prone areas (NOAA 2015).

DEFINITION: Resilience

"Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites."

NOAA 2015

For more information about remote-sensing, please refer to additional material: http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery- products/educational-resources/9309)

Figure 11.9
Port Salut habitat map based on remote sensing and ground-truthed through marine and terrestrial field surveys.

A high resolution satellite image of the municipality of Port Salut was used to map the existing natural coastal ecosystems. A field survey was used to verify, or ground-truth the map and add information about the degradation or health status of coastal habitats using Geographic Positioning System (GPS) devices. The result is a map the types of ecosystems and their location (**Figure 11.9**).

This information was then applied in an open source GIS model, InVEST (Integrated Valuation of Environmental Services and Tradeoffs) developed by the Natural Capital Project. InVEST is a suite of modelling tools that map, measure and value the goods and services that sustain human life while providing several scenarios.

The InVEST Coastal Vulnerability Model was used to determine what areas of the coastline are more exposed to flooding and storm surges, and where habitat conservation or restoration can reduce exposure to hazards (**Figure 11.10**). This model is unique because it includes the protective role of habitats in the exposure assessment. The model was run multiple times with different scenarios of habitat degradation. **Figure 11.10** shows that under current conditions only some parts of the municipality are highly exposed to storms. But if all habitats were to be destroyed in the future, most of the municipality would be highly exposed to coastal hazards. This is where conservation and restoration of seagrasses, coral reefs, mangroves and coastal vegetation would reduce exposure of the municipality while providing livelihoods benefits.

The outputs of the InVEST model are being used in decision making related to land use planning and conservation. In 2013, Port Salut was designated as one of Haiti's first marine protected areas and the results of the spatial analysis are being the basis in the development of a management plan for the protected area.

The Natural Capital Project

"The Natural Capital Project aims to align economic forces with conservation. We are an innovative partnership between Stanford University, The Nature Conservancy, World Wildlife Fund, and the University of Minnesota working together to value nature's benefits to society. We develop tools that make it easy to incorporate natural capital into decisions, apply these tools in select places around the world, and engage leaders to transform decision making by taking up this approach."
https://naturalcapitalproject.stanford.edu/

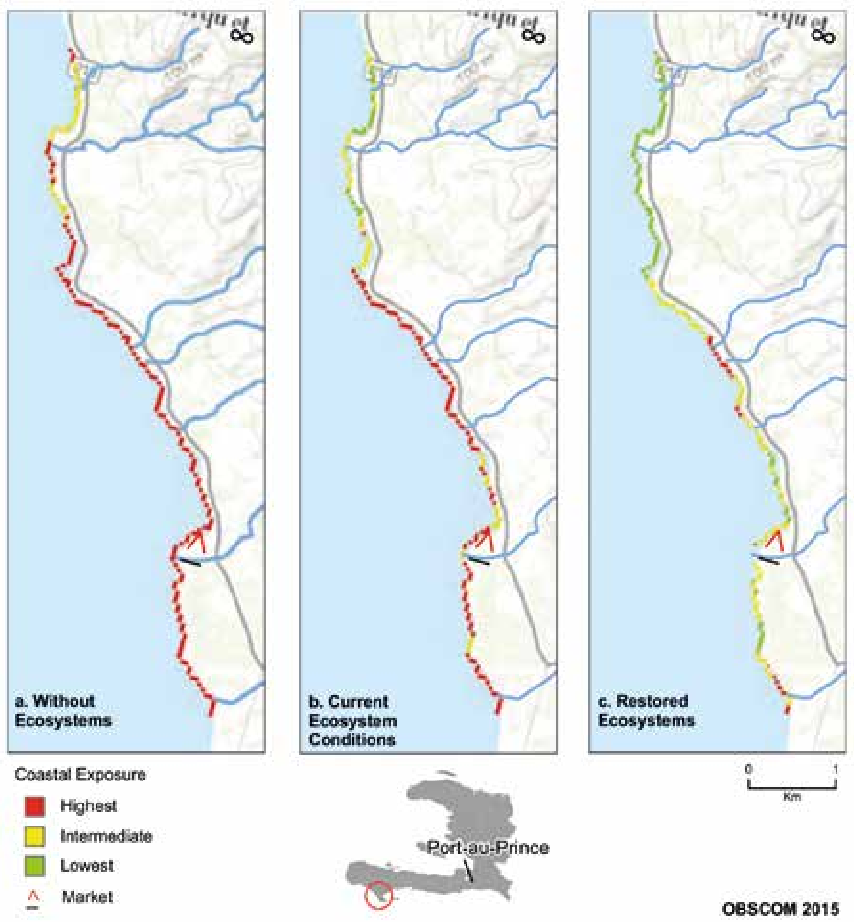

Figure 11.10
Exposure scenarios with and without habitat.

As with any models, InVEST also has its limitations. Furthermore, the terminology used is based on the IPCC terminology prior to 2014, and thus is different from the UNDRR terminology. However, it is currently one of the most advanced open source models available for producing various scenarios of exposure (InVEST refers to this as vulnerability) considering ecosystem services.

SPATIAL MULTI-CRITERIA EVALUATIONS (SMCE)

When resources are limited and several objectives exist that cannot be met simultaneously, we speak of a decision problem. In such situations we turn to spatial decision support systems or spatial planning support systems that help us to make judgments about the facts or expected facts we obtain from GIS and models. They assist individuals to analyze trade-offs, assist groups to understand where compromises can be found and layout possible pathways to make gradual improvements toward several objectives (Boerboom *et al*. 2009).

For example, imagine that the government of a fictional island is proposing a number of measures to reduce risk. A first step will be to determine which measures are the best based on a number of stakeholder-determined criteria. These could be economic, social, and ecological suitability as well as hazard mitigation benefits. Layers of data can then be overlaid in a GIS to find the most optimal alternatives for risk reduction, which can for instance be mangrove restoration along the coastline or establishing protection forests on steep mountain slopes.

DEFINITION:
Environmental impact assessement

"an analytical process that systematically examines the possible environmental consequences of the implementation of projects, programmes and policies"

Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

11.4 Environmental impact assessments

An **Environmental Impact Assessment** or EIA is a formalized and systematic process to identify and evaluate the environmental impacts of a proposed project, such as a road, a dam or some industrial site. EIA can involve the construction, operation, extension, modification or even decommissioning of such projects. The need for an EIA depends on the scale of the project, its location, and the nature and magnitude of the potential environmental impacts. For example, the World Bank has established three categories:

a. 'likely to have significant adverse environmental impacts beyond the project area' and thus requiring a full or comprehensive EIA;

b. 'site-specific potential adverse environmental impacts' which require a limited EIA

c. not requiring an EIA

(World Bank Operational Policy 4.01, Environmental Assessment, January 1999).

Environmental Impact Assessments address goods and services to be protected - they are very similar to ecosystem services as you can see in **Figure 11.12**.

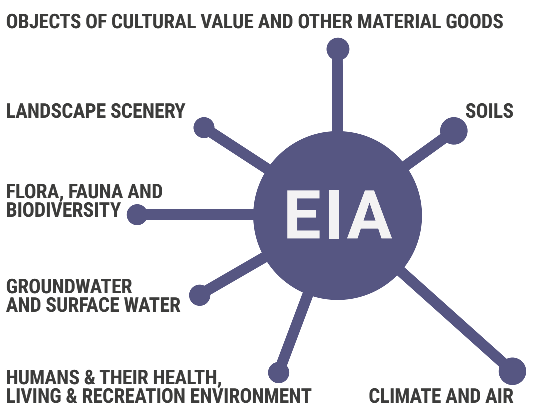

Figure 11.12 Goods and Services to be protected in EIAs. Credits: S. Sandholz and M. Khalifa; Design: S. Plog

An EIA is composed of ten steps (**Figure 11.13**). Consider a plan to construct a dam. The first step is screening to see if an EIA is required. This may depend on the country, the project size or the area. If so, the second step is scoping to identify important impacts the dam construction would have. This is followed by an examination of alternatives. The fourth step is an analysis of the impacts the dam might have.

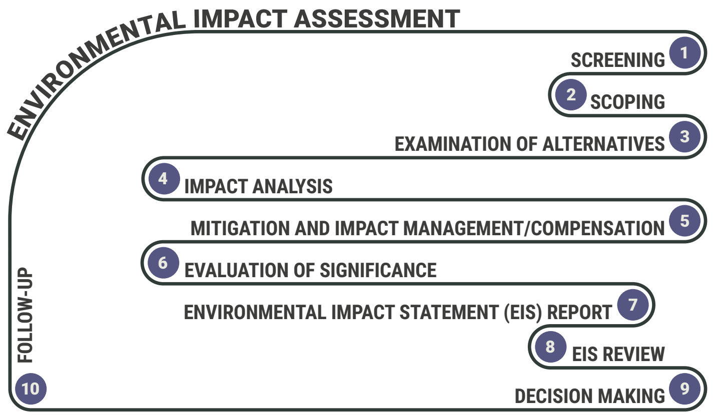

Figure 11.13 EIA steps. Credits: S. Sandholz and M. Khalifa; Design: S. Plog

Next are measures to minimize negative effects on site, or alternatively or additionally some compensation, for example some river renaturation project (**Figure 11.14**) which is not in the dam site. Step six involves analyzing whether impacts that cannot be mitigated are acceptable. Then finally, to approve or reject the dam project, an environmental impact statement report is developed. As a follow-up and last step, a monitoring process is established to see the project impacts and how effective the mitigation measures are.

Increasingly, the EIA is mandatory for planning projects. It is a must in most European countries. It can also serve for Eco-DRR/EbA, especially if it incorporates an assessment of risk.

In summary, EIA is a very helpful tool for better decision making and is used worldwide. But it has its limitations. Indeed, the problems of coherence of EIA for international bilateral aid were addressed by the Working Party of the Development Assistance Committee of the OECD (OECD 2016). A practical guide on this subject was prepared to help both officials in bilateral donor agencies and their counterparts in developing countries. It summarizes the various EIA procedures used by the different agencies and provides two key means of promoting coherence:

- A framework Terms of Reference for the EIA of development assistance projects; and
- A comprehensive checklist for managing EIA.

(OECD 2016)

EIAs are part of an integrated planning process to the extent that two main types of legal provisions are taken into account: general environmental or resource management law, which incorporates EIA requirements and procedures; and an EIA specific law, which can either be comprehensive or take the form of a framework or enabling statute. However, there is no single EIA model appropriate for all countries: for example, some have established a separate EIA authority while in others, the EIA process is administered by environment departments or by the planning authorities. Canada has distinguished its EIA process by applying it only to projects and it applies strategic environmental analysis (SEA) for policy and plans. See below for more information on SEAs.

HOW DO EIAS RELATE TO ECO-DRR/EBA?

By expanding EIAs to incorporate DRR and CCA, they have the potential to be a powerful tool into which disaster risk and climate change concerns can be integrated with development activities. EIAs should also be fully integrated into activities in the post-disaster period in order to help prevent disaster recurrence and to promote sustainability.

Early EIAs focused primarily on the impacts of a project to the natural or biophyisical environment (e.g. effects on air and water quality). Over time, increased considerations have been given to the social, health and ecological consequences of projects. This trend has been driven partly by public involvement in the EIA process and is reflected in the evolving definition of environmental EIA legislation, guidance and practice, which include effects on, among others: human health and safety or on use of land, natural resources and raw materials (Bhatt and Khanal 2009).

Although national policies that integrate environment and DRR are more pronounced in developed than in developing countries, the Philippines offers an interesting example. In 2011, the Department of Environment and

Figure 11.14
River renaturation in Germany.
© Zumbroich Consulting

Resources developed guidelines for integrating DRR and CCA strategies in its EIA processes (see Box).

As illustrated in the Philippines' example, **disaster risk analyses can be incorporated into the EIA process**. Information generated by EIAs can help improve early warning because the EIA process can provide data for risk mapping and scenario building in relation to the potential impacts of projects. Hence, EIAs can be applied to help assess the conditions of hazards and patterns of vulnerability in the context of the developmental planning process. EIA reports also include an environmental monitoring plan. Monitoring parameters usually can cover early signals of potential risks. **EIAs applied in the disaster prevention and mitigation phase can help inform planning for DRR**, for instance by providing guidance on choices mitigation methods (Gupta and Yunus 2004), technology investments and site locations for activities.

In a post-disaster context, conducting a rapid environmental assessment (REA) helps to ensure that sustainability concerns are factored into the relief, reconstruction and recovery planning stages (Gupta *et al*. 2002). The REA does not replace an EIA but fills a gap in an emergency context until an EIA can be appropriately conducted. To conclude on EIA legislations, here is a summary of EIA key international developments.

STRATEGIC ENVIRONMENTAL ANALYSIS

Although EIAs have the significant advantage of being one of the few legally binding environmental instruments, another limitation is that EIAs do not analyse cumulative and large scale environmental and social impacts. Thus, to overcome this limitation, the Strategic Environmental Analysis (SEA) was developed. They can be defined as "analytical and participatory approaches to strategic decision-making that aim to integrate environmental considerations into policies, plans and programmes, and evaluate the interlinkages with economic and social considerations" (OECD-DAC 2006).

The World Bank has reviewed the policies of the energy, rural development and other sectors, in order to integrate environmental concerns at the macro level and has established an environmental framework for its country assistance strategies: it intends to make greater use of SEAs at programme and regional levels. Indeed, the World Bank's broader environmental policy has moved from a 'do no harm' approach to minimizing the adverse effects of its projects, to the use of SEAs as part of a strategy of promoting long-term sustainability (UNEP 2002). Therefore, an increasing number of developed countries and countries in transition now make formal provisions for SEA of policies, plans and programmes. Many developing countries also have planning systems that include elements of SEA. Indeed, the legal, policy and institutional arrangements for SEA are more varied than those for project EIA.

SEAs and EIAs also have many similarities and a common foundation. SEAs were developed largely as a response to the levels and types of decision-making not covered by EIA. In doing so, SEAs have derived, adapted and implemented EIA arrangements, procedures and methodologies, particularly at the plan and programme levels. Other process models also have been adapted, particularly at the policy level where integrative appraisal and environmental "tests" compress the basic steps followed in EIAs, such as screening and reporting.

HOW DO SEAS RELATE TO ECO-DRR/EBA?

In contrast to EIAs, SEAs generally have a broader focus on integrating environmental considerations into policies, plans or programmes at the earliest stages of strategic decision-making. They may be applied to a specific sector or geographical area and ideally prior to the identification and design of individual projects. For example, in Sri Lanka, the Government in collaboration with UNDP and UNEP undertook an Integrated Strategic Environmental Assessment (ISEA) process that took into account major hazards (storm surges, flooding, strong winds, sea level rise and tsunami) in defining a sustainable development framework for post-conflict rebuilding in its Northern Province (PEDRR 2011).

EIA DRR/CCA Guidelines in the Philippines

Environmental Impact Assessment (EIA) Technical Guidelines for Incorporating Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) concerns in the Philippine Environmental Impact Statement System (PEISS; EIA DRR/CCA Technical Guidelines), adopted by Department of Environment and Resources, Republic of Philippines in 2011, intend to promote CCA and DRR at the project level, as well as to streamline EIA requirements under the PEISS. Specifically, the Guidelines aim to:

- provide enhanced standards for the preparation of EIA Reports that are customized for specific industry types as required under the PEISS; and
- to provide guidance for project proponents in integrating DRR and CCA concerns in the project planning stage through the EIA Process to facilitate review and implementation of projects by incorporating international best practices.

These Guidelines were formulated to provide EIA practitioners and stakeholders with:

- an understanding of the implications of disaster and climate change risks in relation to the preparation of an EIA Report;
- direction on a project-specific basis on how disaster risks and climate change need to be considered in an EIA;
- sources of information for use in assessing disaster risks and climate change implications, and guidance in incorporating DRR and CCA considerations into the EIA process.

Thummarukudy and Kanwar 2014

Key international developments in EIA law, policy and institutional arrangements in the last decade:

Rio Declaration on Environment and Development calls for use of **EIA as an instrument of national decision-making** (Principle 17); other principles also relevant to EIA practice (e.g. Principle 15 on the application of the precautionary approach).

UN Conventions on Climate Change and Biological Diversity (1992) cite **EIA as an implementing mechanism** (Articles 4 and 14 respectively refer).

EIA requirements and procedures applied by **international financial and aid agencies** to loans and projects in developing countries.

Amendment of EC Directive on EIA (1997) required all member states to be in compliance by 1999; also being transposed into the EIA laws of certain countries in transition, which are in the process of accession to the European Union.

EC Directive on SEA of certain plans and programmes (2001) which is to be implemented by member states by 2004.

UNECE (or Espoo) Convention on EIA in a Transboundary Context (1991) entered into force in 1997 as the first EIA-specific international treaty.

Doha Ministerial Declaration encourages countries to share expertise and experience with Members wishing to perform environmental reviews at the national level (November 2001).

UNECE (or Aarhus) Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (1998) covers the decisions at the level of projects and plans, programmes and policies and, by extension, applies to EIA and SEA (Articles 6 and 7 respectively refer).

UNEP 2002

Additional resources for this chapter

Blue Solutions is a global platform to collate share and generate knowledge and capacity for sustainable management and equitable governance of our blue planet: **http://bluesolutions.info/**

Marine Spatial Planning Concierge, a website to facilitate marine spatial planning. **http://geointerest.frih.org/msp/**

For free SMCE software, developed by ITC: **http://www.itc.nl/ilwis/downloads/ilwis33.asp**

NASA ARSET for applied remote sensing training and free webinars. **http://arset.gsfc.nasa.gov/**

For GIS software and applications: **http://freegis.org/**

http://www.esri.com/software/arcgis/explorer

11.5 Conclusions

Spatial tools are extremely promising for Eco-DRR/EbA. The example from Haiti is only one of the endless possibilities of applying GIS and remote sensing to support spatial analysis and decision making. As with many other tools that we will be exploring, we find that spatial tools have been used for collecting data and tracking ecosystem health on the one hand, and on the other for assessing post-disaster damages. It is only recently that we are finding an emerging interest in merging these two applications, for example using spatial data on ecosystem services for disaster prevention or to improve land use planning and research on Eco-DRR/EbA. Despite the opportunities, accurate and high-resolution spatial data may be lacking for many parts of the world, which can be a limitation to applying this tool. But certain software, such as InVEST models can be applied even in data poor countries. And fortunately, most countries are now investing in spatial data infrastructure.

Most of the tools and approaches presented above are not new and have been the mainstay of natural resources management for decades. What is innovative is the greater emphasis on combining land use planning and community-based natural resources management with risk reduction (see next chapters), yet such approaches are yet to be mainstreamed. Fortunately, in many countries a risk assessment or risk zoning is mandatory for land use planning approaches (e.g. the consideration of flood, storm, earthquake or avalanche risk zones as done in Austria or for flooding in the Netherlands). While this is a promising development, growing pressures due to population growth, a growing demand for land and increasing risks induced by climate change impacts are resulting in new planning challenges. At the same time, community involvement is increasingly considered as crucial and is being mainstreamed into EIA legislation. Communities have a crucial role in disaster risk reduction as they are often the first responders in case of a hazard event, often with expert knowledge of areas at risk, whereas, a purely top-down disaster risk management and response approach may fail to address specific local needs.

EIAs and SEAs are very promising tools to this effect and are among the few legislated tools that set out to protect environmental resources. To date, with a few exceptions, there has been little effort to integrate DRR in EIAs. There is therefore a huge untapped potential to institutionalize Eco-DRR/EbA by integrating DRR with EIAs and SEAs.

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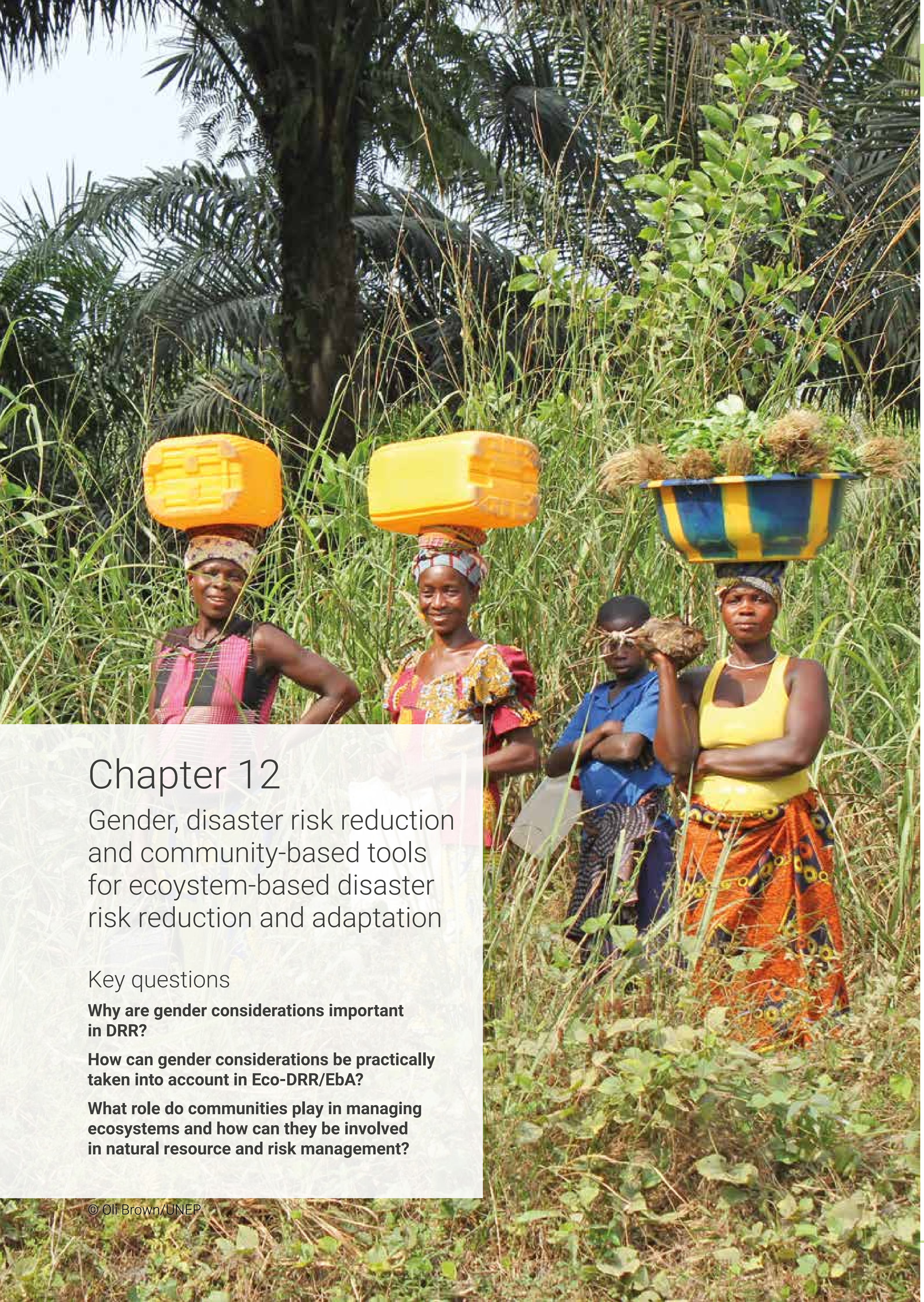

Chapter 12

Gender, disaster risk reduction and community-based tools for ecoystem-based disaster risk reduction and adaptation

Key questions

Why are gender considerations important in DRR?

How can gender considerations be practically taken into account in Eco-DRR/EbA?

What role do communities play in managing ecosystems and how can they be involved in natural resource and risk management?

12.1 Disaster risk reduction and gender

One important factor of community-based DRR is to integrate the voices that are marginalised in crisis periods, including those of women, especially those from underprivileged locations, and gender minority groups. Gender issues and power relations in general that are important are often not sufficiently considered while designing gender-responsive policies and programs. Cultural norms and institutional barriers can get in the way of full inclusion of women and other gender minorities in community-based DRR. The gender mainstreaming approach adopted by the UN and other international organisations places importance on integrating a gender perspective into the design, implementation, monitoring and evaluation, and allocation of resources in all planned policies and programs.

