Chapter 1
Developments and Opportunities for Ecosystem-Based Disaster Risk Reduction and Climate Change Adaptation

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Abstract In the past few years, many advances in terms of research, implementation and policies have taken place around the world with respect to understanding, capturing and facilitating the uptake of ecosystem-based approaches for disaster risk reduction (DRR) and climate change adaptation (CCA). We highlight some of these advances here, particularly for coastal (various hazards), riverine (floods), and mountain (landslides) environments. We also highlight that many international agreements reached in 2015 can facilitate the uptake of these approaches whereas ecosystem-based solutions can facilitate the achievement of many goals and targets related to DRR, CCA, and/or sustainable development enclosed in these agreements. Finally, the chapter provides an overview of the rest of the book.

1.1 Introduction

The role of ecosystems for disaster risk reduction (DRR), climate change adaptation (CCA) and development is increasingly recognised globally. In the short time since 2013 when the book "The role of ecosystems for disaster risk reduction" was

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published (Renaud et al. 2013), tremendous developments have taken place in the field of ecosystem-based DRR (Eco-DRR) research, policies, and implementation on the ground. Some of these new insights were discussed at a workshop[1] co-organised, among others, by the Partnership for Environment and Disaster Risk Reduction (PEDRR), the Centers for Natural Resources and Development (CNRD), and the Indonesian Institute of Sciences (LIPI) in Bogor, Indonesia, in June 2014. The workshop focused on the role of ecosystems for disaster risk reduction and climate change adaptation (Eco-DRR/CCA) and had four main themes, namely (i) Evidence and economics of Eco-DRR/CCA; (ii) Decision making tools for Eco-DRR/CCA; (iii) Innovative institutional arrangements and policies for Eco-DRR/CCA; and (iv) Cutting edge scientific research and technical innovations on Eco-DRR/CCA. These themes were selected as they addressed some of the gaps that were identified in the first book (see Estrella et al. 2013) and now loosely provide the structure for this volume. Chapters written for this book emanate both from participants in the workshop and from invited authors.

2015 has been a critical year in terms of major global agreements and advancing international recognition of ecosystem-based approaches to DRR and CCA: first in March, the Sendai Framework for Disaster Risk Reduction (or SFDRR; UN 2015a) was approved in Sendai, Japan, replacing the Hyogo Framework for Action (UNISDR 2005). In September the UN General Assembly adopted the Sustainable Development Goals (or SDGs; UN 2015b). Finally in December, a new agreement to address climate change was reached in Paris (UNFCCC 2015). Ecosystems and ecosystem services are critical for helping achieve disaster risk reduction, sustainable development and climate change mitigation and adaptation, and this is now recognised by these agreements and others (Fig. 1.1).

In the last couple of decades, the number of concepts on the use of ecosystems for DRR, CCA and sustainable development has rapidly increased, and concepts such as Ecosystem-based Adaptation (EbA), Ecosystem-based Disaster Risk Reduction, Nature-based Solutions, Green Infrastructures, Working with Nature, and many more have emerged or been further developed (see Box 8.1 in van Wesenbeeck et al., Chap. 8). This recognition has facilitated increased implementation of Eco-DRR/EbA projects on the ground. Nonetheless, the variety of ecosystem-based concepts and definitions has generated some confusion, particularly for practitioners and policymakers.

With rapid progress made on concepts, policies, and implementation, it is perhaps time to take stock again on where we stand with respect to Eco-DRR/CCA. This is the purpose of this book, which was produced at a time when the three major global agreements mentioned above were being negotiated and agreed upon. In the next sections of this chapter, we will briefly discuss the concept of Eco-DRR/CCA, and show how in recent years the concept and other related ones have been promoted in research and practice. We will provide insights into some of the scientific advances related to coastal, riverine and forest ecosystems and their role

[1] http://pedrr.org/training/current-event/international-science-policy-workshop-bogor-2014/