As seen in Chapters 2 and 9, women's experiences and needs should be taken into account and women should be included in the DRR process. First of all, human security is a fundamental human right and furthermore empowerment of women can make a big difference to the success of DRR programs (UNISDR 2008). Indeed, without a gender sensitive approach, not all society is taken into account and this can potentially increase or exacerbate vulnerability or exposure. Involving women at all stages of the DRR process, from post-disaster to pre-disaster preparedness can thus improve a community's response and resourcefulness (**Figure 12.1**).

Advantages of gender-balanced DRR

"Disaster risk reduction that delivers gender equality is a cost-effective win-win option for reducing vulnerability and sustaining the livelihoods of whole communities."

Margareta Wahlström,
UN Assistant Secretary-General for Disaster Risk Reduction

Figure 12.1
Women capacitated to participate effectively in natural resource governance and management.
© UNEP 2015

There are many instances of successful DRR programs that demonstrate a) how women may specifically hold the knowledge to strengthen local capabilities in disaster risk management, b) how women's activities can simultaneously conserve the environment and develop entrepreneurship, and c) how women's gender-specific roles can be used as a starting point to combat the adverse effects of climate change while also challenging traditional gender roles.

Case Studies

Reducing Vulnerability in Bolivia (from UNISDR 2008)

An initiative in Bolivia, "Reducing vulnerability through indigenous knowledge of '*Yapuchiri*' ('sowers') in Bolivia", aimed to support and use traditional knowledge of climate prediction for better decision-making in agricultural production and risk management. Gradually, it turned to a focus on strengthening human capabilities of both women and men in rural communities. Local groups of technology suppliers were formed, called *yapuchiris*, who sell their services at market prices to other farmers. Those services are ten times cheaper than training offered by engineers, and just 20% less efficient. The initiative started in October 2006 and concluded in July 2008, covering two complete agricultural cycles. The first cycle emphasized climate prediction through the observation of local flora and fauna. This allowed for crop planning that was more sensitive to risk. The yield losses were reduced by 30-40% in this first cycle. The second cycle then focused increasingly on the empowerment of women in market participation. That year, yield losses from frost, flooding, drought and hail were also reduced by 80-90%.

The initiative strengthened local capabilities in disaster risk management by consolidating and spreading indigenous knowledge through local experts. This has reduced vulnerability to this harsh area's hydrometeorological hazards, particularly frost, rain and hailstorms, and conversely, extreme heat and dryness, which are predicted to intensify due to climate change. The *yapuchiris*' increased outreach to communities in the face of climate shifts will prove a significant step in increasing the region's resilience to these changes. The inclusion of women's expertise in the *yapuchiri* system has been vital for transferring agricultural success into stable livelihoods, through women's traditional skills and roles in crop and seed storage, and in accessing markets. The gender element of the system arose from the need to focus and improve on productive farm work assigned to women. For instance, women are traditionally responsible for the storage of seeds and reproductive materials but not every woman in the community manages this at a high standard. Women *yapuchiris* were storing a very wide quantity of potato varieties, grain seeds, and other species, including medicines. Moreover, they researched and knew under which conditions and where to sow every species and variety. They had the knowledge to design strategies for risk management and assisted other women farmers in doing so. In a majority of cases, women *yapuchiris* did not only transfer knowledge, but helped to build up analytical capabilities of farming women. The female *yapuchiris* are also taking an active role in adaptive risk management, and in monitoring bioindicators of climate and weather-related hazards.

Sustainable livelihoods in Mali (from UNISDR 2008)

The Sinsibere project in Mali aimed to reduce desertification by developing sustainable sources of income for rural women as an alternative to their commerce in wood. These alternative livelihoods include vegetable gardens and making shea butter products like soap. An important part of the success of these alternative sources of income was a microloan system that was developed for the women's groups who participated. This system made it possible to kickstart female entrepreneurship in the villages. The project is based on the Local Environmental Plan that the municipal councils and the local people developed collaboratively, and so, has been a cooperative effort between the project workers and the local communities from the beginning. Literacy and mathematical courses have been organized for the women so that they are able to manage the micro loans and small commerce, encouraging entrepreneurship.

Food security in Brazil (from UNISDR 2008)

Pintadas is located in the Northeastern region of Brazil, the poorest region in the country where 42% of the population, or 18.8 million people, are poor. About half of them live in rural areas, with income and life expectancy well below the national average. The region is characterized by a semi-arid climate with very little precipitation, high temperatures, a deep groundwater table, sandy soils and prolonged periods of drought. Water scarcity in rural areas of Northeastern Brazil seriously affects the economic development of entire villages, because of the limited water available for sanitation and agriculture.

The Project Pintadas Solar is an innovative good practice as it encompasses irrigation and energy efficient technologies for small scale agriculture. Women and other members of the family can learn to use it, and the irrigation can also be used at the level of the household.

Both women and men are learning how to handle new irrigation and water management technologies for the improvement of small-scale agriculture. In the history of Pintadas this is a breakthrough. Due to the participatory process of the initiative and grassroots work with the local Women's Association, gender analysis was a strong factor in choosing beneficiaries, and technologies that could be effectively implemented by all. The impact of this initiative reduces the risks of food and water shortage during the long periods of drought in this region that are becoming even more intense, consistent with climate change predictions.

Women's Leadership in Implementation of Disaster Preparedness Measures in Bangladesh

Some remote coastal villages in southern Bangladesh are not yet reached by the country's elaborate national disaster management system. In light of the above, Action Against Hunger (ACF) implemented a DRR pilot project in 10 villages, establishing a Village Disaster Management Committee (VDMC) and a Women's Committee in each of them. The project targeted over 4,000 households, mostly female-headed households and poor women's households highly exposed to disaster risks. When the tropical storm Mahsen struck in May 2013, shortly after the end of the project, the women put in practice the disaster preparedness measures that were explained to them. They protected their lives and livelihoods, on their own initiative, without the intervention of the national disaster management system.

The successful implementation of preparedness measures can be attributed largely to women's leadership. Indeed, a large percentage of the households targeted by the project were either female-headed or those of women living in extremely poor conditions and highly exposed to disaster risk. Other gender dimensions/issues addressed by the project were special types of vulnerability such as violence, sexual harassment and limited access to recovery support. Women's forums served as key catalysts to raise and address such concerns. The women's forums offered them a place to talk about general and specific feminine issues (health, pregnancy, menstrual hygiene management, etc.). But the pilot project was a new experience for women in the selected villages, and many of the women's forum members never had an opportunity to participate in village meetings previously. Forums served as key catalysts to raise and address such concerns. The women's forums offered them a place to talk about general and specific feminine issues (health, pregnancy, menstrual hygiene management, etc.). But the pilot project was a new experience for women in the selected villages, and many of the women's forum members never had an opportunity to participate in village meetings previously.

Adapted from UNISDR (2015) Women's Leadership in Risk-Resilient Development: Good Practices and Lessons Learned

Figure 12.2
Planning Eco-DRR in Sudan © UNEP 2017

Figure 12.3
Re-greening in Sudan © UNEP 2017

Eco-DRR in Sudan (from UNEP 2016)
A project, funded by the European Commission, led by UNEP and Practical Action Sudan between 2012-2015, partnering with local communities and the state government, won the 2017 Land for Life award for improving food security and disaster resilience and reducing community tensions through sustainable management of dryland areas of North Dafur. Women were involved in every stage from planning, to training and implementation (**Figure 12.2**)

Natural resource management and rehabilitation of the landscape through community forests and planting were an important component that was managed by women to support community forestry and household agroforestry while re-greening the landscape (**Figure 12.3**; UNEP 2016).

WOMEN AS STEWARDS OF CHANGE: ECO-DRR/EBA AS A NECESSITY AND OPPORTUNITY

Given the important involvement many women have in natural resource management, Eco-DRR/EbA strategies can be seen to provide an opportunity for women's groups, planners and policy makers to bring together goals of SGD 5 (Achieve gender equality and empower all women and girls) and 15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss), insights of the GAD framework and expected outcomes of the SFDRR (that also mentions the crucial role of gender in DRR, among others in the guilding principles, stressing that DRR requires an all-of-society engagement and partnership that includes, among others, gender). Women's knowledge, often unrecognized or dismissed as unimportant in policy discussions and planning processes, can be a powerful tool to deal with environmental changes and to prepare for disasters. Some long-term impacts of planning for disasters using gender-sensitive Eco-DRR/EbA strategies are as follows:

- Reduced gender-based vulnerability especially to slow-onset climate-related hazards such as drought, land degradation, sea-level rise etc.
- Disasters – both slow and rapid onset ones - pose developmental challenges for people and countries. Minimizing the impact of disasters is important for the well-being of a nation's population and to reduce the economic impact and social costs of disasters.
- Ensuring women's well-being also ensures the well-being of children in families and maintains positive social dynamics.
- In the long-term, Eco-DRR/EbA is an opportunity to address the complexities of interactional gendered dimensions, thus contributing to the sustainable development goal to "leave no one behind."

While social norms can make women more vulnerable to disasters, the unique position of women and their strengths can be used to plan for Eco-DRR/EbA strategies. The challenge is to ensure that Eco-DRR/EbA measures are planned in such a way that they do not place additional burden on women – mainly in terms of labour and time. Some broad recommendations on what effective Eco-DRR strategies can do are:

1. Building skills to do more rewarding productive and community roles;
2. Education of both girls/women can go a long way in enabling women to increase their leadership roles in NR management, governance, decision making
3. Educating boys/men in sharing responsibility for reproductive roles will also reduce women's burden and free up time for community roles;
4. Changing ownership of, and access to resources to reduce vulnerability.

Accomplishing these necessarily involve a gradual change in power relations too, a process that can also lead to changing women's and men's gender roles. As a society adapts to social, environmental, political, and economic changes, the gender power dynamics may also shift. Changes to the gender relationship can occur from within a society (as when women contest gender-based inequities) or result from external forces. Recognising and rewarding the caring and community roles that women do while being sensitive to social relations can help in increased women's participation that can ultimately be empowering. Thus, Eco-DRR/EbA can present a unique opportunity to redefine social norms through a gender and development framework, while being in tune with the SDGs 5 and 15, and the Sendai Framework.

SEXUAL AND GENDER MINORITIES AND DISASTER RISK REDUCTION

While a long way has still to go to ensure inclusiveness of women in DRR and CCA despite efforts and success stories, mainstreaming other sexual and gender minorities into DRR and CCA has lagged behind (McSherry *et al*. 2014). Yet, studies show that these minorities can be highly vulnerable to disasters because their needs are not taken into account and they may be discriminated against in both unobvious and obvious ways (Gorman-Murray *et al*. 2014; Gaillard *et al*. 2016).

Yet at the same time, these minorities can show great resilience and be an asset during disasters (Gorman-Murray *et al*. 2014, McSherry *et al*. 2014). In Indonesia, *warias* are males that adopt female features and identity. During the 2010 eruption of Mt Merapi, many *warias* chose not to stay in temporary shelter because of the gender binary prescribed and feared hostility (Balgos *et al*. 2012). However, a formalised group of *warias*, a genders rights advocacy group (PLU) responded to the crisis by providing free haircuts and make-up in evacuation centers as well as a drag queen contest to raise money for evacuees (Balgos *et al*. 2012).

In the Philippines, *bakla* are male who identify with female identity and often perform female duties. During disasters, their experience is one of further discomfort because shelters are usually binary and can face other discrimination and harassment. A community DRR project in the Philippines, included *bakla* to learn of their needs and also their potential roles during evacuation. The focus groups discussions and plans including youth *bakla* helped reduce anti-*bakla* discrimination and harassment in one village (McSherry *et al*. 2014).

GENDER BALANCED ECO-DRR PROJECTS

To help make gender-responsive, Eco-DRR projects and/or policies that consider the nexus between ecosystem management and DRR, a checklist was developed (see Additional Resources at the end of the chapter). Two key reasons underlie the development of this check list: a) the current global policy environment that aims to seriously tackle gender-based disparities, and b) the lack of sufficiently comparable national/regional-level data sets that enables policy-makers to frame gender-responsive policies.

Tackling gender-based disparities and advancing gender equality is a concern reflected in the policy approaches of the United Nations in every area of its work, such as the CEDAW General Recommendations, Sustainable Development Goals, the Sendai Framework, the Aichi Targets, the United Nations Framework Convention on Climate Change etc. Ensuring that Eco-DRR measures are in step with the general policy environment is timely and appropriate.

Literature about disasters and their consequences in various parts of the world are readily available. While these provide anecdotal evidence about the gendered impact of disasters, there is a lack of qualitative and quantitative gender-disaggregated data that is comparable across countries, over time. As a result, to frame gender-responsive DRR policies and programs, reliable indicators gleaned from survey of literature around gender is necessary. This checklist hopes to accomplish this task and will be useful for policy makers, project planners, and project level implementors. However, it is important to ensure that this checklist is used as a guide for projects and not as just a checkbox system to label a project as gender-sensitive.

The gender markers used in this checklist draws from UNEP's Gender Marker Two-Pager series that assesses "how well gender is integrated into a new project document".[4] Explanation for the four criteria used in this checklist can be found in the first document of this series.

12.2 Communities and natural resource and risk management

In most planning processes, participatory processes are obligatory, ranging from simple information to complex collaborative decision-making schemes. Communities play a crucial role in sustainable land management and DRR. They often have expert knowledge about their environments and are the most dependent on clean water and locally available resources for sustenance. So including their knowledge in planning is beneficial, while at the same time awareness of the plans, policies and their rights can enhance their resilience. When a disaster strikes, communities are often isolated and must rely on their own skills and resources to save lives and livelihoods until outside assistance arrives, if at all. Often communities are left alone during that phase until help from outside arrives and their knowledge to maintain the local ecosystem and its goods can save lives. The management approach that can help sustaining these benefits is called Community-based Natural Resource and Risk Management (CBNRRM), an approach that combines the sustainable management of natural resources and risks in a given area. It combines the concept of "co-management" of natural resources (IUCN 2007) with community-based disaster risk reduction (Abarquez and Murshed 2004) (**Figure 12.4**).

4 The Gender Marker series can be found here: https://drive.google.com/drive/folders/0B-nbHeF2bGUMY2NFTE5KeVZ6YjQ

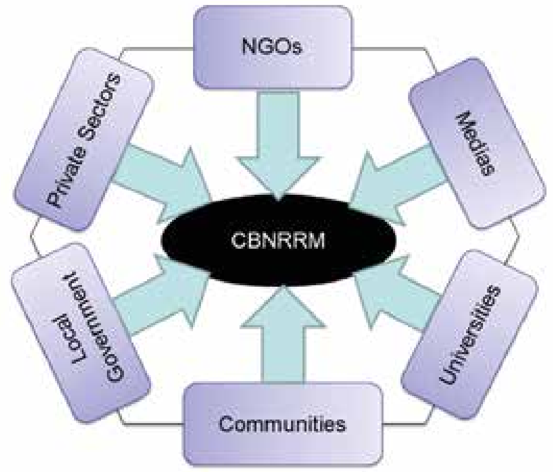

Figure 12.4
Stakeholders in CBNRRM.
© S. Sandholz 2013

Usually at the community level, managing resources, disaster and climate risks are interlinked and should be interlinked, while at the institutional level, we continue to insert institutional divides. By linking natural resources management with risk management and enhancing community capacities to link both, we create much stronger approaches.

But communities can be extremely diverse. The term "community" generally refers to a group of people sharing a common interest in a certain area (i.e., residents of a village, a religious entity, a local civil-society organization, etc.), who are not necessarily homogenous or conflict-free. Thus, it is critical to CBNRRM to develop dialogues and cooperation schemes within the community and between community and other stakeholders. Beside the community itself, other potential actors to be involved in a holistic management scheme include governmental agencies, the private sector, NGOs, the media and academia. This is crucial to ensure the long-term sustainability of a project and to avoid parallel and potentially incoherent or even conflicting planning.

The Eco-DRR project in Sudan, mentioned above, required establishing dialogue with various community actors that had quite different needs (pastoralists and farming communities), which created tension and conflict. The project brought together all stakeholders to improve governance of land and water resources at the community-level in order to enhance community resilience to water hazards and promote sustainable drylands management (**Figure 12.5**).

Figure 12.5
Sudan Eco-DRR project.
***Left*: Consensus building in Sudan on the location and purpose of migratory routes.**
***Right*: Resource conflict prevention.**
© UNEP 2017

This entailed several measures:

- *Establishment of a Water Resource Management Committee* that is responsible for the water retention structure, for undertaking early warning and preparedness for flood and drought, and for ensuring that water is proportionally distributed. The committee also liaises with wider landscape management programmes and the government and NGOs.
- *Demarcation of the migratory route for pastoralist communities* in order to reduce potential conflict over animals entering farmlands, and farms encroaching into rangelands.

CBNRRM creates an environment where people in communal areas can actively manage their ecosystems and reduce risk by working on preparedness. The following chapter will detail environmental management tools that can be used in conjunction with spatial planning and community approaches. It will also be important that the community prepares through the installation of early warning and other preparedness measures, such as having shelters for example.

12.3 Conclusions

Inclusion of women in DRR and CCA at all levels is important for reducing the impact of hazards and for sustainable and equitable development. Beyond women, it is also important to take into account all gender diversity as other gender minorities, from LGBTI group for example, can otherwise be left out of the process and also suffer from the consequences such as not being able to access services that require binary gender or that are discriminatory (Gaillard *et al.* 2016).

NGOs and international development organisations are more and more incorporating gender-sensitive issues in their work, thanks to the advocacy and work also done on international levels (Aguilar 2015). Empowering women and other gender minorities at leadership level is important as still too few are found at this level. The empowering and engagement in DRR can lead to many successes and reduce impact. Especially in terms of Eco-DRR/EbA in some countries, women and other minorities can make a big difference due to their involvement in natural resource management.

Community participation in natural resource and risk management involves more than consultation and active work. It involves communication, capacity building, making links with different organisations at all levels from community to government and can be challenging. However, working through the process from risk assessment, to planning and finally management as a community can help foster understanding and innovations and finally longevity of the process.

Gender Marker 1: Context		
1	Does the program present a gender analysis at the international level?	Y/N
2	Does the program present a gender analysis at the national level?	Y/N
3	Does the program present a gender analysis at the field- level?	Y/N
4	Does the program present statistics and examples to supplement or substantiate the gender analysis?	Y/N
5	Does the program have any experts or partner organisations who are specifically skilled in gender analysis at the field-level?	Y/N
Gender Marker 2: Implementation		
Design		
1	Does the program resonate with international approaches or frameworks to addressing gender? (For example: gender mainstreaming, gender and development, gender components of SDGs, Sendai framework, CEDAW General Recommendation No. 37, Aichi Target 14, UNFCCC)	Y/N
2	Does the program propose concrete measures to address gender-based inequalities?	Y/N
3	Do the proposed measures show a clear causal pathway between activities and outputs (results) to close specific gender gaps?	Y/N
4	Does the planned program build on any gender stereotypes?	Y/N
5	Does the planned program reinforce stereotyped gender expectations?	Y/N
6	Does the planned program have any components that challenge existing gender norms?	Y/N
7	Do the planned activities take into account women's daily routines and responsibilities? (For example: training programs planned at times convenient for women)	Y/N
8	Can women who work outside the household participate in the planned program activities?	Y/N
9	Can women who work within the household participate in the planned program activities?	Y/N
Monitoring and Evaluation		
10	Does the planned program account for differences between women and men depending on their class/race/ethnic/caste positions or other relevant identity markers?	Y/N
11	Does the program use data collection tools that are gender-responsive (For example: questionnaires that account for gender-specific activities, focus group discussions or stakeholder consultations that involve women and enable meaningful participation of women and men in separate and mixed spaces, interviews with both men and women etc.)	Y/N
12	Does the program use tools that show gender-disaggregated patterns? (For example: patterns of time use, income earning work, invisible reproductive work, community work?)	Y/N
13a	Does the planned program have the potential to negatively affect women from any community in any way?	Y/N
13b	If yes, does the program include plans for mitigation of backlash or risks that women may potentially face?	Y/N
14	Does the planned program put any additional non-remunerated burden on any group of women when compared to men or other women?	Y/N
Staffing		
15	Does the program have gender balance in staffing?	Y/N
16	Does the program have women in leadership positions among its staff?	Y/N

Gender Marker 3: Log frame		
1	Can the program demonstrate/target gender specific outcomes that measure women's participation, influence, shifts in attitudes about women's capabilities and leadership in the short term? (Example: creating awareness through gender research, training programmes, distribution of pamphlets, creating opportunities and spaces conducive for women's increased participation, having women in leadership positions in field-level activities etc)	Y/N
2	Can the program demonstrate/target gender specific outcomes that measure women's participation, influence, shifts in attitudes about women's capabilities and leadership in the medium term?	Y/N
3	Can the program demonstrate/target gender specific outcomes that measure women's participation, influence, shifts in attitudes about women's capabilities and leadership outcomes in the long term?	Y/N
4	Does the program explicitly show gender-disaggregated results? (For example: questionnaire/survey analysis disaggregated for gender, even when considering other vulnerabilities such as class, race, disability, age increased participation of women in Eco-DRR activities, increased number of women leaders?)	Y/N
5	Does the program have the potential to bring about outcomes that challenge/change gendered work patterns at any stage? (example: creating Eco-DRR related jobs for women that can be paid, increased participation of women in paid work, sharing of unpaid work by all members of the household, sharing of caring jobs, sharing or reduced burden for reproductive work such as collecting water, firewood, water management)	Y/N

Gender Marker 4: Budget		
1	Is the program budget gender-responsive? (Example, through allocation for specifically hiring international, national, local gender experts; making loans available for women for empowering individual and group entrepreneurial activities; allocation for providing assistance for victims of domestic violence in a post-disaster scenario etc?)	Y/N
2	Does the program budget account for expenses for advancing gender equality? (Example, holding gender sensitisation training/awareness programs, printing/distribution of pamphlets, distribution of bicycles for girls to go to school, scholarships for girls/women to undertake training, childcare etc.)	Y/N
3	Does the budget reflect any investment in changing gendered expectations from women and men and/or their work patterns? (Example: paying women to attend certain training programs thus valuing their time and effort instead of taking it for granted.)	Y/N

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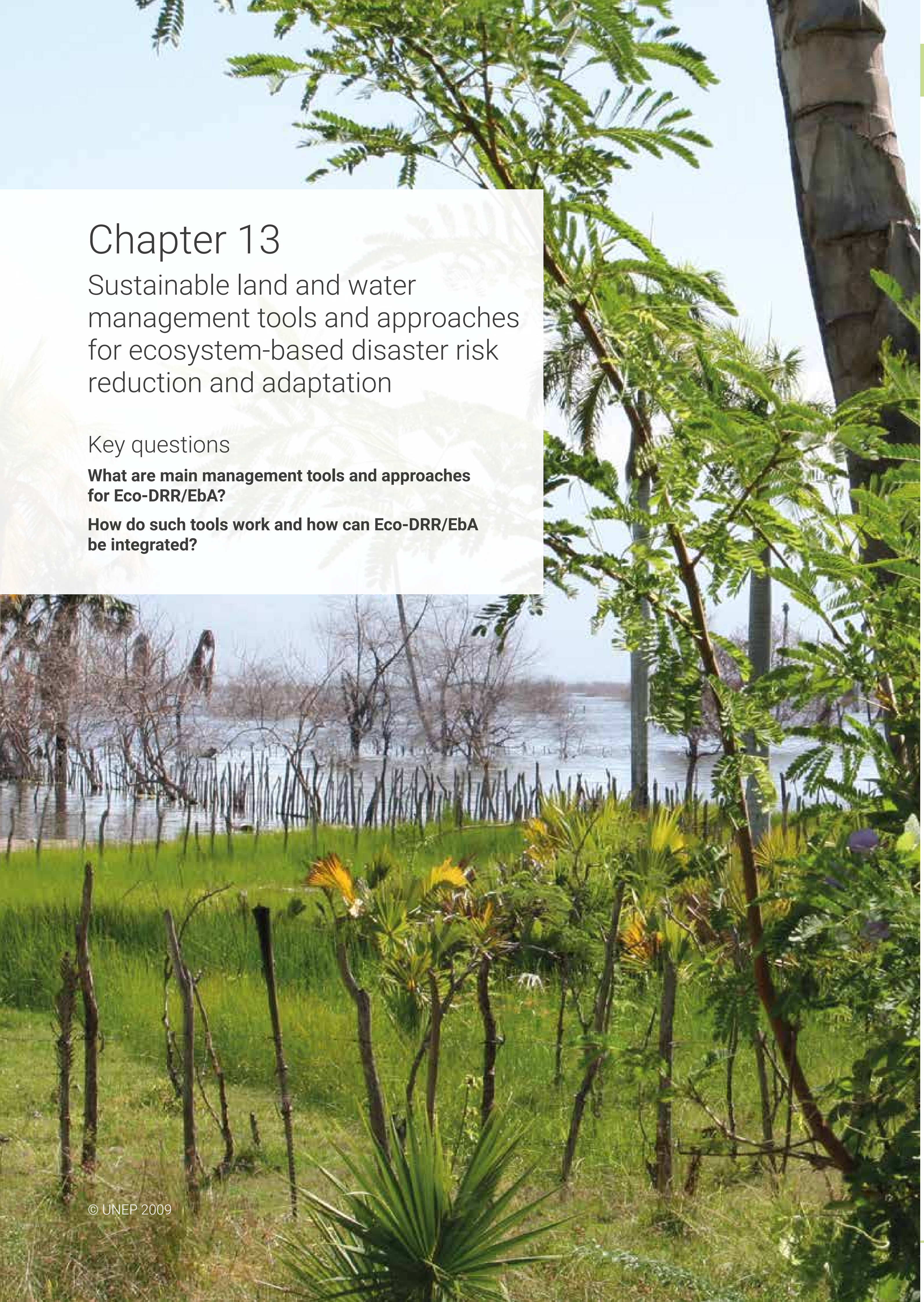

Chapter 13

Sustainable land and water management tools and approaches for ecosystem-based disaster risk reduction and adaptation

Key questions

What are main management tools and approaches for Eco-DRR/EbA?

How do such tools work and how can Eco-DRR/EbA be integrated?

13.1 Management tools and approaches for ecosystem-based disaster risk reduction and adaptation

This chapter provides an overview of main Eco-DRR/EbA management tools and approaches for long-term risk reduction. These need to be integrated with the cross-cutting themes of spatial planning and community-based involvement.

While the focus will be on Integrated Water Resource Management (IWRM), this chapter will also briefly describe:

- Sustainable Land Management (SLM)
- Integrated Coastal Zone Management (ICZM)
- Integrated Fire Management (IFM)
- Protected Area Management (PAM)

Most of the approaches and tools presented here are found in the context of natural resources management. They are appropriate and can be very effective for reducing disaster risks and adapting to climate change. However, their link with DRR is not commonly made because disaster managers do not always consider the role of ecosystem in reducing disaster risk.

Integrated Water Resource Management or **IWRM** is one of the most common approaches for Eco-DRR/EbA as water-related disasters are those which affect most people around the globe. IWRM is a governance and development process to manage water, land and related resources, in order to maximize economic and social welfare. Good IWRM means better policies for improved catchment management, enhanced sanitation services, reduced pollution, and good governance – all factors which can help in DRR/CCA practice (**Figure 13.1**) (Blackwell and Maltby 2006, Butterworth *et al*. 2010).

Tools and approaches

We refer to IWRM or ICZM as management approaches, or processes to addressing planning issues related to water resources or coastal areas. Each management approach will have a set of tools (e.g., GIS, land use and risk mapping) that it uses to enable decision-makers or project managers to make informed choices between a set of management actions.

INTEGRATED WATER RESOURCE MANAGEMENT

What is it? Governance and development process to manage water, land and related resources.

Why is it done? Many disasters are result of too much or too little water.

How is it done? Through a flexible common-sense approach that creates an enabling environment, defines an institutional framework, and develops appropriate management instruments.

REFERENCES:

Global Water Partnership (GWP)
http://www.gwp.org/en/The-Challenge/What-is-IWRM/

The UN interagency mechanism on all freshwater related issues, including sanitation (UN Water)
http://www.unwater.org/

Capacity Development in Sustainable Water Management (Cap-Net UNDP)
http://www.cap-net.org/

Figure 13.1
Water reservoir in Morocco.
© S. Sandholz

Sustainable Land Management or **SLM** includes management practices in agriculture and forestry aiming at sustaining ecosystem services and livelihoods. Agroforestry systems combine agricultural and forestry practices to create productive and at the same time healthy land-use systems. Due to the improvement of soil stability and reduced run-off, disasters such as landslides and flooding can be reduced while at the same time providing benefits to livelihoods (**Figure 13.2**) (Sanz *et al*. 2017).

Figure 13.2
Agroforestry system in Brazil. © U. Nehren

SUSTAINABLE LAND MANAGEMENT

What is it? Multi-disciplinary approach combining agriculture and forestry.

Why is it done? To combine productive agriculture and forestry systems with sustainable land use.

How is it done? Using soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.

REFERENCES:

World Overview of Conservation Approaches and Technologies
https://www.wocat.net/

Food and Agriculture Organization of the United Nations (FAO) on Sustainable Land Management
http://www.fao.org/nr/land/sustainable-land-management/en/

Integrated Coastal Zone Management or **ICZM** is a multi-disciplinary approach to manage the coastal zone including planning, resource management, information bases, and community involvement. It is a natural resource management approach which is increasingly including risk considerations by adjusting planning and management of resources and people to reduce coastal risks.

ICZM is of growing importance as a large share of the global population is living in coastal areas, often at risk from sea level rise or storm surges (Marfai and King 2008) and many coastal areas comprise of such plan (cf. Coast Conservation Department 1997). On a local scale, Eco-DRR/EbA measures like mangrove replantation or protection of sand dunes as natural buffers are of growing importance (**Figure 13.3**). Other measures include managed realignment, where sea protections are moved back to allow natural ecosystems, such as salt marshes and flooding areas, to buffer the coast.

Figure 13.3
Flooded coastline of Java, Indonesia. © S. Sandholz

INTEGRATED COASTAL ZONE MANAGEMENT

What is it? Multi-disciplinary approach to manage the coastal zone.

Why is it done? Coastal areas are exposed to multiple hazards and often highly populated.

How is it done? Includes planning, resource management, information bases, and community involvement.

Adopts a combination of ecosystem-based, engineered and non-structural measures.

REFERENCES:

European Coastal Zone Policy
http://ec.europa.eu/environment/iczm/home.htm

World Bank – Projects and Operations: ICZM
http://www.worldbank.org/projects/P097985/integrated-coastal-zone-management?lang=en

The aim of **Integrated Fire Management** or **IFM** is to balance the beneficial and negative effects of fire on the natural environment and socio-economic circumstances in a given landscape or region, and reduce risk of wildfire disasters that threaten human life and ecosystem functions (**Figure 13.4**) (Bryant 2008, Myers 2006).

Figure 13.4
Forest fire early warning system in Chile. © U. Nehren

INTEGRATED FIRE MANAGEMENT

What is it? Range of technical decisions and actions to prevent, maintain, control or use fire.

Why is it done? To balance the beneficial and negative effects of fire on the natural environment and socio-economic circumstances in a given landscape.

How is it done? Various elements including early warning, capacity building, and sometimes controlled fires.

REFERENCES:

321 Fire Management:
http://www.321fire.co.mz/

Global Fire Monitoring Center (GFMC)
http://www.fire.uni-freiburg.de/

The Nature Conservancy
http://www.nature.org/ourinitiatives/habitats/forests/howwework/integrated-fire-management.xml

A **Protected Area** or **PA** is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Protected areas are increasingly including DRR and adaptation goals in their management plans (**Figure 13.5**) (Murti and Buyck 2014).

Figure 13.5
Community forest in PA buffer zone, Nepal. © S. Sandholz

PROTECTED AREA MANAGEMENT

What is it? Approach to ensure that protected areas are managed to preserve values for the future.

Why is it done? PAs cover almost 20% of the earth, offer benchmarks for effective long-term management towards resilient ecosystems globally.

How is it done? Assessments covering values, threats and vulnerabilities, recommendations for conservation of ecosystem and natural capital.

REFERENCES:

International Union for Conservation of Nature (IUCN)
http://www.iucn.org/about/work/programmes/gpap_home/gpap_capacity2/gpap_bpg/

IUCN publication on Urban Protected Areas
https://portals.iucn.org/library/sites/library/files/documents/PAG-022.pdf

Center for Protected Area Management
http://warnercnr.colostate.edu/hdnr-research-outreach/outreach/center-for-protected-area-management-and-training

Each of the presented approaches aims at a long-term sustainable management of a given geographic area or ecosystem, depending on the area's assets. The tools can potentially be combined, for example when linking SLM to IFM in a community-based approach (see Chapter 12).

13.2 An example of integrated water resource management for disaster risk reduction and adaptation

How do these integrated management approaches work and how can Eco-DRR/EbA be integrated? Let us answer these questions by taking the example of integrating Eco-DRR/EbA measures in IWRM in order to reduce flood and drought risk.

Like many other sector policies, IWRM is the result of realizing that water resources management is closely related to other sectors like agriculture and forestry, energy or urban planning and taking an integrated sectoral approach (Butterworth *et al*. 2010, Hey and Heltne 2014).

IWRM is typically implemented at the watershed level, such as the Mississippi River (The Wetlands Initiative 2004). It aims at the comprehensive management of the whole water cycle, including headwaters and coastal areas, surface and groundwater, water quality and quantity, harmonizing water availability with demands from different water users in order to maximize social welfare without compromising the sustainability of vital ecosystems.

IWRM can and should include linkages to Eco-DRR/EbA through links to DRR and CCA policy and implementation, in particular to water-related disasters like floods and droughts which are known to be associated with very high losses and damages.

Water cycle link to floods and droughts:

Strong rainfall events create surface runoff causing downstream inundations (**Figure 13.6**).

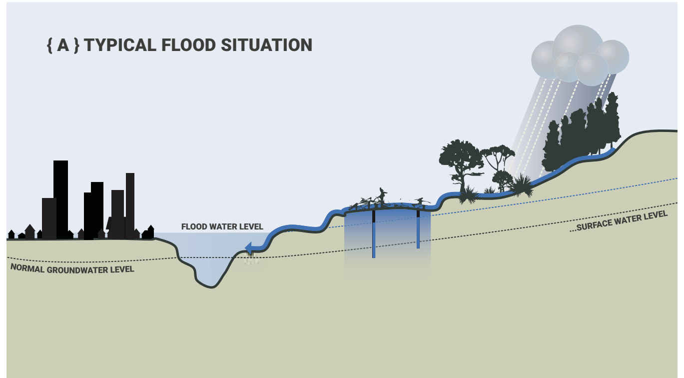

Figure 13.6
Typical flood situation.
Concept: L. Ribbe; Design: S. Plog

Prolonged droughts diminish water available to agriculture, people and ecosystems in soil and groundwater (**Figure 13.7**).

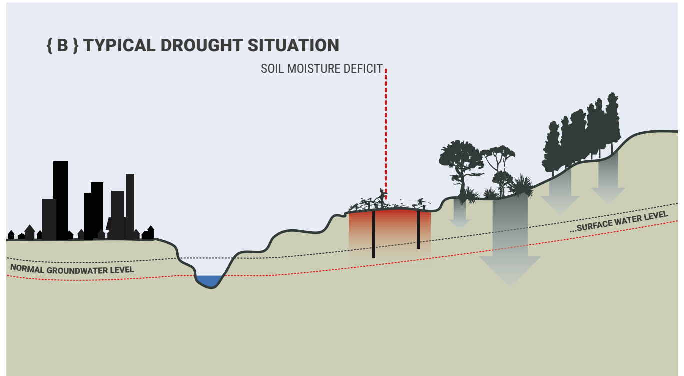

Figure 13.7
Typical drought situation
Concept: L. Ribbe; Design: S. Plog

IWRM and risk reduction:

Storage has been a pivotal management option since centuries to mitigate the impact of climate variability – it helps to control flood peaks and provides a water reserve for drought periods. The way ecosystems are managed within watersheds can be decisive in offering storage solutions which can be an alternative or addition to building large reservoirs. In any catchment water is stored naturally in soils, in wetlands and in aquifers.

It is possible to use ecosystem functions which help to increase storage in different forms in order to cope better with floods and droughts by for example:

1) Managing the landscape through contour trenches or bunds to support rainwater harvesting (**Figure 13.8**).
2) Managing soils to increase infiltration through mulching; augmenting soil porosity and soil water storage through increasing soil organic matter within the soil (**Figure 13.8**).
3) Managing vegetation to intercept rainwater and to support deep percolation of water through reforestation or introduction of agroforestry systems (**Figure 13.8**).

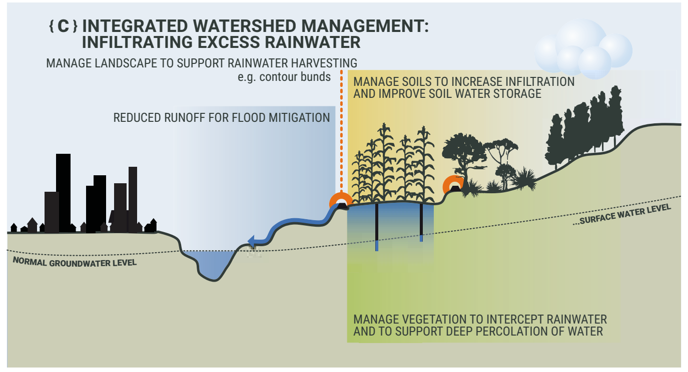

Figure 13.8
Integrated watershed management: infiltrating excess rainwater
Concept: L. Ribbe; Design: S. Plog

4) Other ecosystem-based options to curb inundation risk include measures which control storage or drainage within the floodplain including density of riparian vegetation and adjustments of river morphology. These measures combined help to reduce peak surface runoff and inundation risk (**Figure 13.9**).

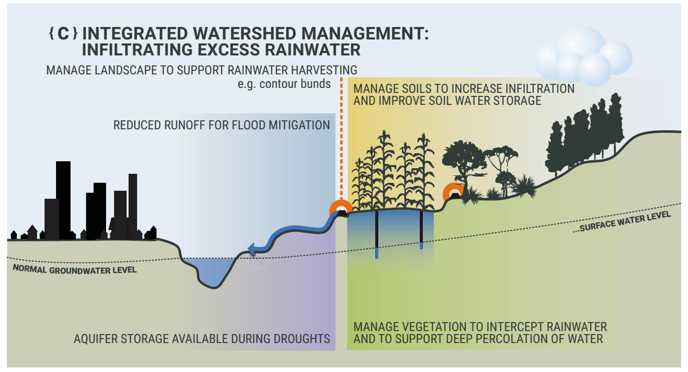

Figure 13.9
Integrated watershed management: infiltrating excess rainwater
Concept: L. Ribbe; Design: S. Plog

At the same time these measures help to increase stored ground water – often the last resort for water supply during prolonged droughts.

Proper IWRM includes Integrated Flood Management and Integrated Drought Management in which ecosystem-based approaches should play a central role (WMO/GWP Integrated Drought Management Programme 2014, WWF 2002). Infiltrating rainfall by proper watershed management practice is an excellent example of how IWRM contributes to mitigate floods and droughts at the same time. Using hazard maps and future projections of climate change ensures targeted measures to reduce risk. Planting species that are adequate to current and projected climate, are diverse, and have root systems and functions required for slope stabilisation, infiltration and water usage are all important considerations in Eco-DRR/EbA.

13.3 Conclusions

The presented tools and approaches are not new and have been the mainstay of natural resources management for decades. What is emerging is a greater emphasis on combining risk reduction with natural resources management, increasingly also linked to CCA. Such ecosystem-based approaches, combined with more classical DRR actions such as early warning, preparedness and risk mapping are proving more effective and sustainable in terms of reducing risks and saving lives.

IWRM and other integrated approaches provide multiple opportunities to include Eco-DRR/EbA measures. These measures typically target to improve ecosystem function. In IWRM, these increase water storage in adequate compartments of the catchment like soils, groundwater and floodplains in order to reduce the flood peak on one hand and to provide stored water for drought periods on the other hand. ICZM aims to comprehensively manage the coastline, sea resources and also all inputs to the sea, such as river and runoff. When comprehensive, ICZM can take a ridge-to-reef approach.

SLM alleviates land degradation through management of grazing, agriculture, forestry and other land uses. IFM can help regulate fires, while PA management is an approach to effectively manage protected areas, which can be a big asset for Eco-DRR/EbA because they often contain relatively undisturbed ecosystems.

Ensuring the right use of management techniques is dependent on the ecosystem, and thus local or indigenous knowledge can be vastly important. When revegetating, it is important to think about the diversity and type of species used. The following chapter will elaborate on this. Ecological engineering is sometimes the term used when specifically using certain species for protection services.

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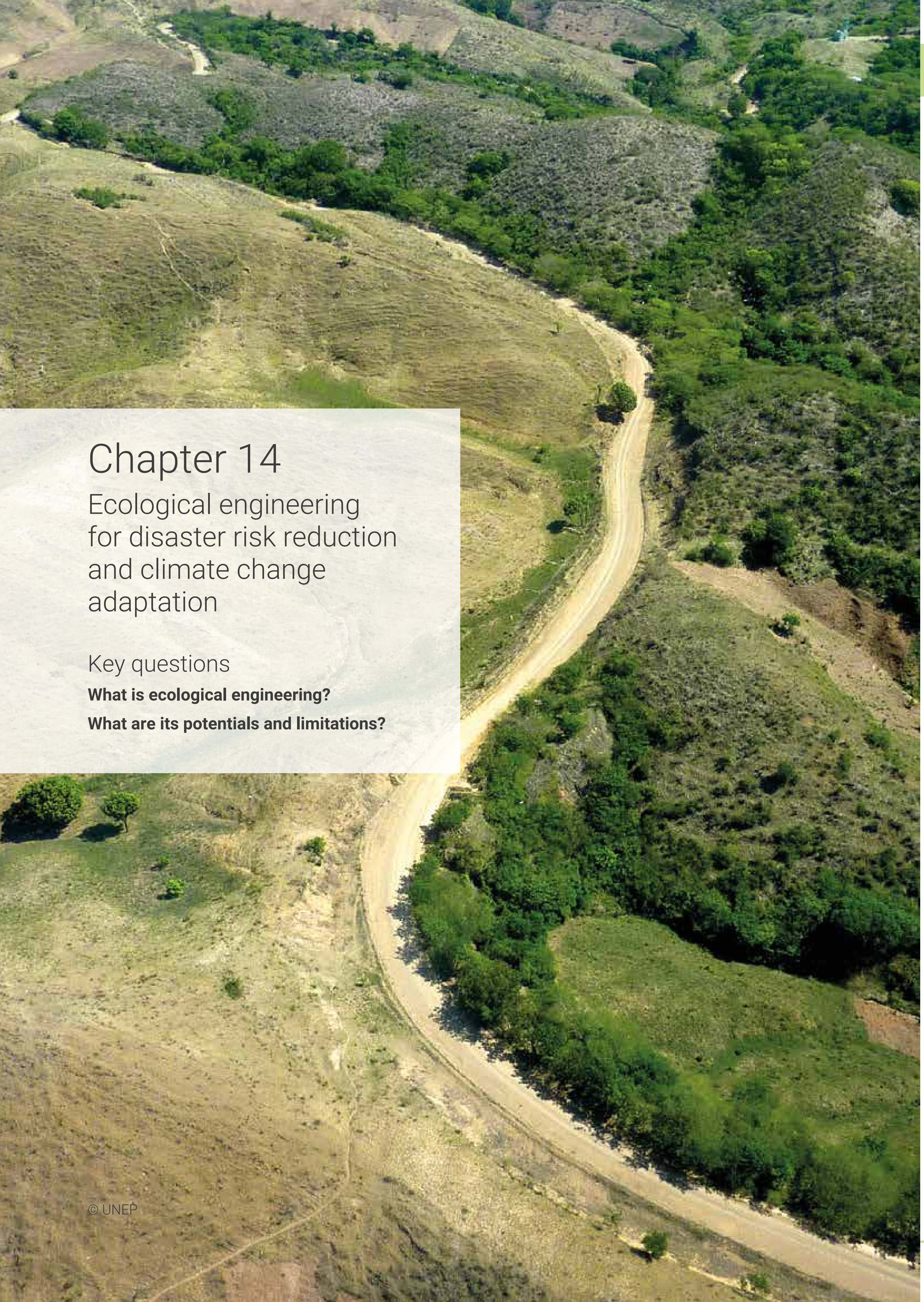

Chapter 14

Ecological engineering for disaster risk reduction and climate change adaptation

Key questions

What is ecological engineering?

What are its potentials and limitations?

14.1 Ecological engineering

DRR structural measures most often involve "grey" infrastructure, such as sea walls, dykes and embankments. While their efficacy is proven in many cases, these too can fail and provide only a limited set of benefits. Green and blue infrastructure (GBI) has gained increasing attention in the last ten years for DRR and CCA. Furthermore, they are also recognized as a type of critical infrastructure under Sendai Monitor Targets C and D, that can be reported against.

The terms natural and green infrastructure are often used interchangeably although a fine distinction could be made to distinguish various levels of natural versus reconstructed infrastructure. Green infrastructure refers to elements in a landscape such as "green belts", protection forests or revegated river banks. Blue infrastructure refers to water-based areas, such as ponds in cities or coral reefs and thus combine both as GBI (Sebesvari *et al*. 2019). Da Silva and Wheeler (2017) proposed to use the term green infrastructure over 'natural', 'blue', or 'ecological' infrastructure, because it is the term most widely used and has been adopted in US and EU policies. In addition, it corresponds to the terminology used in the Technical Guidelines of the SFM.

Combining engineered (or grey) and ecological/green infrastructures, is often referred to as hybrid solutions. Ecological engineering combines engineered infrastructure for DRR (e.g. dikes, embankments or seawalls) with the protective functions of ecosystems, also referred to as natural infrastructure, or green infrastructure (Dow Chemical Company, Shell, Swiss Re, Unilever, and TNC 2013).

Engineered infrastructure for DRR is mainly designed for specific functions such as protection from landslides, floods, waves or wind. Sometimes engineered infrastructure provides additional benefits such as storage for drinking and irrigation water or generation of hydropower.

However, such measures often are very costly and maintenance-intensive. Furthermore, they are designed for only a limited lifespan. Especially in the context of CCA, the scale of solutions needed to adapt to increasing weather extremes is sometimes hard to predict. Engineered infrastructure may not always be feasible due to the high costs and technological requirements.

Ecological infrastructure for DRR/CCA, also placed under the umbrella term of Eco-DRR/EbA, can be less costly, more locally feasible and provide multiple benefits (Jaffe 2010, European Commission 2016), compared with engineered solutions (**Figure 14.1**). In many cases, maintaining and restoring natural infrastructure can offer a high benefit to cost-ratio compared to engineered infrastructure, when taking into account the full range of benefits provided by ecosystems. For example, coastal green belts or wetlands as natural buffers are often less expensive to install and maintain than engineered constructions over time. In addition, they also provide supplementary co-benefits regardless of a disaster event (Narayan *et al*. 2016, Wamsler *et al*. 2016). In comparison engineered infrastructure may fulfill the same main targets and provide more easily quantifiable disaster prevention and hazard mitigation, which may be why there is often a bias towards engineered solutions, but comparably fewer co-benefits.

DEFINITION OF GREEN INFRASTRUCTURE

"Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation, and management of wet weather impacts that provides many community benefits."

Technical Guidance of the Sendai Monitor Framework - UNISDR 2017

DEFINITION OF ECOLOGICAL ENGINEERING

"Ecological engineering is the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both. It involves the design, construction and management of ecosystems that have value to both humans and the environment. Ecological engineering combines basic and applied science from engineering, ecology, economics, and natural sciences for the restoration and construction of aquatic and terrestrial ecosystems. The field is increasing in breadth and depth as more opportunities to design and use ecosystems as interfaces between technology and environment are explored."

Ecological Engineering Group
http://www.ecological-engineering.com

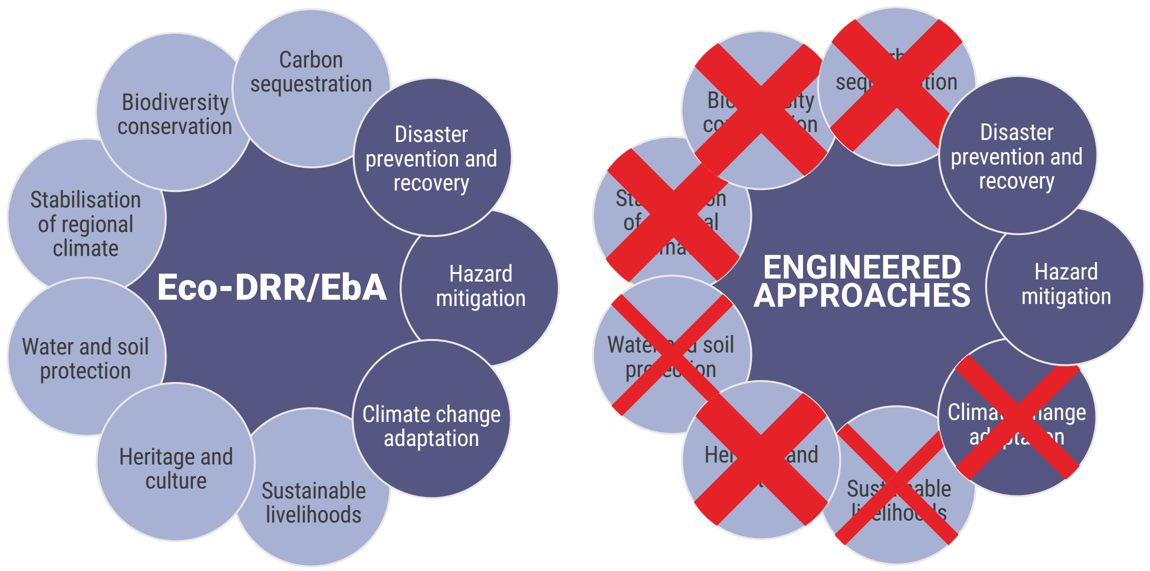

Figure 14.1
Multiple benefits of Eco-DRR/EbA as compared to engineered infrastructure.
Credits: U. Nehren, and S. Sandholz, Design: S. Plog

To be effective, ecological engineering for DRR requires reliable data on hazard frequencies and an expert understanding of the local geo-hydrological and ecological conditions. Often ecological engineering may be the most cost-effective and appropriate solution to reducing risk, as compared to grey infrastructure alone. The issue of cost-benefit of Eco-DRR/EbA and grey versus green infrastructure is something we will explore in more detail in chapter 15. Green/blue infrastructure solutions can also protect grey infrastructure, thus reducing maintenance costs and enhancing the sustainability of grey infrastructure.

In recognizing the benefits of Eco-DRR/EbA, one must also be aware of the limits, which depend on the type and intensity of the hazard, the type and health of the ecosystem, and the correct application of ecosystem management. After decades of straightening rivers, building dams and dykes, the US Army Corps of Engineers has reversed many of its practices and realized the importance of building with rather than against nature. They have developed useful guidelines for ecological restoration and ecological engineering[5]. Some regions in Switzerland have also embarked on a river renaturalisation project spanning over more than 10 years to reduce flooding by returning the rivers in their natural state (Département du territoire 2009).

5 see USACE publications: https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/ Accessed 30 August 2019.

Examples of ecological engineering

ECOLOGICAL ENGINEERING APPROACH	EXAMPLES OF ECOLOGICAL ENGINEERING
Active restoration of ecosystems	• Aeration of lakes • Restoration of banks (rivers, canals), wetlands, areas affected by opencast mining • Application of defragmentation measures to roads
Sustainable use of ecosystem goods and services	• Traditional use of ecosystems • Combined agriculture and forestry • Integrated agri-/fishculture • Dynamic coastal management by sand supplementation on foreshore
Waste processing (imitation of natural cycles in ecosystems)	• Composing of organic substances • Urine separation in toilet systems for agricultural use • Use of vegetation for absorption of dust/pollutants
Creation of 'constructed' ecosystems	• Constructed wetlands as biotopes • Green roofs as water buffers and plant/animal habitats • Creation and management of gardens, parks, wind belts and wildlife corridors – habitat and corridor functions

Updated and amended from Van Bohemen (2012)

14.2 The potentials and limitations of ecological engineering

Ecosystems also have limitations. Installing ecological infrastructure can be time-consuming and require additional space. For example, trees need time to grow before the forest can provide effective protection from landslides and avalanches. Ecological infrastructure should not replace other critical life-saving DRR measures, such as early warning systems, preparedness and adequate contingency planning.

Depending on the circumstance, in particular the type of disaster risk (i.e. expected magnitude of the hazard and density of settlements) natural infrastructure should be considered as complementary to engineered infrastructure as long as there are no additional environmental impacts. It is critical to involve environmental experts together with disaster risk experts, to do site- and context-specific planning and to consider future climate scenarios. Ecological infrastructure can fail as well, for example when long-term maintenance is not guaranteed, or inappropriate species are selected. In some cases, natural buffers are not feasible due to biological limitations, space constraints, incompatibility with priority land uses, or prohibitive costs (**Figure 14.2**).

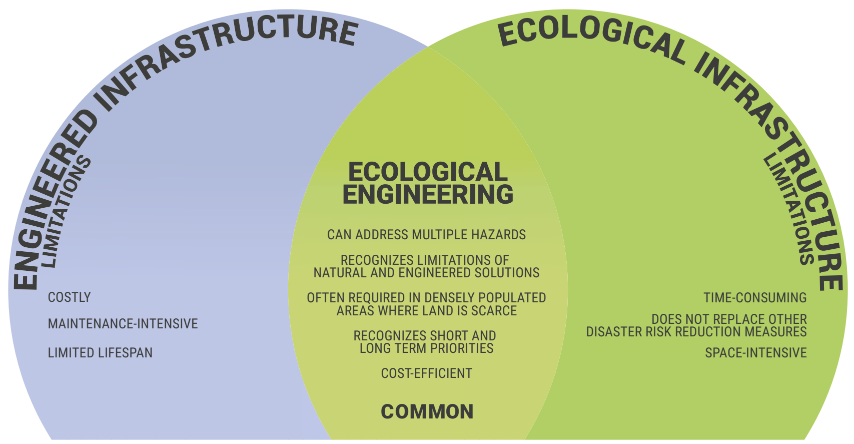

Figure 14.2
Potential of ecological engineering.
Credit: S. Sandholz, Layout S. Plog

Valuing urban coastal resilience nature's role

Post-Hurricane Sandy, the Urban Coastal Resilience Project found that nature-based features (such as mussel beds and restored marsh) can be successfully used in a dense, urban setting in combination with "grey" defences (like sea walls and flood gates) to provide efficient and cost-effective protection from sea level rise, storm surge and coastal flooding. The study found that combining natural and grey defences holds the most benefits. Analysis shows that a hybrid alternative could result in avoided losses in one neighborhood of up to $244 million from the current 1-in-100-year storm event.

TNC 2015

Evaluation of green versus grey solutions

EVALUATION CRITERIA	GREEN INFRASTRUCTURE	GREY INFRASTRUCTURE
Engineering approach	- Green solutions require a custom-made, location, specific design and do not easily lend themselves to standardization and replication	+ Traditional engineering solutions enable standardization and replication which can significantly reduce project costs and delivery times
Physical footprint	- A large physical footprint is often required due to low energy density	+ Usually, only a small physical footprint is required due to high energy density
Environmental footprint	+ Often reduced environmental footprint due to green solutions being nature-based and self-regenerating	- Often increased environmental footprint due to material and energy intensive processes (manufacturing, distribution, operation)
Speed of delivering the functionality	- Green solutions may take time (years) to grow to provide a certain service and capacity	+ Traditional engineering solutions provide a certain service and capacity from day 1 of operation
Susceptibility to external factors	- Green solutions are susceptible to extreme weather conditions, seasonal changes in temperature or rainfall and disease, although natural systems will regenerate naturally after a disaster	- Grey infrastructure is susceptible to power loss, mechanical failure of industrial equipment and price volatility
Operational and maintenance costs	+ Often significantly lower as only monitoring and feedback is required	- Operating costs are often significantly higher due to power consumption, operational and maintenance requirements
Need for recapitalization	+ Recapitalization during the life of the green solution is usually not significant. The end of life replacement/ decommissioning will vary greatly depending on the technology selected but is usually not necessary as solutions are self-sustaining and do not depreciate	- Grey solutions are depreciating assets with a finite performance capacity and usually require significant replacement/ decommissioning at end of life

Amended from Joint Industry White Paper, TNC 2013

There are many opportunities for ecological engineering, which is itself only beginning to emerge as a growing field. Especially in urban areas, land is scarce and there may not be enough space for green infrastructure without major relocations. At the same time, urban areas are currently at the forefront of much innovation when it comes to urban greening whether with green roof tops, replacing impervious surfaces with plant boxes to promote drainage, permeable pavements, creating artificial wetlands for storm water treatment and planting more trees to promote cooler cities. Many cities and regions are introducing green solutions. For instance, Bogotá, Columbia is pursuing upstream landscape conservation and restoration as an alternative to more conventional water treatment technologies. Ho Chi Minh City in Vietnam restored mangroves instead of building dikes in order to protect shorelines from storm damage (Talberth *et al*. 2012).

Another example is the European Union that has adopted a Green Infrastructure Strategy to promote its development in EU's urban and rural areas. This strategy is considered as cross-cutting because its goals support – among others – the EU Biodiversity Strategy and the Roadmap on a Resource Efficient Europe (European Commission 2016).

Riverine cities are usually built just up to the waterfront, without any retention areas. Such cases require cooperating on a river basin or watershed scale to create room for natural water retention further upstream, and also in certain city areas, redesigning the landscape to include both engineered structures such as flood protection walls and more ecosystem-based structures that can also be used for recreation, may be possible. The city of Munich restored an artificial canal bed to a more natural shape and function in order to improve flood control, biodiversity and recreational opportunities, using a combination of approaches (Arzet and Joven n/a).

Another example, mangrove belts can be used hand-in-hand with engineered coastal defences, where appropriate for coastal dynamics. Similarly, wetlands can be used to reduce wave action to protect human-built levees, increasing their effectiveness and lifespan. The need for combined solutions using engineering options also depends on the local context (**Figure 14.3**). For instance, forests may stabilize snow on avalanche-prone slopes but depending on the magnitude and strength of the forest, it will not be able to stop an avalanche once it has started.

What is Ecosystem Restoration?

Ecosystem Restoration is the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed".

Society for Ecological Restoration International Science and Policy Working Group 2004.

Figure 14.3
***Top left*: hybrid avalanche protection with snow fence and forest, Austria** (Credit: S. Sandholz). ***Top right*: river renaturation, Germany** (Credit: Zumbroich Consulting)**. *Bottom left*: hybrid coastal protection, Sri Lanka** (Credit: B. McAdoo)**. *Bottom right*: hybrid landslide protection with geotextile, Brazil** (Credit: W. Lange)**.**

Combining natural and engineered measures makes sense, because:

- A combined approach can benefit from the potentials of both types of measures and address multiple hazards, for example protection from flooding and landslides.
- Combined natural and engineered solutions can complement each other and minimize limitations. However, it is important that the engineered measures do not severely damage the ecosystem and natural processes in an unsustainable manner.
- Hybrid solutions are often required in densely populated areas where land is scarce and can also address both, short- and long-term priorities.

The cost-efficiency of hybrid solutions has been proven by a growing number of case studies. Take the example from New York City which launched its green infrastructure plan in 2010 (**Figure 14.4**).

At the time, the grey infrastructure of the sewer system was in urgent need for upgrading with estimated costs of 6.8 billion US$. Instead, the city decided to invest in a «green infrastructure» plan which cost 5.3 billion US$. The plan includes green roof tops, green sidewalks, upstream and urban wetlands, and ponds for cooling the city, aesthetics and for storm water retention, serving not only for DRR but also for CCA. In addition to its initial lower cost, over time the benefits of green infrastructure accrue while grey infrastructure requires renewed investment after 10-15 years (NYC 2013).

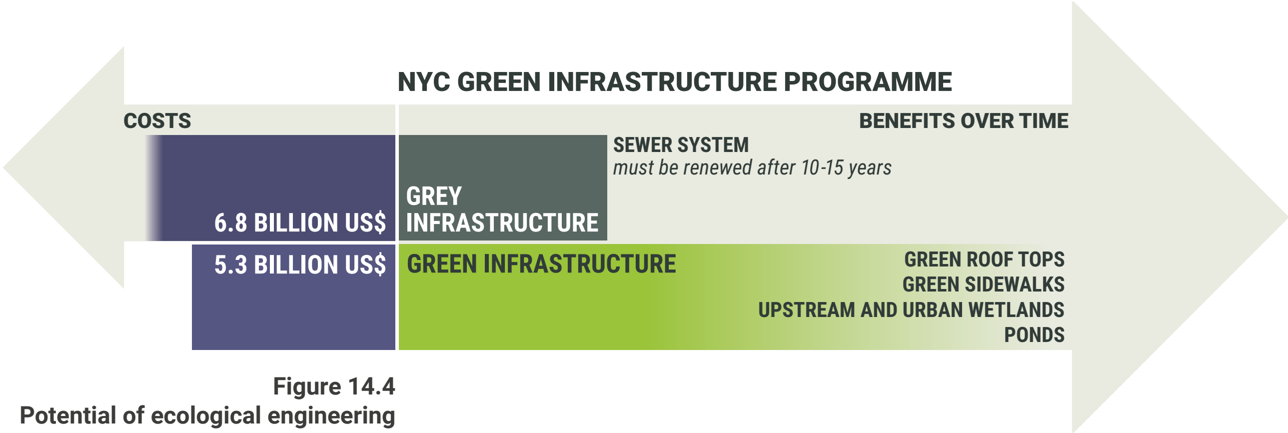

Figure 14.4
Potential of ecological engineering and cost benefit of grey versus green infrastructure.
Credit: NYC 2010. Design: S. Plog

The early results of the program monitoring indicate that:

- All green infrastructure practices have provided benefits for storms greater than one inch;
- Green infrastructure retains substantial runoff volumes, supporting more effective stormwater control;
- Growth and establishment of plants improve the infiltration and evapotranspiration of stormwater runoff.

In addition, the following co-benefits were highlighted:

- Carbon sequestration by vegetation is helping NYC to meet its greenhouse gas reduction goals;
- Shading and improved insulation from green infrastructure reduces the energy demand;
- Green infrastructure offers opportunities for improved soil health and urban habitat that supports pollinators and other wildlife;
- Vegetation is supporting an improved air quality;
- Vegetation is supporting human well-being;
- Green infrastructure offers potential for the establishment of green jobs (as amended from NYC 2013).

The World Resources Institute conducted a study on two major watersheds in Maine and North Carolina, USA, in support of emerging payments for watershed services (PWS) programs. For water utilities, PWS that protect "green" infrastructure like forests and riparian buffers can be a far more cost-effective approach for meeting water quality standards than building new "grey" infrastructure, such as filtration and wastewater treatment plants. The preliminary results indicate that investment in a package of these green infrastructure options could represent a cost savings of $68 million or 51%, relative to the grey infrastructure option in the low-cost scenario (Talberth *et al*. 2012).

The EU undertook a study on how green infrastructure can mitigate flood risk as well as their financial, economic and social impacts. An analysis of 363 floods recorded between 2002 and 2013 in the EU estimated that total damages amounted to €150 billion. Concerning the potentials of green infrastructure, it found that "*investment in flood protection typically returns benefits 6-8 times the costs, with green infrastructure projects potentially delivering significant environmental benefits as well as cost savings*." Green infrastructure projects were found to require significant upfront investment but at the same time a high potential to deliver significantly greater environmental benefits alongside reduction in flood damages and, potentially savings from reduced costs compared with traditional defenses (Udo *et al*. 2014).

14.3 Conclusions

Ecological engineering is a no-regrets strategy, and it has already proven to be effective (Dudley *et al*. 2010, Trzyna 2014, UNEP *et al*. 2014, Narayan *et al*. 2016). Where the ecological system is not critically damaged, grey and green approaches can be complementary and combined. Furthermore, with the inclusion of green infrastructure in the Sendai Monitor, the global DRR community is encouraging investments in resilient infrastructure, including green and blue infrastructure. The indicators under Target C5 focus on direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters and Target D4 on the number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters. For these two indicators, a footnote in the Sendai Monitor directly suggests that green infrastructure can be reported against (Sebesvari *et al*. 2019).

Knowledge on ecological engineering exists thanks to work undertaken in a few countries and guidelines written for example ´Engineering with Nature´ (Bridges *et al*. 2018) and EcoShape (2014). However, implementation may be locally specific depending on local climate conditions and protection needs. Fortunately, there are a growing number of case studies from various countries, scales and settings that prove its efficiency, also in economic terms. However, both ecological and engineered infrastructure for DRR, have their limits and opportunities, their pros and cons. For an engineer who is usually trained in engineering solutions, it is certainly worth considering hybrid solutions for reducing disaster risk and adapting to climate change impacts. The same is true for environmental managers, trained to think in terms of green solutions. There are few engineering programmes that offer specialisations in ecological engineering but growing interest in this topic should pave the way for new opportunities in this innovative field.

EXAMPLE: WATER-RELATED AGRO-ENVIRONMENTAL MEASURES

In the village of Sint-Truiden in Belgium, measures were taken for soil erosion and mud floods protection, including grassed waterways, grassed buffer strips and retention ponds in the catchment area. The total cost of these measures was low (126€/ha/20 years) compared to damage remediation and clean-up costs caused by muddy floods (54€/ha/year). Secondary benefits include better downstream water quality; lower downstream dredging costs; less psychological stress for inhabitants and greater biodiversity. Greater biodiversity and better landscape quality created new agro- and eco-tourism opportunities.

European Commission 2016

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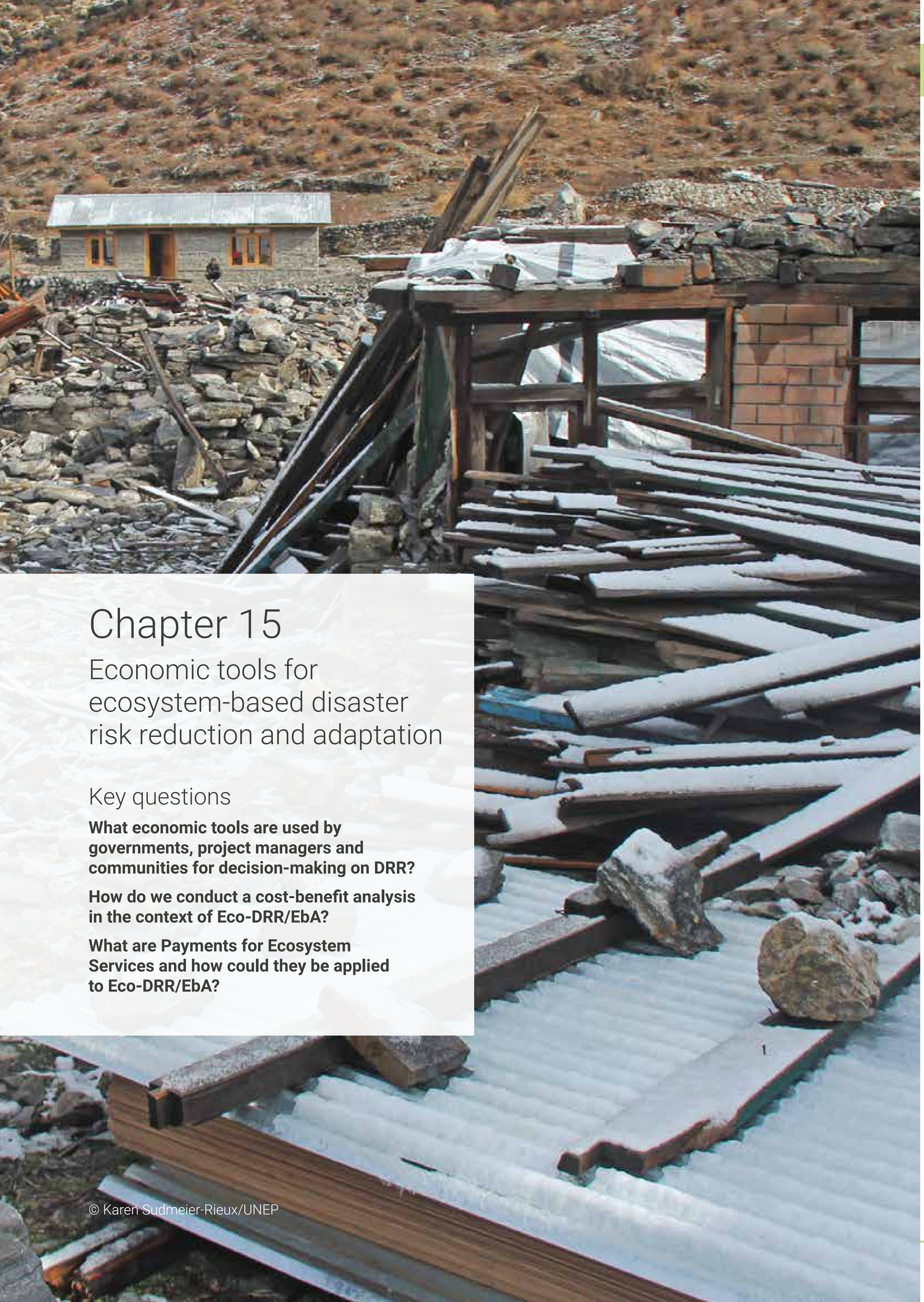

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Chapter 15

Economic tools for ecosystem-based disaster risk reduction and adaptation

Key questions

What economic tools are used by governments, project managers and communities for decision-making on DRR?

How do we conduct a cost-benefit analysis in the context of Eco-DRR/EbA?

What are Payments for Ecosystem Services and how could they be applied to Eco-DRR/EbA?

15.1 Main economic tools used for decision-making on disaster risk reduction

Decisions on how to reduce disaster risks are often made based on a variety of economic tools and at various scales from the international down to the local levels. Decision-making on DRR at the macro level by governments will differ from decision-making by local stakeholders. Yet the principle is very similar: we want to have the best protection against hazard events, if possible with the least amount of investments and costs over a certain time period. There are also certain constraints that affect decision-making on investments in DRR and adaptation. These include limited financial resources, time frames and the expertise available. In developing countries especially, financial resources are scarce and the budget available for DRR and adaptation must be subdivided in technical, ecological, and socio-economic measures.

In many cases, major financial decisions and implementation of DRR are taken following a disaster. Disasters cause economic losses which are more readily absorbed by larger economies and may actually stimulate growth but overall are setbacks for developing countries which may take years to recover. After a disaster, a Post Disaster Needs Assessment (PDNA) is a suitable tool to assess losses and where to place effort and investment in a holistic cross-sectoral approach. It is often at this stage that ecosystem-based management and other preventative measures are considered and implemented with part of the influx of calamity funds now available to a country.

Cost-benefit analysis (CBA) is one of the most common economic tools to guide decision-making, multi-criteria evaluations is another. This chapter will focus on cost benefit analysis as it is the most common economic tool for decision-making and thus relevant for Eco-DRR/EbA. However, it is also important to understand ecosystem valuation. We usually consider investments in DRR as either structural or non-structural measures: examples of structural measures include retrofitting buildings or investments in engineered (grey) or ecological (green) infrastructure. Non-structural measures include emergency training, early warning systems or spatial planning (**Figure 15.1**).

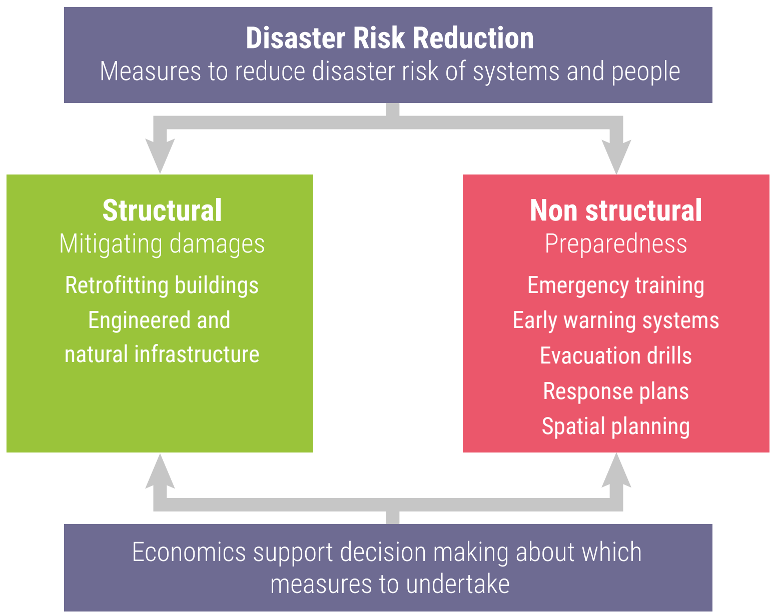


Figure 15.1
Structural and non-structural measures for reducing disaster risk.
Design: L. Rharade. Redrawn by L. Monk

Unfortunately, many governments do not often consider investments in ecosystems, or green infrastructure as part of the range of possible DRR measures. However, CBAs have shown that investments in ecosystem-based measures can be cost-effective in the long run and have additional benefits which technical measures cannot offer. Over the long-run, green infrastructure benefits often accrue while grey investments require renewal or high maintenance costs. **Figure 15.2** shows the strength of structures of civil engineering measures (i.e. gabion walls) as compared to soil bio-engineering/green infrastructure measures (i.e. a re-vegetated slope, where appropriate). After some years, the wall will need to be replaced while the vegetation on the slope will continue to grow and strengthen the slope (e.g. the New York City Green Infrastructure Programme in Chapter 14).

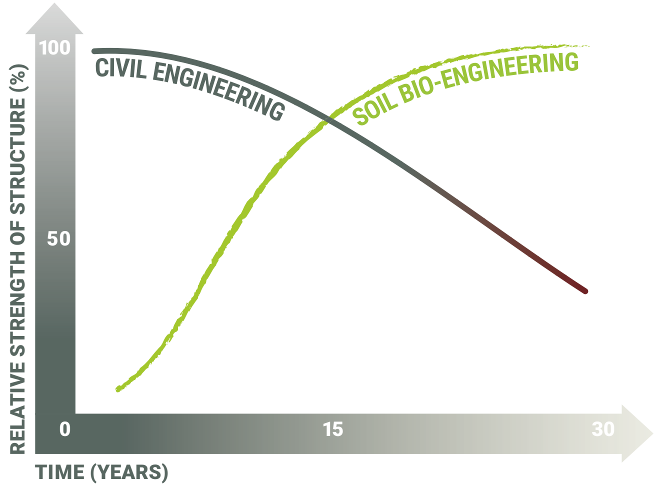


Figure 15.2
Civil engineering versus green infrastructure (in this case, soil bio-engineering) for strength of structures over time.
Source: modified from CESVI 2013.
Design: S. Plog

As discussed in Chapter 14, it is of course possible and often necessary to combine grey and green infrastructure to optimize protection as long as civil engineering structures do not create unsustainable ecological harm.

15.2 Post-disaster needs assessments

Disasters cause not only devastation to people and cities but they also have large economic consequences. The following table shows economic consequences of disasters similar to the typhoons Ondoy and Pepeng in the Philippines in 2009.

DISASTER	COUNTRY	YEAR	TOTAL EFFECTS (US$ million)	MAGNITUDE (% of GDP)
Earthquake	Pakistan	2005	2,876	0.4
East Asia Tsunami (Aceh)	Indonesia	2005	4,452	1.6
Cyclone Sidr	Bangladesh	2007	1,640	2.8
Cyclone Season	Madagascar	2008	333	4.0
Cyclone Nargis	Myanmar	2008	4,060	19.7
Storm and Floods	Yemen	2008	1,638	6.0
Typhoons Ketsana and Parma	Philippines	2009	4,383	2.7

Table 15.1
Damage, losses and magnitude of similar disasters to the tyhoons Ondoy and Pepeng. Source: modified from the World Bank Post-Disaster Needs Assessment on the Philippines typhoons Ondoy and Pepeng. Design: L. Rharade

The PDNA methodology is an important tool for assessing post-disaster costs. The main goal is to assess the full extent of a disaster's impact, define the needs for recovery, and, in so doing, serve as the basis for designing a recovery strategy and guide donors' funding. A PDNA looks ahead to restoring damaged infrastructure, houses, livelihoods, services, governance and social systems, and includes an emphasis on reducing future disaster risks and building resilience. As it usually covers infrastructure, agriculture, social and DRR sectors (among others), it has a huge potential for mainstreaming Eco-DRR/EbA in "build back better" approaches (Hinzpeter and Sandholz 2018).

ESTIMATED DAMAGE, LOSSES AND NEEDS:

Typhoons Ondoy and Pepeng on the Philipinnes caused substantial **damage and losses**, equivalent to about 2.7% of GDP.

Damages:
The storms hit regions of the country that account for over 60% of the GDP (including the National Capital Region, which accounts for about 38% of the total GDP). The PDNA found that damage to physical assets in the affected areas amounts to an estimated Php 68.2 billion, equivalent to **US$1.45 billion**.

Losses:
The adverse impacts on the productive sectors were largely due to damaged or lost inventories, raw materials and crops. In addition, business operations were interrupted by power and water shortages, damaged machinery, and absent employees, which contributed to an overall reduction in production capacity. While the destruction or damage to assets occurred at the time of the storms, the associated changes in economic flows lasted beyond the present calendar year. In some sectors and cases, the effects were felt in 2010 and 2011 depending on the speed and efficiency of the post-disaster recovery and reconstruction activities.

Needs:
A total of US$ 942.9 million was required to meet recovery needs, and a total of US$ 3.48 billion was required for the reconstruction efforts over the short term (2009-10) to medium term (2011-12).

(Teves and Hofman 2011)

WHAT IS A POST-DISASTER NEEDS ASSESSMENT (PDNA)?

Guiding Principles:
A Post-Disaster Needs Assessment (PDNA) is a government-led exercise based on a guideline developed by the UN Development Group, the World Bank and the European Union. It:

- provides a platform for the international community to assist the affected Government in recovery and reconstruction;
- provides a coordinated and credible basis for recovery and reconstruction planning;
- incorporates risk reduction measures and financing plans;
- provides a systemic link into sustainable development.

Methodology:
The PDNA is comprised of a 'Damage and Loss Assessment' (DALA), a 'Human Recovery Needs Assessment' (HRNA) and a 'Recovery Framework'.

In prior PDNAs, the World Bank and IFIs have focused on the damage and loss assessment, the UN agencies on the identification of human impact and needs. Together, the analyses of damages, losses and needs are used to develop the Recovery Framework.

The DALA is quantitative in nature and is used to value damages arising from a hazardous event, and the subsequent economic losses caused by the event. This methodology, developed by the United Nations Economic Commission for Latin America (ECLAC) in the 1970s, provides a standardized tool for the valuation of disaster damage (in physical assets, capital stock, material goods) and losses (in flows of goods and services, income, costs) that arise due to the temporary absence of the destroyed assets. The DALA highlights the possible consequences on the growth of the national economy, the external sector and the fiscal balances, as well as the impact due to decline of income and livelihoods of households or individuals.

The HRNA focuses on the social impact of disasters, analyzing how disasters affect local patterns of life, social structures and institutions. A HRNA includes analysis of primary data from household or other units of analysis and provides insight into the recovery and reconstruction from the viewpoint of the affected community.

The Recovery Framework summarizes the recovery recommendations from the sectorial assessments within the PDNA. It outlines the short, medium and longer term priorities for the country's recovery.

Global Facility for Disaster Risk Reduction and recovery PDNA

The PDNA carried out in the aftermath of typhoons Ondoy and Pepeng in the Philippines provided a quantification of the damage and losses to the economy, the social and economic impacts of the disaster, as well as a recovery and reconstruction strategy to address these (World Bank 2011). The 2011 National Greening Program was created in the Philippines in the aftermath of Hurricane Haiyan. It seeked to grow 1.5 billion trees in 1.5 million hectares nationwide within a period of six years, from 2011 to 2016 to improve the resilience of the area. Thus, Eco-DRR/EbA measures can be planned within the PDNA.

Kerala's PDNA report after the floods in 2018, has incorporated Eco-DRR/EbA by suggesting to build back better to a green and resilient state, including 1) Integrated Water Resource Management, 2) an eco-sensitive and risk-informed approach to land use, 3) inclusive and people centered, and 4) Knowledge, innovation and technology (Kerala PDNA 2018).

15.3 Cost benefit analysis in the context of ecosystem-based disaster risk reduction and adaptation

CI, the SPREP, UNEP and UN Habitat for the town of Lami, Fiji, carried out a cost-benefit analysis to assess adaptation options for the city (**Figure 15.3**). They compared green solutions such as planting mangroves and replanting stream buffers with engineering measures such as building seawalls and increased drainage.

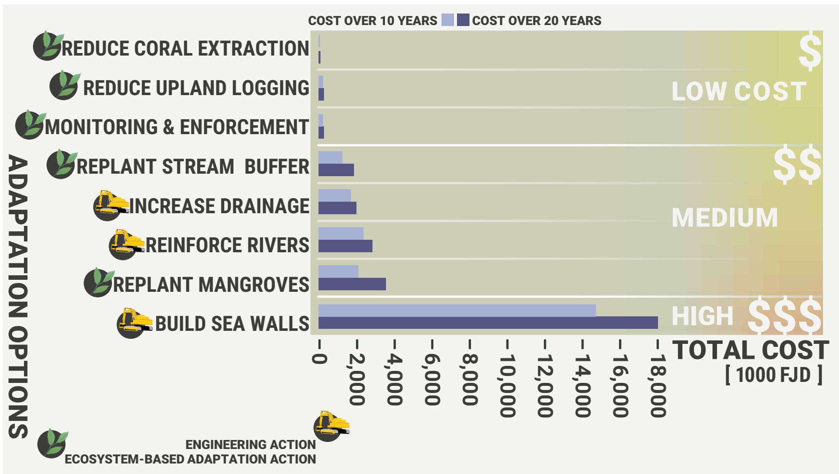


Figure 15.3
Adaptation options, Lami Town, Fiji.
Source: modified from: Rao *et al*., 2013. Design: S. Plog

The study concluded that ecosystem-based measures yielded a greater benefit to cost ratio, as compared to engineering actions (**Figure 15.4**). Nonetheless, the study also revealed that in terms of avoided (flood) damage, engineered measures provided 15-25% greater protection than ecosystem-based measures, thus recommending that a hybrid between green and grey infrastructure be used as part of the city's coastal defence and adaptation strategy.

Figure 15.4
Cost of adaptation options for Lami Town, Fiji.
Source: modified from: Rao *et al*., 2013. Design: S. Plog

Based on the Lami, Fiji study, here are steps for developing scenarios for decision-making on green, grey/green or grey investments in DRR/adaptation (**Figure 15.5**).

1. **Identify possible grey and green DRR/CCA measures and the type of hazard or threat**. You can use a vulnerability and capacity analysis (VCA) to identify the greatest threats and hazards.
2. **Estimate the costs of implementing each measure**. What are the costs for installation, maintenance, labour and opportunity costs for each measure?
3. **Estimate the costs of inaction**. Inaction can be expressed as expected damage losses, which can be estimated either by using existing data on previous losses to infrastructure, households and businesses, the cost of repairs, provision of relief supplies, health and education costs. However, when action is taken, then we expect some proportion of storm damages to be reduced. These benefits are considered "avoided costs".
4. **Develop scenarios**. These can range from completely green to grey/green to completely grey engineering measures for a given hazard or multi-hazard situation. Consider that climate change is creating more uncertainty so your scenarios will need to include the possibility of more extreme events.
5. **Perform a cost-benefit analysis for each scenario and consider the avoided damages**. You must include a net present value (NPV), an annualized net present value and a benefit-cost ratio. NPV analysis estimates the difference in the present value of the benefits (accrued revenues or monetary savings from a proposed investment) minus the present value of the costs (accrued expenditures from a proposed investment). The annualized NPV (ANPV) is the average yearly net return over the lifetime of the suite of adaptation options, that is, the annualized cash flow (Rao *et al*. 2013).
6. **Estimate the value of the ecosystem services** to development, livelihoods, environmental quality, and carbon sequestration that you may be able to value, and some that cannot be valued monetarily. You can do this by using a combination of global and local economic valuation studies that you can find in the reference materials. Also see the section below for more details on valuing ecosystem benefits.
7. **Communicate** the co-benefits of ecosystem services as both direct and indirect values, carefully documenting and justifying your approach.

8. **Consider non-structural measures** for reducing disaster risks, such as capacity building, early warning systems, legal, policy or regulatory actions.
9. **Discuss the different scenarios** for structural and non-structural measures. The results can be presented to the stakeholder group as a basis for your discussions. Consider who will benefit from the various options and what could be other hidden social or environmental costs linked to the various scenarios.

Note: Be transparent about the limitations of your scenarios and suggest ways to improve the method for next time.

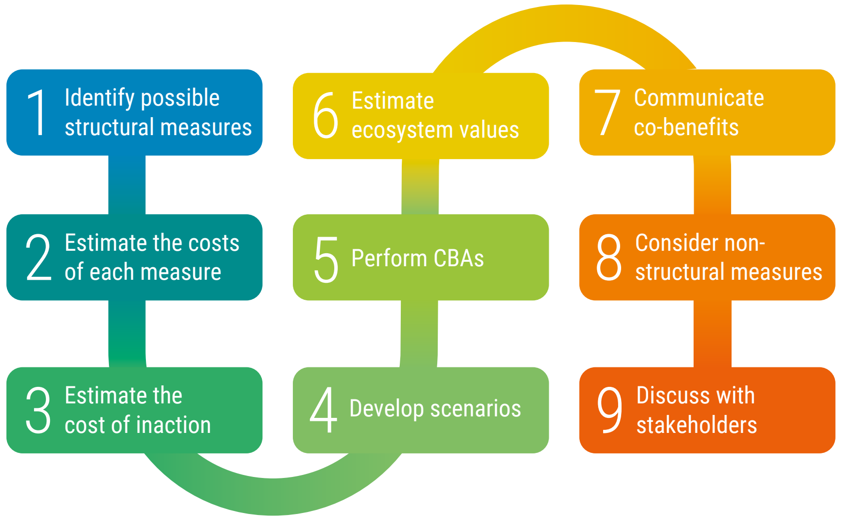


Figure 15.5
Steps identifying for green, grey/green or grey scenarios.
Inspired by Rao *et al.* 2013.
Design: K. Sudmeier

15.4 Ecosystem valuation

In economics, money is usually the common denominator for attributing value to ecosystem services. These can fall into three basic types: direct market valuation; indirect market valuation; and survey-based valuation (i.e. contingent valuation and group valuation) (de Groot *et al.* 2010). If data are lacking, economists often use "replacement or avoided costs". This refers to the cost that would be incurred if an ecosystem (i.e. coral reefs) is destroyed and has to be replaced by an engineered structure (i.e. seawalls). Replacement costs also refer to the cost of having to rebuild infrastructure (i.e. roads, housing) that are no longer protected by ecosystems (i.e. forests on mountain slopes). Emerton (2009) estimated that along the coast of Indonesia, the cost of replacing roads and houses in the event of strong waves is estimated at US$50,000/km, and the cost of maintaining sandy beaches for tourism is US$1 million/km, both are protected and maintained naturally by coral reefs (Emerton 2009), saving society large sums of money. Considering the case of Lami, Fiji, the replacement cost would include the cost to build a sea wall and most likely also frequent beach replenishment. And this does not include many other values such as water filtration, tourism or aesthetics provided by the ecosystems. Therefore, we observe that valuing ecosystems as part of cost-benefit analysis is limited as such economic tools do not take into account the total value of ecosystems.

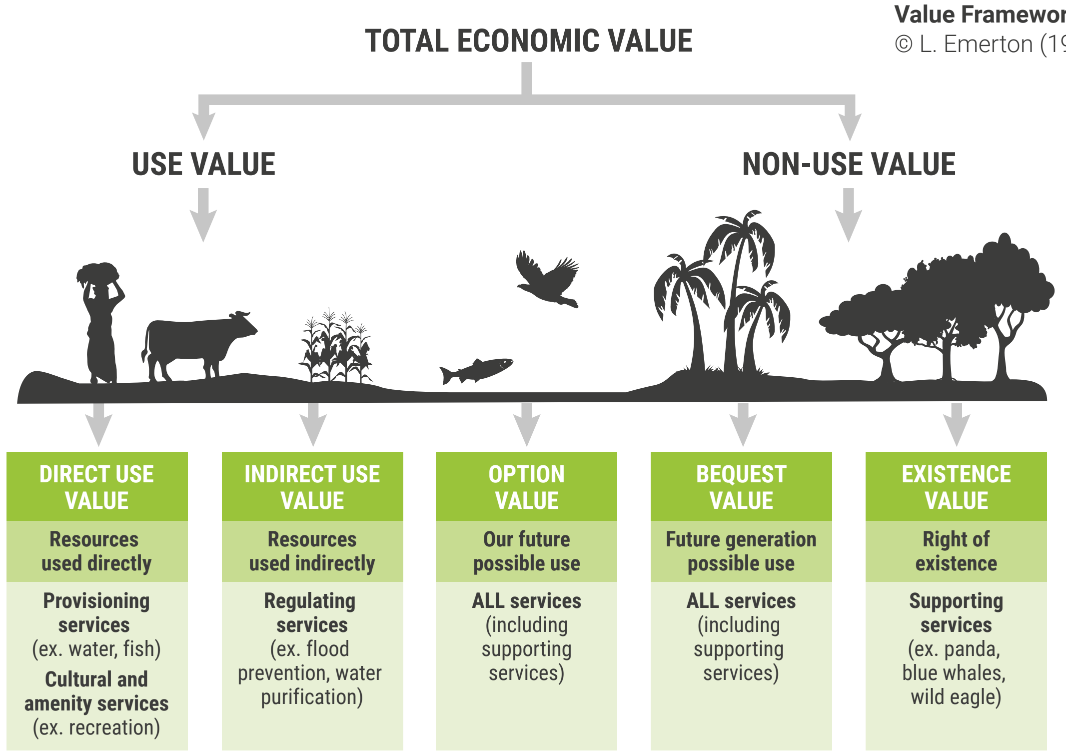
TOTAL ECONOMIC VALUE OF ECOSYSTEMS

The Economics of Ecosystems and Biodiversity (TEEB) series is one of the most comprehensive studies of ecosystem values and led greater awareness about ecosystem valuation. Other studies have assessed the economic value of ecosystems (e.g. Costanza *et al.* 1997, Daily 1997) and the concept of Total Economic Value (TEV) (**Figure 15.6**) has become a widely used framework for looking at the utilitarian value of ecosystems). This framework typically splits TEV into two categories: use values and non-use values (Emerton 1998, de Groot *et al.* 2010).

Use values are composed of three elements: direct and indirect use and option values. Direct use values encompass goods which can be extracted, consumed or enjoyed directly. Indirect use values are the services the environment provides such as air and water purification and pollination. Option values are those related to maintaining the option use an ecosystem good or value in the future (de Groot *et al.* 2010).

Non-use values consider the benefits the environment may provide without direct or indirect use. Oftentimes, this relates to ethical values such as protection of endangered species. Finally, bequest values are those related to the willingness to pass on values to future generations. Although this distinction between values is extremely useful as it helps to value such things that cannot easily be monetized, often decision-makers unfortunately only consider mainly direct use values or possible indirect use values of ecosystem services (de Groot *et al.* 2010).

Figure 15.6
The Total Economic Value Framework.
© L. Emerton (1998)



THE VEOLIA WATER CASE STUDY

Another study of ecosystem services was conducted by the World Business Council for Sustainable Development (WBCSD) in one of Veolia Water's (a large French water utility) sites. The water catchment of Crepieux Charmy is located in the northeast of Lyon (France) and represents the largest water catchment in Europe, supplying water to 90% of the Grand Lyon population (about 1.3 million people). It is also a unique site in terms of its biodiversity with 500 plant species and broad range of animals. Veolia has developed an ecological management plan in order to preserve water quality and biodiversity of this site. The objective of the study was to investigate the hidden benefits arising from the ecological management of the site. The study was carried out by the Corporate Social Responsibility Department of Veolia Water with the help of Ecowhat, an environmental consultancy. The approach adopted followed the recommendations established by the Guide to Corporate Ecosystem Valuation (CEV) published by WBCSD in 2011.

Two main benefits were evaluated: water purification and carbon sequestration:

Water purification is provided by the alluvium of the Rhone River and the grassland and wetland habitats on the Crepieux Charmy islands. It has been assessed using an "avoided cost/replacement cost method" because without the protection of the Crepieux Charmy management regime, it is likely that a traditional water treatment plan would be needed to guarantee an appropriate level of water quality. The **carbon sequestration** function is provided by the soil and grasslands on the islands. It is therefore stored by the soil, the forest and the lawns of the Crepieux Charmy islands. This continual carbon sequestration can be seen as a positive externality of the activities that maintain it. The **financial benefit** (i.e. internal company benefit), corresponding to the avoided water treatment costs, represents an amount equivalent to 80% of the total annual costs of water production at the site and up to 16 times the ecological management costs of the site. The **economic benefit** (i.e. external benefits accruing to society) which includes the natural heritage and carbon sequestration values of the site, represent two times the total annual costs of water production and up to 45 times the ecological management costs. The **ecosystem service benefits** generated through the ecological management regime represent an amount equivalent to 29% of the drinking water part (excluding taxes and fees) of the water bill paid annually to Veolia Water (site manager) and Grand Lyon (site owner) to have clean tap water at any time.

Overall, the study confirms the positive impact of Veolia water in maintaining the ecosystem services at the site. It also highlights the modest cost of the ecological management with regards to the amount of economic benefits associated with it (WBCSD 2012).

WATERSHED CASE STUDY

Figure 15.7 illustrates how forested watersheds can reduce the cost of water treatment significantly by comparing the percentage of watershed cover and water treatment costs. This case study demonstrates that a well-functioning ecosystem can deliver the equivalent water availability and filtration as a major physical infrastructure project flood control and shoreline protection. Therefore, natural infrastructure, in many cases, can provide the same services and benefits as man-made infrastructure and at a lower cost.

Nevertheless, one of the main gaps in current DRR and CCA practices is the need for more cost-benefit analysis of ecosystem-based approaches as measured against physical infrastructure.

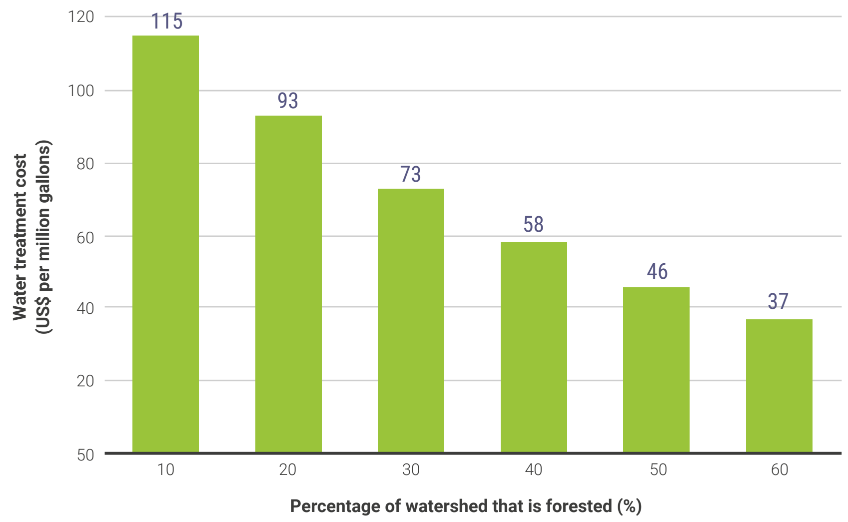


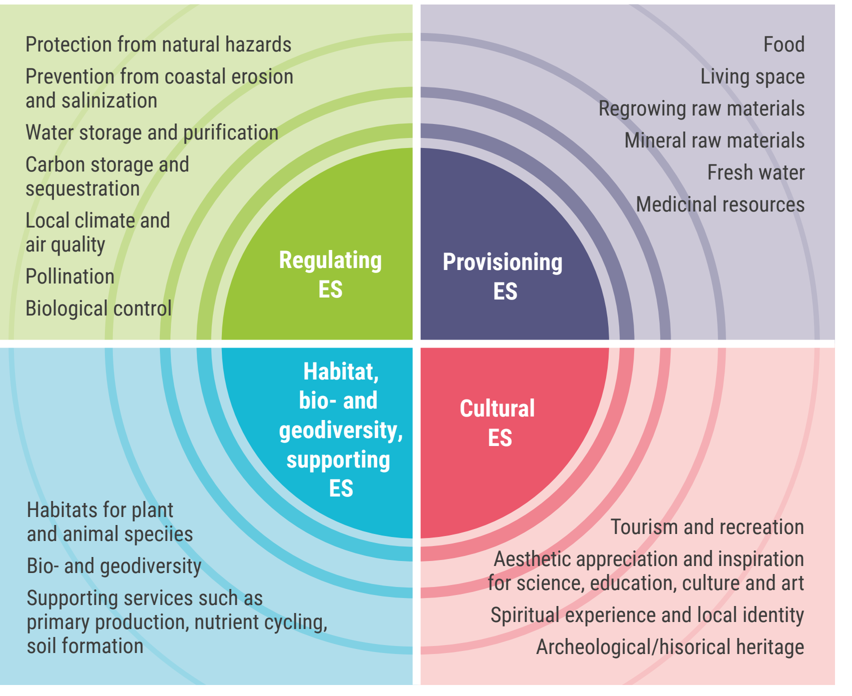
Figure 15.7
Forested watersheds reduce the cost of water treatment significantly.
Source: Modified from The Trust Public Land and American Water Works Association (2004). Design: L. Rharade and H. Van Rossum. Redrawn by L. Monk

15.5 Payments for ecosystem services

Payment for Ecosystem Services (PES) is an incentive-based mechanism to support sound ecosystem management. The basic idea is that ecosystems provide a variety of services which support human well-being. To protect and efficiently use these services, landowners and farmers receive payments to manage their land properly to avoid costs that are related to unsustainable land use, such as water contamination and soil degradation. PES can therefore be described as a financial transaction between providers and beneficiaries of ecosystem services.

To give an example, **Figure 15.8** shows ecosystem services provided by coastal dunes based on case studies in Central Chile, Central Vietnam, and Java island, Indonesia. Apart from hazard protection and mitigation of coastal erosion and salinization, coastal dunes provide a variety of other ecosystem services. For example, dunes protect coastal aquifers, provide important habitats for plants and animals, and offer several cultural services such as tourism and recreation. Some of these services have a direct economic value for humans such as sand and minerals, while others indirectly support livelihoods, for instance by storing and purifying water, supporting fisheries, or having a cultural value for the local communities.

Figure 15.8
Ecosystem services (ES) of coastal dunes.
Source: Nehren *et al*. 2016. Redrawn by L. Monk



The PES approach is based on the concept of ecosystem services. Among the 24 ecosystem services which have been assessed in the Millennium Ecosystem Assessment (MA 2005), in most cases only three are being applied for PESs: **carbon sequestration for climate change mitigation, watershed services, and biodiversity conservation**. PES schemes in many countries address these three services, and few include other services such as preserving the landscape beauty, which is for instance included in PES schemes in the Atlantic Forest of Brazil. Most PES schemes are initiated and funded by governments and often involves NGOs, but there are also several examples where the private sector is involved. This is for example the case where a private water supplier pays upstream users not to use pesticides.

DRR and CCA are usually not directly addressed in PES schemes. However, measures such as reforestation and forest management that aim at carbon sequestration, watershed protection and biodiversity conservation often also contribute to DRR and CCA, for instance by reducing the risks of floods, droughts, and landslides. Among the few examples where DRR is directly addressed are protection forests in Switzerland, where the national government pays land owners not to cut down protection forest trees that prevent from avalanches, landslides, and rockfall.

Within the last few years, PES approaches and the work of The Economics of Ecosystems & Biodiversity (TEEB) (2010, 2011, 2013, 2014), which is globally assessing economic benefits of ecosystems and biodiversity, have received much attention. Therefore, we expect that PES schemes that directly or indirectly address DRR and CCA will also become increasingly important. In the case of coastal dunes it would for instance be important to consider the value of protection services for DRR and CCA and convince decision makers of their importance. It is therefore recommended to evaluate and where possible monetize the ecosystem services provided by these ecosystems.

Only when direct and indirect ecosystem values are taken into account, can we for instance comprehensively estimate costs and benefits of conservation and restoration measures for DRR and CCA and compare them to technical measures for coastal defence. However, particularly in data-poor regions monetization of ecosystem services has its limitations. Therefore, we have to work with comparable data from other regions, use rapid assessments, and develop semi-quantitative indicators and models.

15.6 Conclusions

Disasters cause economic losses which are more readily absorbed by larger economies and may actually stimulate growth but overall are setbacks for developing countries which may take years to recover. Calamity funds may be the best opportunity for funding preventive DRR activities, including Eco-DRR. The PDNA is the first step in recognizing loss and damage to ecosystems and also for recommending investment in restoration/conservation.

Making decisions for reconstruction and DRR is often based on money and economic valuation and decision-tools are often at the forefront to help decision-making. It is important to include ecosystem-based approaches in such analyses. However, first it can be a challenge to value ecosystems and their services. Yet including them in cost-benefit analysis allows better comparison with engineered approaches.

It is also important to remember that structural and non-structural measures for reducing disaster risks and adaptation have diverse time horizons. For example, structural measures (which include grey/green infrastructure) are usually designed for 15-20 years, while green infrastructure benefits generally accrue over time. Non-structural measures such as the effectiveness of training may be long lasting. However, it is not easy, or possible to monetarily value all ecosystem benefits, including those related to disaster risk reduction. In addition, future benefits have high uncertainty characteristics due to temporal changes of overall contexts. Thus, the probability of future hazards must be considered, in particular when hazard-related measures are prioritised.

Finally, ecosystems need to be considered as an integral part of DRR and development. Grey and green infrastructure can be mutually compatible, when properly designed, as both may be needed to deliver essential protection and livelihoods support for human security.

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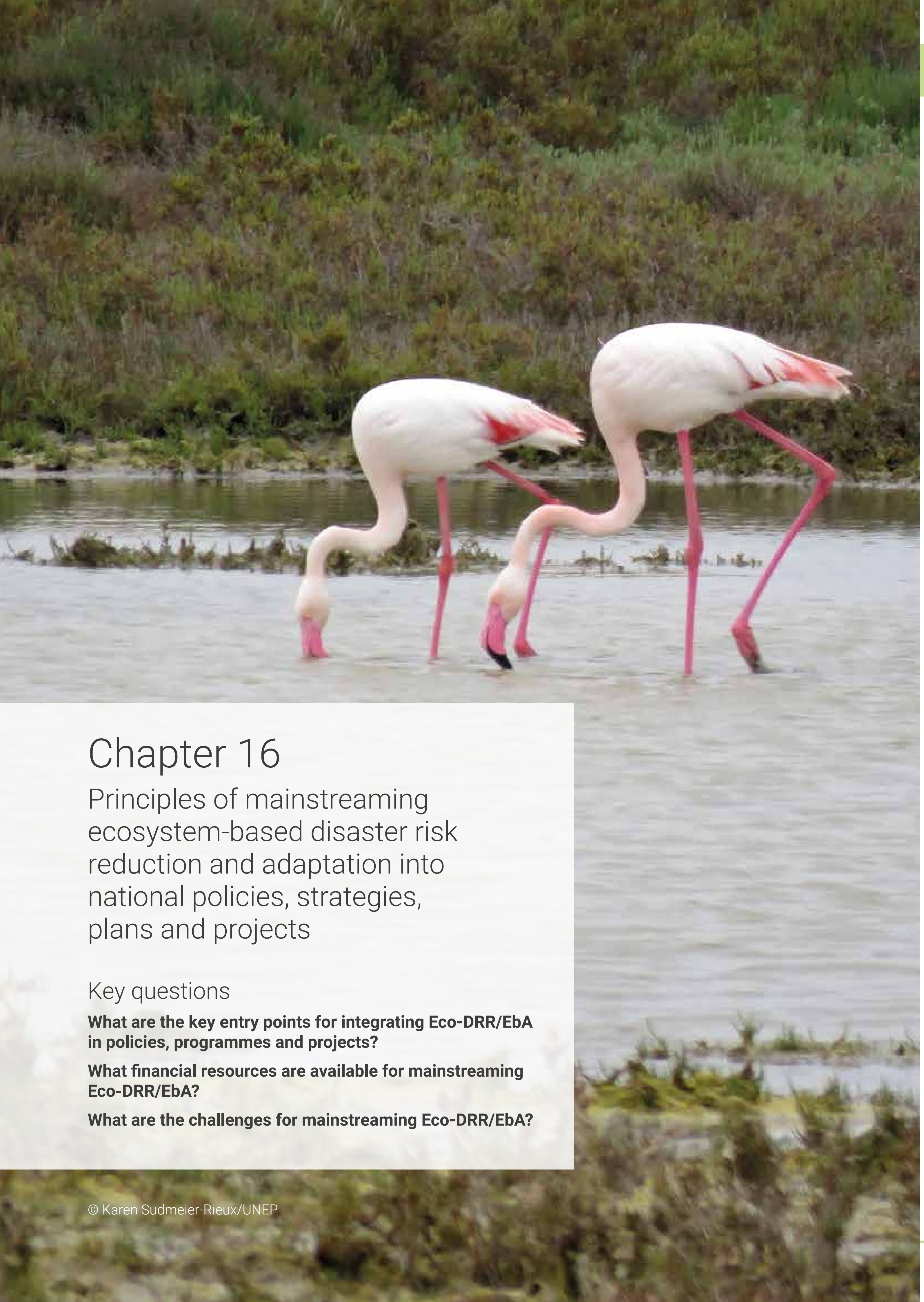

Chapter 16

Principles of mainstreaming ecosystem-based disaster risk reduction and adaptation into national policies, strategies, plans and projects

Key questions

What are the key entry points for integrating Eco-DRR/EbA in policies, programmes and projects?

What financial resources are available for mainstreaming Eco-DRR/EbA?

What are the challenges for mainstreaming Eco-DRR/EbA?

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16.1 Key entry points for integrating ecosystem-based disaster risk reduction and adaptation in policies, programmes and projects

Mainstreaming is about integrating a less common concept or approach into a more common approach. In this case, we are referring to integrating ecosystem management into DRR and CCA to achieve sustainable and resilient development (**Figure 16.1**). There are several ways this can be done at various scales, which we will describe in this chapter.

Mainstreaming Eco-DRR/EbA in development has multiple entry points and benefits. It helps protect development gains, reduce underlying vulnerabilities to future disasters, and increases access to sectoral resources and budget that can support such ecosystem-based activities.

KEY INFO: The GAR

The Global Assessment Reports on Disaster Risk Reduction (GAR) are biannual reports released by the United Nations International Strategy for Disaster Reduction (UNDRR, formerly UNISDR) since 2009. The GAR is published every two years.

Learn more about the GAR and the previous reports by clicking on: https://www.preventionweb.net/sendai-framework/gar

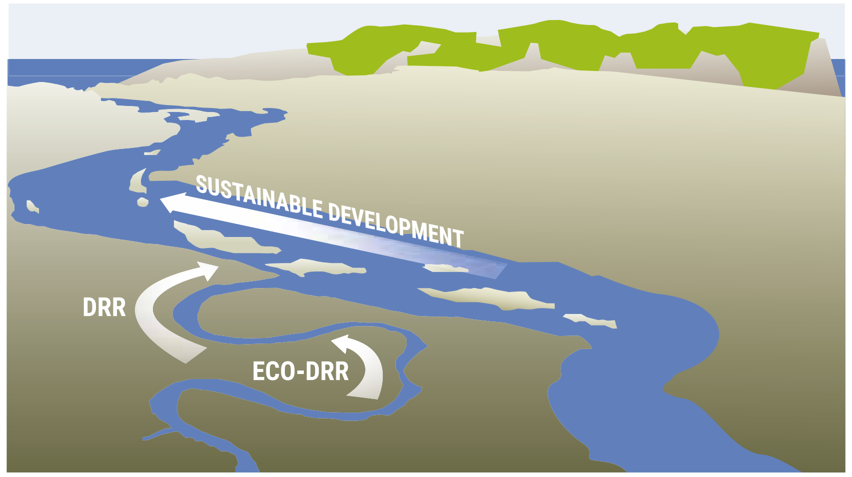

Figure 16.1
Mainstreaming Eco-DRR in DRR and sustainable development.
Design: S. Plog

The first entry point is at the global and national policy level, where organizations such as PEDRR, a global alliance of currently 23 organizations including the CBD, are working with national governments to include Eco-DRR/EbA into key international agreements, such as the SFDRR, Climate Change agreements, SDGs, and the CBD.

At the international level, the Global Risk Assessment (GAR) is a key document for information to policy makers. The GAR 15, published in 2015, focused on strengthening the governance of disaster risk, while the previous ones, with different themes, addressed the underlying risk drivers of disaster risk. GAR15 included ecosystem-based approaches and emphasizes new approaches blending grey and green infrastructure to maximize ecosystem services (UNISDR 2015). Thus, the GAR 15 is an example of a key report which has to a certain extent mainstreamed Eco-DRR and EbA. The GAR 17 provided an atlas of risk. The latest GAR report was launched at the Global Platform for Disaster Risk Reduction in 2019. The GAR 19 moves beyond disaster risk to consider the pluralistic nature of risk: in multiple dimensions, at multiple scales and with multiple impacts. It highlights environmental degradation as a key aspect in creating risk and promotes systems-thinking and calls for urgent action (UNDRR 2019).

The second entry point is national plans and strategies, such as **National Development Strategies and Plans**, **National Poverty Reduction Strategies**, **Land use plans** and **sectoral development policies and plans**. These may include **national environmental policies**, and **climate change adaptation plans**.

For example, the Maldives illustrates an interesting example of mainstreaming Eco-DRR/EbA into its Seventh National Development Plan. The Maldives is an island nation in the Indian Ocean formed by a double chain of twenty-six atolls. With an average ground level of 1.5 meters above sea level, it is the planet's lowest country. Its specific characteristics render the Maldives particularly vulnerable to flooding, storm surges, tropical storms and tsunamis as well as general sea-level rise. The Indian Ocean tsunami in 2004 caused considerable damage to the atolls.

The Seventh National Development Plan (2006-2010) incorporated several Eco-DRR/EbA aspects. These include:

- Multiple benefits of natural systems, 'soft engineering' for coastal protection;
- Integrated coastal zone management (ICZM) for flood protection;
- Water resource management;
- Environmental governance (e.g. EIA process);
- Land-use plans for safety and sustainable development.

The Maldives' Safe Island Program is an example of risk-sensitive land use plans. It provides safe havens for people who are forced to migrate before or after disasters caused by natural hazards. Several larger islands are designated to provide environmental protection zones, ecologically safe zones and structures to mitigate the impact of events such as storm surges, tidal swells and tsunamis. In addition, elevated areas and buildings are provided to enable vertical evacuation. **Figure 16.2** illustrates what such a scenario may look like.

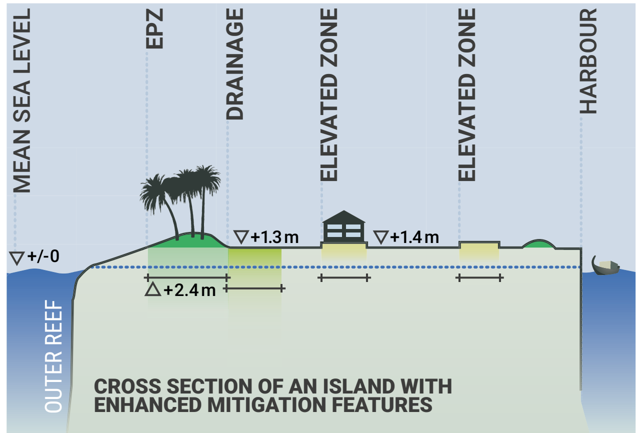

Figure 16.2
Cross section of an island with proposed enhanced mitigation features.
Modified from Government of Maldives (2007) Design: S. Plog

Another example is the 2012 Government of Colombia Risk Management law, act 1523; entitled the National System for Disaster Risk Management, the law directly associates risk management with sustainable environmental management (Article 1). This includes not only the improvement of disaster response mechanisms, but also disaster preparedness, risk knowledge and new territorial funds for both prevention and post disaster. The act mentions environmental sustainability as one of its general principles (Article 3) and it encourages environmental territorial planning that combines ecosystem services and risk mapping.

A third entry point for Eco-DRR/EbA are development projects and all phases of a project cycle, from initial assessments, problem and stakeholder analysis, to project design and implementation, monitoring and evaluation (**Figure 16.3**).

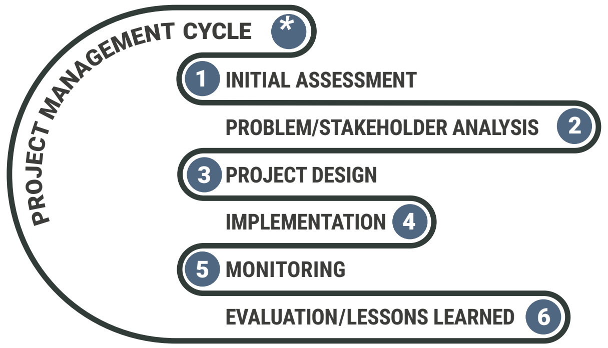

Figure 16.3
Project management cycle.
Design: S. Plog

Enabling factors for mainstreaming Eco-DRR/EbA:

Allocating resources, scaling up pilot projects, capacity development, and integrated structures and platforms can all act as enabling factors for mainstreaming Eco-DRR/EbA. In addition, incentives for individual and multi-stakeholder participation are important incentives for people to take on these approaches (**Figure 16.4**).

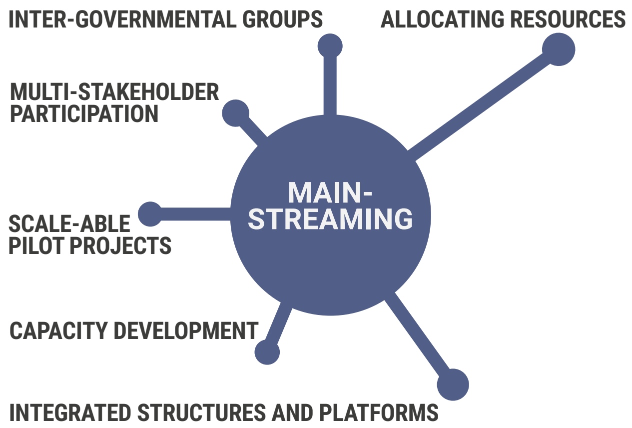

Figure 16.4
Enabling factors for mainstreaming.
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Therefore, mainstreaming Eco-DRR/EbA requires not only balancing between economic and environmental interests but also between stakeholders' competing interests. These challenges are beyond the capacity of any group or institution to address single handedly. Promoting effective participation by all stakeholders requires approaches that are multi-sectoral. Mainstreaming Eco-DRR/EbA in development should therefore be pursued at different levels, involving different actors and sectors (**Figure 16.5**).

SOME OF THE KEY ACTORS:

- Government
- Communities
- International development agencies (donors)
- NGOs
- Community-based organizations
- Academia and research institutions
- Media
- Private sector

Figure 16.5
Mainstreaming is a balancing act.
Design: S. Plog

16.2 Financial resources available for mainstreaming ecosystem-based disaster risk reduction and adaptation

Figure 16.6
Mangrove replanting in Tacloban, Philippines, by communities and Partners for Resilience to support them in rebuilding their lives after Typhoon Haiyan in 2013.
© Nicola Ward/Climate Centre

There are various national budgets that could be tapped into for Eco-DRR/EbA. These include DRR budgets, calamity funds, national environment funds, climate change funds and risk transfer instruments. Here are some examples:

The 2011 National Greening Program was created in the Philippines in the aftermath of Hurricane Haiyan. It seeked to grow 1.5 billion trees in 1.5 million hectares nationwide within a period of six years, from 2011 to 2016 (**Figure 16.6**). The goal was to mitigate climate change, reduce poverty and protect communities and coastal ecosystems from strong waves and soil erosion.

Sectoral budgets, which are not DRR specific (i.e. agriculture, forestry and water resources), could also be used for Eco-DRR/EbA. For example, Eco-DRR/EbA measures could be included by taking into account the cost of 'disaster proofing' measures that make them more environmentally and economically sustainable in the long-run.

Finally international resources for Eco-DRR/EbA could include multilateral climate funds such as the Adaptation Fund or the Green Climate Fund (GCF), which aims to respond to climate change by investing in low-emission and climate-resilient development. GCF was established to provide funds to limit or reduce greenhouse gas (GHG) emissions in developing countries, and to help vulnerable societies adapt to the unavoidable impacts of climate change. Other climate change related funds have and can be used for DRR and mainstreaming Eco-DRR/EbA. Development aid is another avenue that has invested in DRR albeit more on post- rather than pre-disaster (Kellett and Caravani 2013).

Colombia:

- A national fund for disaster risk reduction which is subdivided in five accounts: knowledge, reduction, disaster management, recovery and financial protection.
- Each department and municipality should have its own local fund (Art. 54)

http://www.alcaldiabogota.gov.co/sisjur/normas/Norma1.jsp?i=47141

Bangladesh

- Local disaster risk reduction fund that enables communities to invest in vulnerability reduction

Mexico

- FONDEN (Mexico's Natural Disaster Fund) was established to ensure adequate funding of reconstruction after national calamities
- 0.4% of national budget is allocated to reconstruction which emphasizes public infrastructure, low income housing and natural environment
- Another fund FOPREDEN is smaller but dedicated to prevention activities at all levels of government.

16.3 The challenges of mainstreaming ecosystem-based disaster risk reduction and adaptation

Having a dedicated national DRR budget is still uncommon. What is more common is to use the large influx of post-disaster funds to finance prevention projects, including Eco-DRR/EbA. In terms of funding, we should note that although there are different national budgets that could technically be used for Eco-DRR/EbA there are also many challenges of tapping into these sources. These include:

- Competing priorities
- Long-return investments vs. short-term election cycles
- Difficulty in measuring impacts of DRR
- No specific budgets for Eco-DRR/EbA measures.

Other challenges include lack of political will, limited expertise and resources on Eco-DRR/EbA and constrained institutional mandates of institutions to address cross-sectoral approaches such as Eco-DRR/EbA. Finally, there is often a preference for engineering, or grey infrastructure, approaches (Gupta and Nair 2013).

Nevertheless, some progress has been made in mainstreaming Eco-DRR/EbA. For instance, EIAs are gradually incorporating DRR components as discussed earlier. In the Cook Islands, EIAs are made compulsory for any developmental infrastructural project in several sectors such as tourism, fisheries and agriculture. In Germany, a broad range of projects and activities are covered under Germany's Environmental Impact Assessment Act (2001), which indicates the extent to which disaster risk and vulnerability factors could be addressed in EIAs. Moldova has also merged DRR into its agricultural policies, environmental policies with protected areas legislation, PES, EIA and CCA projects and programs. Finally, in the framework China's law on EIAs (2003), information on natural hazards and technological or chemical risks must be incorporated.

As illustrated in these examples, disaster risk analyses can be incorporated into the EIA process by utilizing data generated through the EIA process itself. Information generated by EIAs can help improve early warning because the EIA process can provide data for risk mapping and scenario building in relation to the potential impacts of projects. Hence, EIAs can be applied to assess hazard conditions and patterns of vulnerability in the context of the developmental planning process. EIA reports also include an environmental monitoring plan. Monitoring parameters usually cover early signals of potential disasters. EIAs applied in the disaster prevention and mitigation phase can help inform planning for DRR, for instance by providing guidance on choices mitigation methods (Gupta and Yunus 2004), technology investments and site locations for activities. In a post-disaster context, conducting a rapid environmental impact assessment (REA) helps to ensure that sustainability concerns are factored into the relief, reconstruction and recovery planning stages (Gupta 2002 *et al*, Hauer and Kelly 2018). The REA does not replace an EIA but fills a gap in an emergency context until EIA can be appropriately conducted.

In parallel to these EIAs and REAs, greater emphasis has also been placed on incorporating hazards and disaster risk analysis into the environmental assessment process itself. ProVention Consortium and the Caribbean Development Bank published Tools for mainstreaming DRR, which include a guidance note on "Environmental Assessments" (Benson and Twigg 2007). This important publication focused on environmental assessment as the natural starting point in the design of a project to address natural hazards and related risk. It provides guidance on analysing disaster risk related consequences of developmental activities as a result of their environmental impacts, as well as the potential threat posed by natural hazards to the projects. Environmental assessments are now expected to measure the risk reduction benefits of proposed environmental impact mitigation measures within the proposed development project (Carribean Development Bank and CARICOM Secretariat 2004).

16.4 Conclusions

Integrating ecosystem management into DRR and CCA strategies requires not only a balance between the interests of society, the economy and the environment, but also between the diverse interests of different stakeholders within a community or country. This requires promoting effective participation by all stakeholders and multi-sectoral approaches. Mainstreaming Eco-DRR/EbA in development should therefore be pursued at different levels, involving different actors and sectors.

The key issues for mainstreaming are 1) cross-sectoral integration, 2) enabling conditions or incentives to facilitate mainstreaming of Eco-DRR/ EbA into sustainable development policies and practices and 3) capacity building and awareness, which are all essential.

Eco-DRR and EbA are becoming more mainstreamed into influential policies and scientific reports such as the GAR or IPCC reports. Indeed, several international framework agreements, e.g. the SFDRR, the SDGs, the Paris Agreement, the CBD and the Ramsar Convention, have all included various decisions, targets and goals with various components recommending that governments and other stakeholders consider how to implement and mainstream Eco-DRR/EbA. The question now is how to do this in an integrated manner – this will take time, political will and evidence-based guidance.

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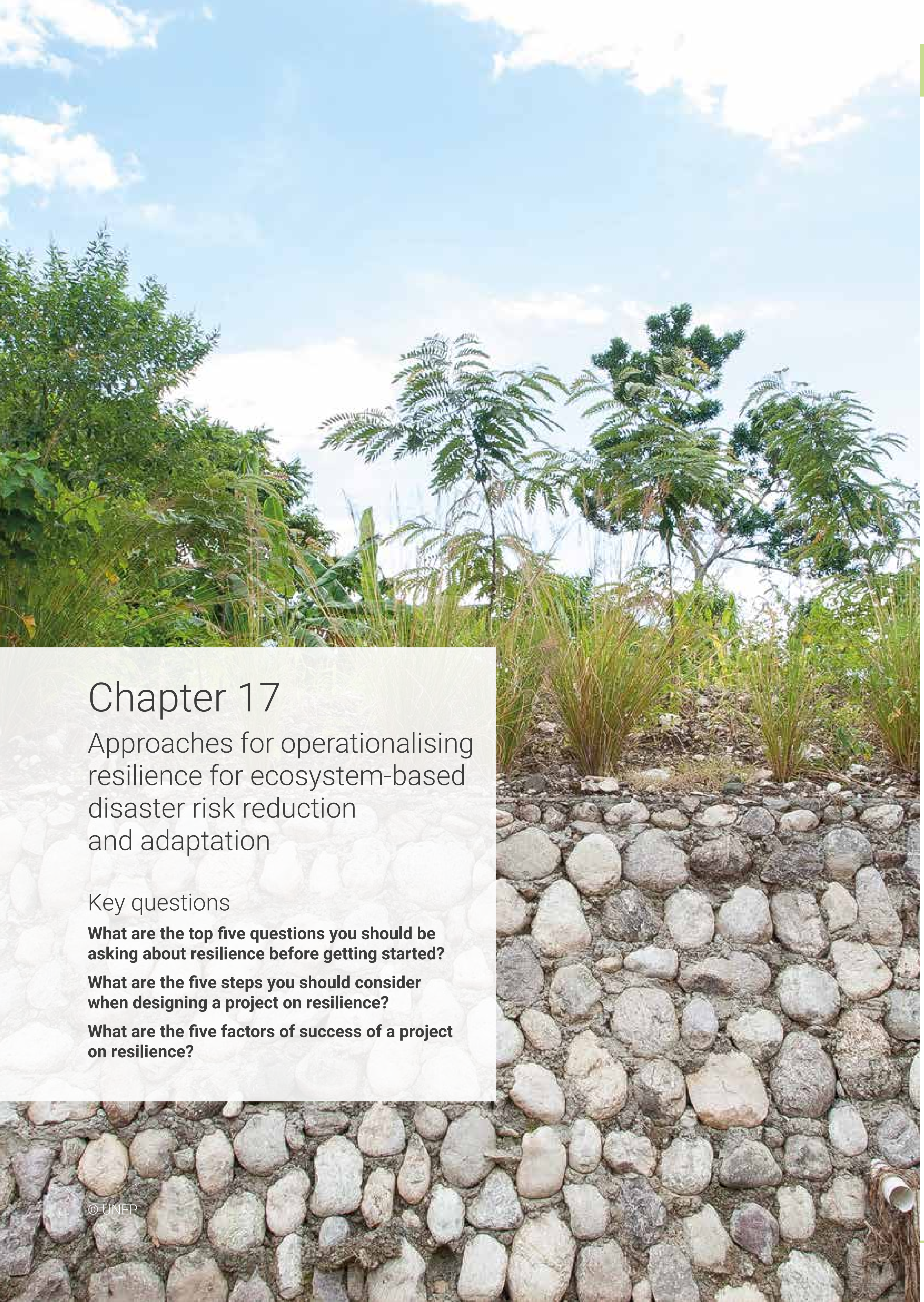

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Chapter 17

Approaches for operationalising resilience for ecosystem-based disaster risk reduction and adaptation

Key questions

What are the top five questions you should be asking about resilience before getting started?

What are the five steps you should consider when designing a project on resilience?

What are the five factors of success of a project on resilience?

17.1 Project development

In the previous chapters, the importance of Eco-DRR/EbA, its principles and tools were described. Implementing Eco-DRR/EbA to create resilience requires thinking through project development within a learning framework to enable adjustment, or adaptive management. Designing a successful project requires thinking through the following five questions (**Figure 17.1**):

1. What are my project objectives?
With resilience as a goal, it is important to think through the distinction between "bouncing back" resilience or what we call "passive resilience" and transformative "bouncing forward" resilience (see chapter 8). You need to know the type of resilience you are expected to increase, and what other project objectives you have, also depending on what your budget will allow.

2. What is the system that your project is targeting?
Here you need to know the scale at which your system is operating, the major internal components of the system, and the larger social and ecological environment in which it occurs. Who and what do you want to make resilient?

3. Define resilience to which type of disturbance?
It is important to know to what you want to increase resilience to, as that will change the set of interventions. For example, a population may be resilient to earthquakes, but not to epidemics, which requires a different set of measures.

4. How you will make the project sustainable?
In other words, how will you ensure that project activities continue after the project ends? This is a challenge with all projects but it is especially a concern for building resilience, which requires long-term measures and commitment by both the project implementers and local partners.

5. How will you monitor your project and what constitutes a successful resilience building project?
Will your project achieve resilience outcomes or put into place mechanisms for resilience-building?

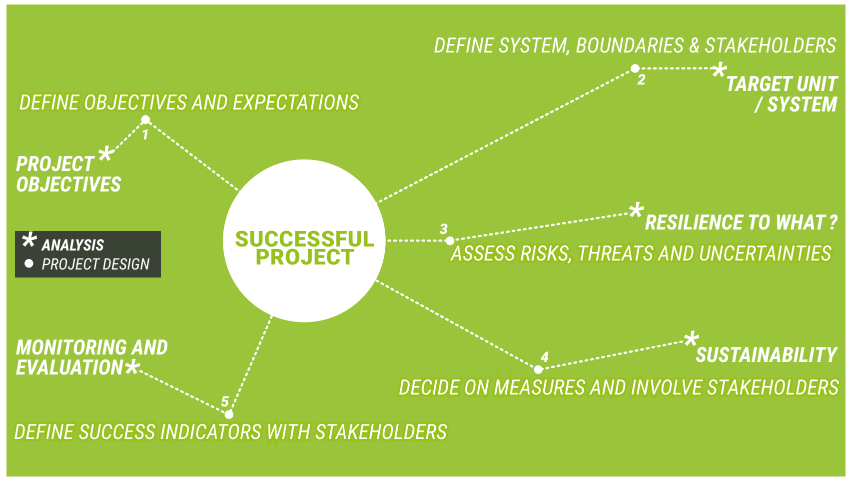

Figure 17.1
Questions to guide project development.
© K. Sudmeier-Rieux and S. Sandholz. Design: S. Plog.

DEFINITIONS

"**Passive resilience**" encompasses interventions in an emergency situation where relief is the main intervention and there is resistance to change, while "**Transformational resilience**" refers to a high degree of flexibility to change, including interventions that address risk factors, i.e. ecosystem management, risk sensitive land use planning, women leadership programs to reduce structural vulnerability and risk.

(Sudmeier-Rieux 2014).

In ecology, relating to natural disturbance of ecosystems, resilience is considered as: the ability of a system to adapt to and either maintain its pre-disturbance equilibrium or its ability to transform to a different state as a consequence of stress or shock, or "**adaptive capacity**".

(Folke 2006, Holling 1973).

General resilience capacity of all parts of the system to cope with all kinds of shocks and disturbances, and so be able to avoid crossing thresholds, known or unknown, to alternate regimes or systems. It is sometimes referred to as "**coping capacity**" and in this report is used synonymously with adaptive capacity.

(O' Connell 2019).

This next section details these five steps for operationalizing resilience for an Eco-DRR/EbA project:

1. Project objectives
As with any project, you should first clearly define your objectives and expectations. Some practitioners may prefer to start with analyzing the system, its components, its boundaries and the dynamic interactions between components before defining the objectives.

Consider these three types of more specific resilience (O'Connell *et al*. 2015): physical resilience of infrastructure to a hazard event, social resilience to disasters and ecological resilience to a changing climate. **Physical resilience** may refer mainly to ensuring that infrastructure, such as the electricity grid, resists a shock. This is often the perspective of engineers. **Social resilience** most often refers to improving livelihoods, reducing vulnerabilities and increasing adaptive capacities due to natural hazards. This is often the perspective of development agencies. **Ecological resilience** considers how an ecosystem can remain functional considering human-nature interactions and pressures. This is often the perspective of ecologists. An Eco-DRR/EbA project is at the forefront of innovation as it seeks to combine aspects of all types of resilience: physical – you may need to build a seawall if necessary; social – of course we need to consider how to improve livelihoods and adaptive capacities; and ecological – as most societies are dependent on natural resources for their protection, well-being and livelihoods.

2. Target of the project
2.1 Define the scope. Are you mainly targeting passive resilience (i.e. increasing coping capacities to enable them to bounce back after a shock, or recovery) or are you able to tackle transformative resilience (i.e. a more long-term comprehensive approach, which also tackles risk reduction and improved livelihoods consideration)? Consider that the two (bouncing back and bouncing forward) can be compatible. A population that is affected by a disaster may first need the time to bounce back to the 'normal state' and recover before being able to move forward. The shock may be an impetus for a process leading to transformative resilience. One example might be the notion of 'building back better' after a disaster. A population first needs to recover, learn from the disaster and understand how they can better protect themselves from the next hazard and then adapt, restructure and hopefully rebuild in a safer location in a safer way in order to reduce risks.

The answer to this question about scope will most likely depend on the available time, resources and your organization's mission (i.e. humanitarian or development-related). **Figure 17.2** illustrates a resilience ladder from passive to transformational where the focus gradually shifts from bouncing back and recovery towards livelihood improvement, investments in risk reduction and ecosystem management to address vulnerability and power relations.

The goal of transformational resilience is improved livelihoods, well-being, sustainability and risk reduction. Perhaps this may seem utopic, but disasters can be the impetus toward the type of socio-political transformation that may be needed for a community or society to shift to an improved state with the right conditions. This may be the case of the Philippines, post-Haiyan, thanks to several large international and national programmes, including the Philippines National Greening Programme.

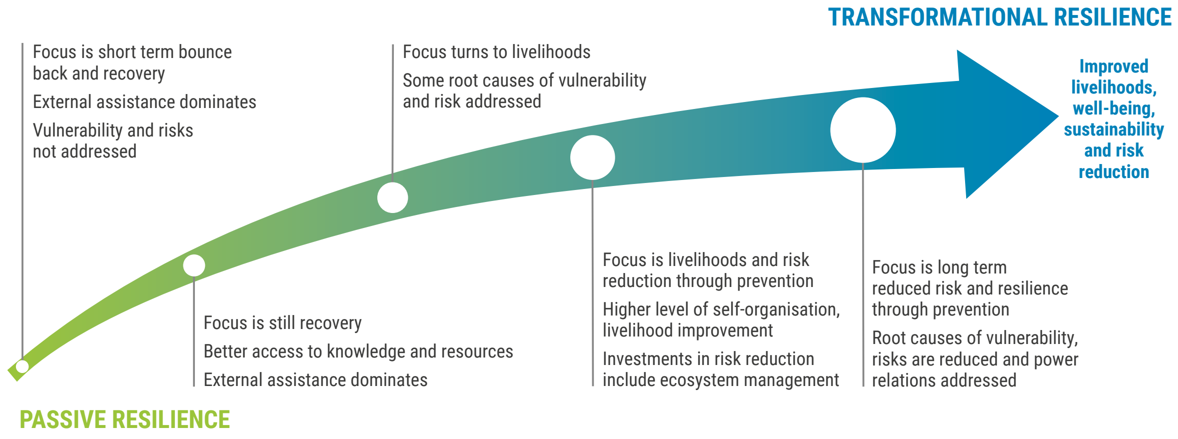

Figure 17.2
Resilience ladder: from passive to transformational resilience.
Design: K. Sudmeier-Rieux. Redrawn by L. Monk

Unfortunately, in many cases however, without additional resources or improved governance, disasters may continue to undermine development efforts with little possibility of transformation. Here passive resilience, or returning to the post-disaster phase, may be the only realistic option.

Consider what are the actual measures required for passive versus transformational resilience? How will the project objectives and on-the-ground actions differ in order to achieve these different types of resilience?

2.2. Define your system, its boundaries and dynamic linkages between the systems main factors and external forces. Identify the stakeholders and the relationships between stakeholders. Are there conflicts or areas of contention between them or are there areas for opportunities? There are a variety of different tools that you can use, from more simple vulnerability and capacity analysis (VCA), a participatory Venn diagram showing interlinkages, to participatory risk mapping. Or consider more sophisticated modelling of systems dynamics such as a resilience assessment to assess risks and uncertainties in socio-ecological systems, the Resilience, Adaptation Pathways and Transformation Approach (RAPTA) (O'Connell *et al*. 2019) (**Figure 17.3**).

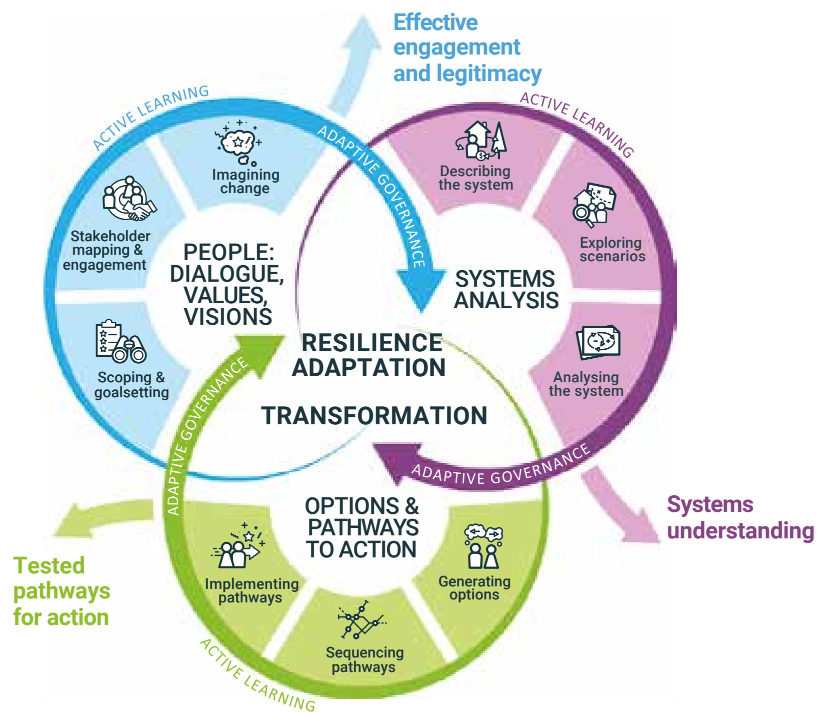

Figure 17.3
Resilience, Adaptation Pathways and Transformation Approach (RAPTA) (version 2).
Source: O'Connell et al. 2019

The RAPTA framework

Resilience, Adaptation Pathways and Transformation Approach (RAPTA) consists of three modules:

1: People – Dialogue, Values and Vision

2: Systems Analysis

3: Options and Pathways to Action

"The modules are supported by two continuous processes (*Active Learning* – establishing learning practices that build capacity for responding to rapid, unprecedented change; and Adaptive Governance – coordinating iterative, flexible and responsive interactions between the modules when designing the intervention and for its implementation and evaluation).

This leads to achieving specific sustainability goals underpinned by Resilience, Adaptation and/ or Transformation pathways depending on the systems assessment."

O'Connell *et al*. 2019: 4

Consider the tipping points or thresholds of the system: these mark the boundaries between different possible states of a system or 'system regime' (Renaud *et al*. 2010, O'Connell *et al*. 2019). A system that is healthy and resourceful will be more flexible and dynamic to self-organise in order to stay within its system boundaries, than one that is unhealthy, damaged or frail. If confronted with a shock, such as a hazard event, the healthy system is more likely to recover quickly, while the frail one may cross a threshold to a different state and perhaps 'lower state'. Let's take the example of a forest along a heavily polluted mountain road. The forest may be less healthy and less able to withstand shock, such as a strong wind storms. It may cross a threshold to a new state which is no longer able to function in the same manner as before (i.e. less water retention, soil stabilisation, biodiversity, etc.). It is of course also possible for a state to cross a threshold to an improved state but this may require additional time and resources (i.e. reducing pollution along the road, replanting trees or encouraging regeneration).

We may find similar examples of thresholds or tipping points for human systems that are subject to shocks. Consider the state of New Orleans post-Katrina, which lost a large proportion of its population as a result of the hurricane. In the weeks, months and perhaps years after Hurricane Katrina, we can most definitely say that the city changed states. Time and resources were needed to rebuild the city yet many years later, it has still not returned to the pre-Katrina state and there is debate whether this new state is an improvement 'transformative'.

3. Assess current risks, threats and uncertainties

A risk assessment can be done as a formal risk mapping exercise, or a community-based analysis of risks. Consider a simple SWOT [Strengths, Weaknesses, Opportunities and Threats] analysis and consider which measures would be appropriate for reducing which threats and which risks. Assess stakeholders' main concerns. You may find that the everyday risks: mainly livelihoods, education, employment or access to roads - are often more pressing than concerns about landslides or flooding. Again, consider using the above mentioned RATA framework.

4. Build sustainability into your project

This is where you need to decide which measures you will undertake to address risks and build resilience and how you involve stakeholders in carrying through proposed measures even after your project has ended. Stakeholder engagement is one aspect of sustainability: local self-sufficiency must be taken in account too, i.e., the community's capacity to continue developing without project support. Capacity building is a very important part of this step. It can involve "learning while doing" and/or more formal training processes.

If your aim is transformative resilience through Eco-DRR/EbA, consider investing in measures that will both reduce disaster risks and address livelihoods' needs. One example could be involving stakeholders in establishing a watershed management council so that upstream and downstream users are connected and can equally benefit. Or planting fruit trees alongside vegetation with deep roots for erosion control and including a local school in monitoring and maintaining the vegetation.

5. Monitoring and evaluation

5.1 Work with stakeholders to define your indicators of success. Indicators of resilience will depend on whether you assess resilience as a dynamic process with such as 'ability to learn', 'ability to self-organise', 'capacity to recover', or progress or results indicators, which may be likened to a snapshot of a system state at the beginning of a project as compared with the same variables during and at the end of the project. In other words, results indicators measure whether tangible results are being achieved (e.g. new roads have mitigation measures). Process indicators however, convey the state of a dynamic process (e.g., stakeholder dialogue, capacity building training). The difference between the two may be time dependent. For example, a capacity-building training workshop on landslide mitigation may lead to attitude changes among participants and a process toward new measures may be undertaken.

5.2. Develop indicators. Depending on your project, you should consider developing both types of indicators based on primary system components and the interactions between them. The process of developing indicators often involves identifying key stakeholders or experts, in particular, women and women's groups, asking them what indicators they propose, then weighing these against available data, or the possibility of collecting these data. In a field situation, you are mostly likely first to be confronted with the reality and cost of collecting sound data (whether quantitative or qualitative) versus the need to be scientifically rigorous. Well-established participatory tools for developing qualitative and quantitative indicators include: wealth ranking, preference ranking, matrix ranking and matrix scoring and participatory numbers (Chambers 2007, Mayoux and Chambers 2005). Such methods are well tested and very commonly used among researchers and practitioners studying livelihoods, vulnerability, hazards, natural resource management, etc. Depending on your scope and resources, consider also the RATA framework presented above for determining system dynamics, primary drivers of change and their impacts in that system.

Since there is no set of pre-existing indicators of resilience, ensure that the intended purposes are clearly and explicitly stated, and check that the indicators are fit for these purposes. Ensure that the indicators are consistent with the underlying theory and behaviour about the systems the indicators are intended to provide information. It is also important to check the feasibility of implementation of project activities, including data availability, replicability, potential for operator bias and level of skill required, among other factors.

Examples of some commonly quoted process indicators of mainly social resilience:

- Diversification (e.g. multiple sources of income, back-up power systems, or redundancy)
- Time and cost effectiveness (e.g. short recovery period after a crisis, or rapidity)
- Access to resources (e.g. savings, family ties, power, natural resources, education, information, or resourcefulness)
- Buffering capacity of a social or natural system to absorb shock (e.g. due to natural, physical or economic protection measures, or robustness)
- Self-organization, preparedness, planning and readiness (e.g. early warning, protection measures and first aid)
- Ability to learn and improve after an event (e.g. preparedness increases after every crisis)
- Effective governance/institutions/control mechanisms (e.g. civil protection, zoning enforcement to reduce exposure)
- Community involvement and inclusion of local knowledge in planning (e.g. local risk maps and evacuation plans)
- Critical thresholds are identified and monitored to improve recovery (e.g. e-coli bacteria amounts in drinking water are monitored and addressed before critical level is reached)
- Flexibility (e.g. within organizations, livelihood systems, economic systems, water management systems)

Source: Bahadur *et al*. (2010); Moench and Dixit (2007)

The following indicators are a mix of **progress and results indicators** that were developed to assess resilience of mountain populations in Nepal (Sudmeier-Rieux *et al*. 2013; **Figure 17.4**). They are problematic because not all are SMART indicators, they can be difficult to assess and are at times overlapping. However, they may provide some ideas for indicators of resilience, combined with some of the above-mentioned process indicators. The figure shows the difficulty in developing a global set of indicators as these may often be locally specific.

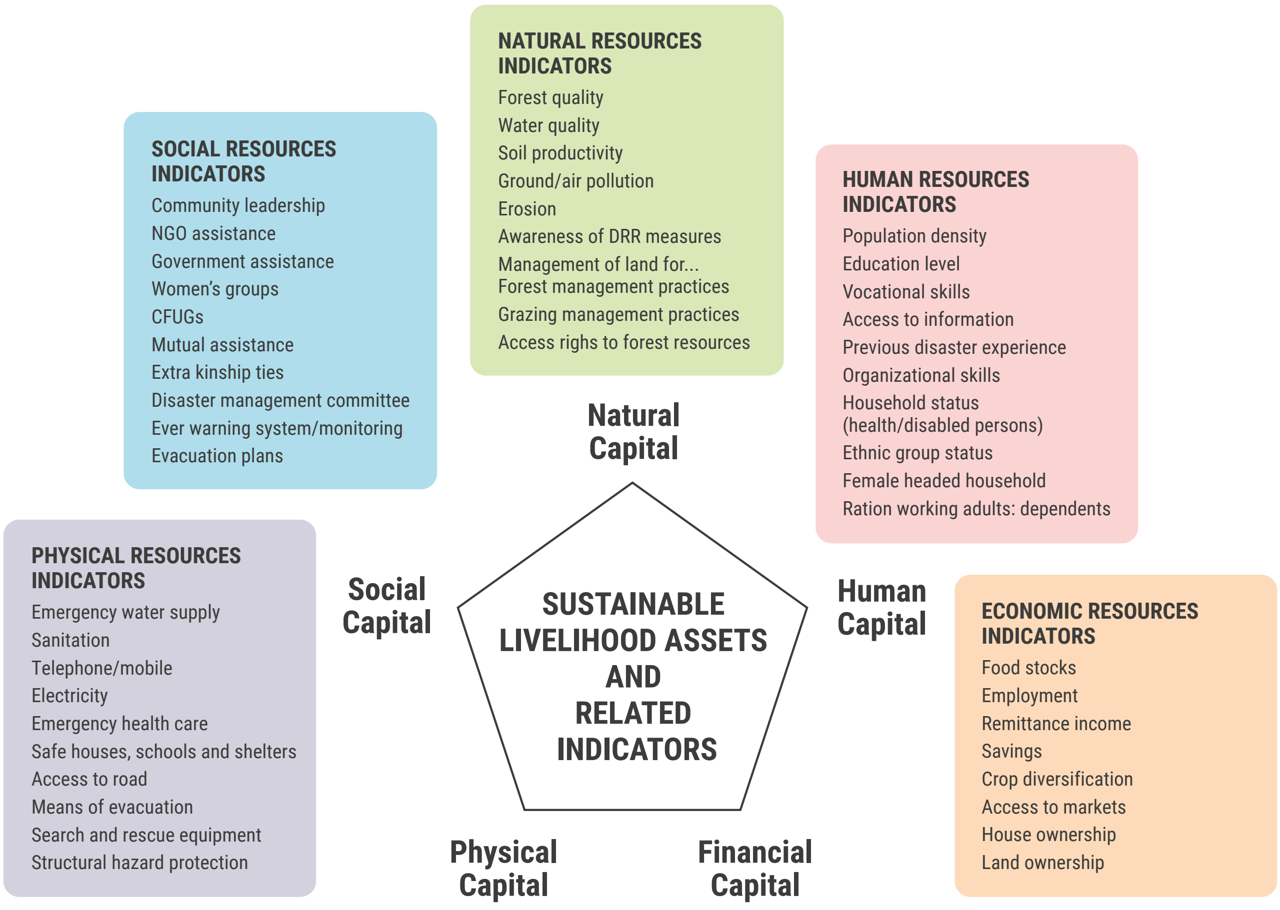

Figure 17.4
Results indicators of resilience developed for assessing landslide affected communities in Nepal.
Source: K. Sudmeier-Rieux (2013); Design: S. Sandholz. Redrawn by L. Monk

Therefore, consider drawing upon results and progress indicators as well as physical, socio-economic, and environmental indicators. Be aware that resilience is not always a term that is easy to convey or translate into local languages and that different stakeholders may have even contradictory visions, addressing different types of resilience. Thus, it is important that you carefully define how you will define and assess resilience from the project outset.

Indicators for Eco-DRR

For indicators on Eco-DRR, please refer to the "Environmental Guidance Note for Disaster Risk Reduction" Sudmeier-Rieux *et al* (2013) https://www.iucn.org/about/union/commissions/cem/cem_resources/cem_ems/?uPubsID=4888

10 THINGS TO KNOW ABOUT RESILIENCE, ADAPTATION, TRANSFORMABILITY:

Resilience is about complex, dynamic, linked social-ecological systems (SESs, of which agro-ecosystems are one example), not the separate dynamics of social, economic and environmental systems.

Resilience is about how linked SESs self-organize in response to shocks/disturbances – their resilience determines the limits to that capacity.

Resilience, adaptation and transformation are neutral system properties when used in a technical sense. They are neither 'good' nor 'bad'. It is the system, or the state of the system, or the broader sustainability goal which defines a 'desirable' or 'undesirable' system or goal. Desirability is a value judgement that will vary according to the world views of the stakeholders in a system. Restoration of degraded systems can be difficult and may be impossible at least within the time frame of development project or a person's lifetime.

Making a system resilient in one way can cause it to lose resilience in other ways or at other scales – there are trade-offs in resilience building projects.

Understanding and managing resilience requires consideration of 'specified' and 'general' resilience, adaptation and transformation: – specified resilience describes the resilience of particular parts of a system to particular kinds of disturbance – general resilience is the capacity of a system to absorb disturbances of any kind, including novel and unforeseen ones; it is related to adaptive capacity (adaptability) – the capacity of the system to manage specified resilience; either stop it crossing a threshold, or engineer crossing into a desired regime.

No system can be understood or managed at a single scale – all systems function at multiple (nested) scales, and interactions across scales affect resilience at any particular scale, and therefore the set of interacting scales.

Many losses in resilience are unintended consequences of narrowly focused optimization and 'efficiency' drives that remove currently 'unused' reserves and 'redundant' functional capacities.

Resilience is NOT about reducing variability or not changing. Trying to prevent disturbance and keep a system constant reduces its resilience. Probing the boundaries of resilience is necessary for maintaining and building resilience, including the capacity for adaptation and transformation.

Adaptation and transformation are complementary processes – managers often need to transform a lower scale of system in order that a higher scale can remain resilient (e.g. portions of the catchment might change the enterprise in order that the broader catchment remains viable). When an undesirable regime shift has happened or is inevitable it calls for intentional transformational change. The capacity to achieve this is called transformability.

An adaptation pathways approach helps inform the sequencing of decisions within long decision time frames and incorporates flexibility to enable social learning, co-creation, experimentation and iteration, scenario planning and livelihood innovation. It provides an appropriate framework in situations where goals are ambiguous, decision-making is contested, social-ecological systems are complex and highly dynamic and trajectories are unpredictable.

O'Connell *et al.* 2019

17.2 The five factors of success of an ecosystem-based disaster risk reduction and adaptation resilience-building project

We wrap up this chapter with what we consider to be five factors of success of a resilience-building project (**Figure 17.5**).

1. The project has clearly defined project objectives and defines resilience as either passive, transformational or somewhere in between. Transformative resilience will most likely include aspects of social, ecological and physical resilience.
2. Project boundaries and stakeholders are clearly defined. Natural and human system components and their interlinkages are identified. You have considered undertaking a resilience assessment.
3. Current risks and threats have been identified, assessed in terms of their severity or impact and prioritized in terms of possible measures to reduce these risks and threats.
4. To ensure sustainability, or local capacity to continue with project activities after the project is over, your project is designed to address stakeholder concerns and turn over ownership. Inclusiveness has been considered and specific gender concerns have been included in the project design.
5. Interventions are chosen that have considered various aspects of ecological, social and/or physical resilience – and would naturally include the concept of Eco-DRR/EbA.

Figure 17.5
Factors of a successful "resilience-building" project.
Concept: K. Sudmeier-Rieux.
Design: S. Plog

17.3 Conclusions

Although this chapter attempts to present some simple and practical guidance as to how to operationalize resilience at the project level, in reality we are often confronted with complex, dynamic situations and interactions between social, economic, political and ecological realities. As a project manager in charge of increasing resilience in a certain location, you will find that the variables that make systems resilient are constantly changing as a consequence of project interventions, interactions between socio-ecological system components and the occurrence of disasters. Monitoring the outcome of project interventions and key drivers of change so that people can learn how change works in their system is one of the more important aspects of resilience building projects.

There is no simple way of increasing, managing or measuring resilience as there are many ways of interpreting this concept, depending on your project scope, your background and perhaps what your boss wants you to accomplish. However, the goal of this chapter was intended to provide some steps and tools for defining and operationalizing resilience in quantitative and qualitative terms. In the additional reading resources for these chapters, we have listed several documents for those who would like a much more thorough academic analysis of resilience and transformability. Remember that resilience should not be considered a normative term (O'Connell *et al*. 2015). 'Passive resilience' (or recovery to the pre-disaster state) may be the most appropriate objective, at least in the short-term, immediately after a disaster and depending on the time frame and available resources, especially if it acts as a springboard for more transformative resilience. Hence, transformative resilience is more compatible with long term risk reduction and improved livelihood conditions.

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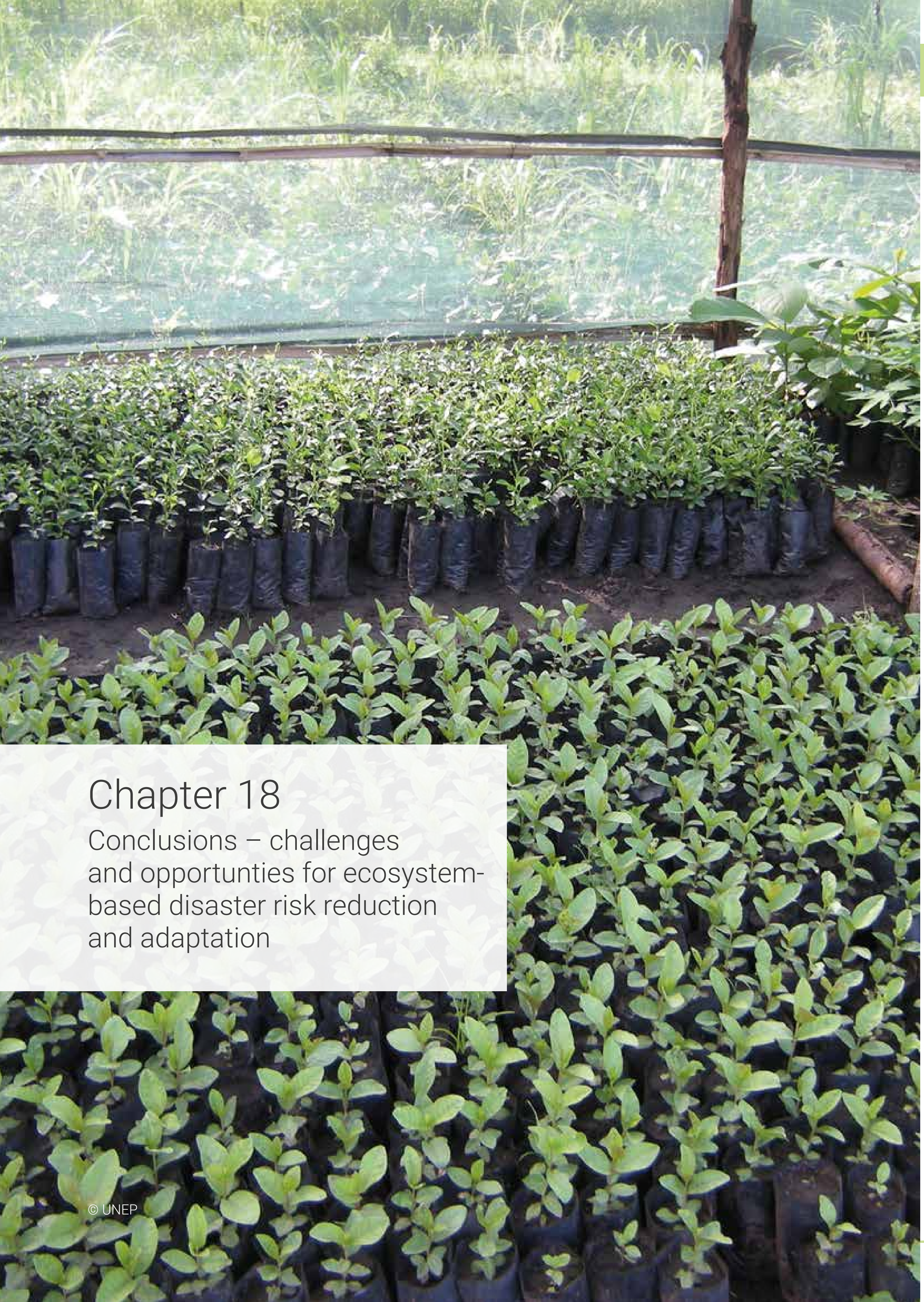

Chapter 18

Conclusions – challenges and opportunties for ecosystem-based disaster risk reduction and adaptation

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The importance of ecosystems and their management for DRR and CCA is gaining traction on the international scene, with mention and/or mandates in different international agreements, such as the three Rio Conventions (UNFCCC, CBD and UNCCD) and the SFDRR as well as in many national policies, whether within their national climate change plans (e.g. National Adaptation Plan of Action or Nationally Determined Contributions) or other development or DRR plans. Yet, ecosystem-based approaches are far from being mainstream. Grey infrastructure and non-structural approaches, such as early warning systems, remain the norm. Furthermore, post-disaster relief and reconstruction rather than prevention is still the prevailing paradigm in use despite the knowledge of the importance of DRR and adaptation. Moving beyond a reactive and coping approach to a proactive and transformative approach is feasible and necessary especially with global challenges such as CCA and increase in disaster risks due to climate change.

Benefits of Eco-DRR/EbA

One of the main components that distinguishes Eco-DRR/EbA from engineering measures are **the multiple co-benefits** that ecosystems provide: support to livelihoods, poverty reduction, protection of culture and identity, of water and soil resources, stabilisation of the regional climate, biodiversity conservation as well as carbon storage and sequestration. Eco-DRR and EbA are thus no-regrets strategies, which was also clearly stated in the 2014 IPCC AR5 and reflected in the SFDRR.

More and more examples are demonstrating that over 15 to 20 years, green, or nature-based solutions to reducing disaster and climate risks are the most **cost-effective** compared to solely grey infrastructure. However, sometimes the hybrid green-grey solutions are the most appropriate, especially in densely populated areas, as long as they do not cause unsustainable ecological damage.

Last but not least, ecosystem management is one of the few approaches that **address all three components of the risk equation**. This is logical considering that environmental degradation and people living in exposed places are two of the most important drivers of disaster risk.

- **Ecosystems can prevent or mitigate hazards;**
- **Ecosystems can reduce exposure by functioning as natural buffers;**
- **Ecosystems can reduce vulnerability by supporting livelihoods before, during and after disasters.**

Clearly, ecosystem-based approaches are not the silver bullet to either DRR or CCA, since the issues underlying these run much deeper. Yet, gender-sensitive Eco-DRR/EbA is an important step in the direction of transformative resilience. Despite growing awareness of Eco-DRR/EbA and gender sensitive approaches, there are still gaps and challenges in mainstreaming them.

GAPS AND CHALLENGES

Mainstreaming and scaling up from locally successful projects

There have been a number of Eco-DRR/EbA projects implemented successfully at the project scale. Mainstreaming and scaling up from those to more nationally derived programmes is challenging depending on the situation of each country. It is feasible, however, and Switzerland is probably a good case. Indeed, forests are a main component of its disaster risk reduction program in the Alps to protect critical infrastructure from frequent disaster such as rock fall, avalanches or shallow landslides. Furthermore, within some of its cantons, large scale renaturation of rivers is taking place to reduce flooding risk, while at the same time protecting biodiversity and providing recreation areas. But this example, is of a country where management of the land is fully under government control and it has the means to do so. In other situations, more community-led approaches may be necessary. However, in these cases, it is vital to show-case the benefits of environmental management and include livelihood and community concerns within any plans. Indeed, even when communities are not directly implicated in land management, community consultations and involvement are necessary because it can cause miscontent when land is used in a certain way. For example, managed realignment, where land is "sacrificed" for flooding to reduce sea/ocean wave power, can cause some landowners or land users to be upset if they do not understand or have their needs heard.

While progress has been made with regards to gender and inclusiveness in DRR/CCA, ensuring gender sensitive involvement in DRR/CCA is still an issue that must not lag behind. Understanding the impact on and the role of women and other minorities in disasters and Eco-DRR/EbA still needs more research and effort to ensure equality and equity.

How to up-scale successful local level Eco-DRR/EbA projects whether they emanate from the private or public sectors remains a challenge; another is how to translate global policies into national and local-level policies and legal frameworks that facilitate further mainstreaming and upscaling of Eco-DRR/EbA (Estrella *et al*. 2016).

Knowledge

There rests much which is still unknown. Although there is solid empirical evidence that Eco-DRR/EbA works in many contexts, another challenge for Eco-DRR/EbA is in providing sufficient and scalable data about the role of ecosystems in DRR. As ecosystem protective functions can be locally specific, for example it has been difficult to establish standard ecological engineering guidelines for various types of ecosystems and hazards. This can make it difficult to replicate and upscale the same measures in other locations and achieve the same results which can increase uncertainties when planning and implementing Eco-DRR/EbA projects. This also includes data about the cost effectiveness of ecosystems due to difficulties in conducting ecosystem valuation (Chapter 15).

Other gaps are tipping points of ecosystems and the related socio-ecological system, the effect of ecosystems in reducing creeping, or slow on-set disasters such as drought; the effect of disasters on ecosystem health and resilience, and time taken for their protection to be effective and services to be provided. Furthermore, climate change will impact ecosystems too and while there is much research on impacts on biodiversity, making sense of this to operationalise natural infrastructure is not easy given the uncertainty of climate change in itself. This is one of the reasons why it has been seen as easier to fall back on grey infrastructure, for which knowledge is easier to derive within laboratory settings and simulations. Yet more and more studies show how green infrastructure and hybrid solutions, combining green/grey approaches can be effective, cost-wise and protection-wise, while bringing a number of benefits that can address underlying issues within a community such as livelihoods and water availability. Continuing research in this area is necessary. However, more than that, applying an adaptive management or learning approach to implementation of Eco-DRR/EbA is the only way forward under uncertain conditions. This requires monitoring and evaluation not being neglected or seen as of secondary importance or only to fulfill donor requirements.

Developing indicators for Eco-DRR/EbA and monitoring green/blue infrastructure

Socio-ecological factors which create disaster risks are complex complex as are notions of resilience. These complexities make for difficulties to measure and monitor Eco-DRR/EbA and their outcomes, especially when outcomes may not be seen for decades, as in the case for CCA. Fortunately, there are many initiatives working to improve on developing indicators and monitoring for both resilience and ecosystem-based approaches, including in the SFDRR. The first step towards this is identifying and providing baseline information on ecosystems, their services, their status and risks. Creating a set of indicators that are process and result based may be necessary to cover all aspects. Finally, setting up a monitoring and evaluation scheme that is sustainable can be challenging but creatively possible when perhaps tapping into existing (sub)national reporting mechanisms or using some form of community-based approach.

Despite these gaps and challenges, we hope that this book, which provides general guidelines for Eco-DRR/EbA, places us one step further by providing the background and impetus to overcome some of these gaps and challenges.

OPPORTUNITIES

The preceding chapters outlined many opportunities for Eco-DRR/EbA, although we also need to be realistic about the limits to ecosystems in reducing disaster risks. Eco-DRR/EbA should not be considered as stand-alone strategies but ones that often need to be combined with other risk reduction strategies, including hybrid solutions, early warning and other disaster prevention and preparedness measures.

As seen in Chapter 3, new opportunities have been created for Eco-DRR/EbA thanks to the inclusion of ecosystem approaches in the SFDRR, the Paris Agreement, the SDGs and recognition of the need to link ecosystems with DRR in the CBD and the Ramsar Convention. At the local level, there is also an increase in the number of Eco-DRR/EbA field projects (Doswald and Estrella 2015).

As we pointed out in Chapter 16, in order for Eco-DRR/EbA to be truly effective in addressing disaster risk, it needs to be fully integrated in development planning and financial decisions at national and local levels. As called for in the SFDRR, mainstreaming Eco-DRR/EbA needs to be more directly addressed in national environmental policies and legislative frameworks, as well as in environmental strategies and programming, such as environmental impact assessments (EIAs) and strategic environmental assessments (SEAs) (Estrella *et al*. 2016). Programmes that offer especially promising entry points for Eco-DRR/EbA include protected area management and IWRM, with several examples of successful Eco-DRR/EbA were demonstrated in Chapter 13.

Another range of emerging opportunities are new financial instruments that encourage investments in ecosystem management and restoration for DRR amongst other goals. These include Payment for Ecosystem Services (PES) (Chapter 15) and co-financing of Eco-DRR/EbA projects between local governments communities or as public-private projects. Although not discussed in detail in this book, there are promising private sector initiatives in promoting natural infrastructure for waste water treatment, air purification flood protection and land restoration (WBCSD 2016). The insurance sector is also increasingly becoming more active in seeking ways to reduce insured losses while exploring new business opportunities from implementing Eco-DRR/EbA measures (UNEP 2014).

WAY FORWARD

One of the main issues is the need to mainstream and upscale Eco-DRR/EbA in development planning. This becomes a challenge given the multi-disciplinary and multi-sectoral nature of Eco-DRR/EbA, whereas most existing legal and institutional frameworks do not necessarily support nor encourage such integrated approaches, including overlapping, unclear institutional mandates and legal frameworks that are not enforceable. However, it may be possible to overcome such challenges by working through development planning and initiatives that serve as an 'umbrella' framework for multi-sectoral engagement (Estrella *et al*. 2016).

Finally, improving the inclusion of women and other minorities in Eco-DRR/EbA is vital because reducing marginalisation and improving equality and equity will increase resilience of communities as a whole. Furthermore, due to a number of social and cultural reasons, women are often key stewards of natural resources (**Figure 18.1**) and as such, are important allies to a greener and more resilient world.

Figure 18.1
Women as key actors of change for Eco-DRR/EbA in Nepal.
Credit: K. Sudmeier-Rieux

To conclude, we hope that this volume provided an overview of the foundations of Eco-DRR/EbA, with examples for implementation, some challenges and many opportunities for new emerging fields of study for students and researchers on the various ecological, political and economic possibilities of Eco-DRR/EbA.

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ADDITIONAL WEBSITE RESOURCES

Environment and Gender Index, IUCN: http://genderandenvironment.org/egi/

Gender and Environment, UNEP http://www.UNEP.org/gender/data/AboutUs/tabid/54765/Default.aspx

Global Gender and Climate Alliance: http://gender-climate.org/

Partnership for Environment and Disaster Risk Reduction, UNEP: http://pedrr.org

UN Third World Conference on Disaster Risk Reduction, Sendai (Japan) 2015: http://www.wcdrr.org/home

IUCN Commission on Ecosystem Management – Disaster Risk Reduction https://www.iucn.org/about/union/commissions/cem/cem_work/tg_drr/

Wetlands International – Reducing disaster risks - http://www.wetlands.org/OurWork/DisasterRiskReduction/tabid/2752/Default.aspx

UNEP- Disasters and Conflicts

http://www.UNEP.org/disastersandconflicts/

UN environment

United Nations
Environment Programme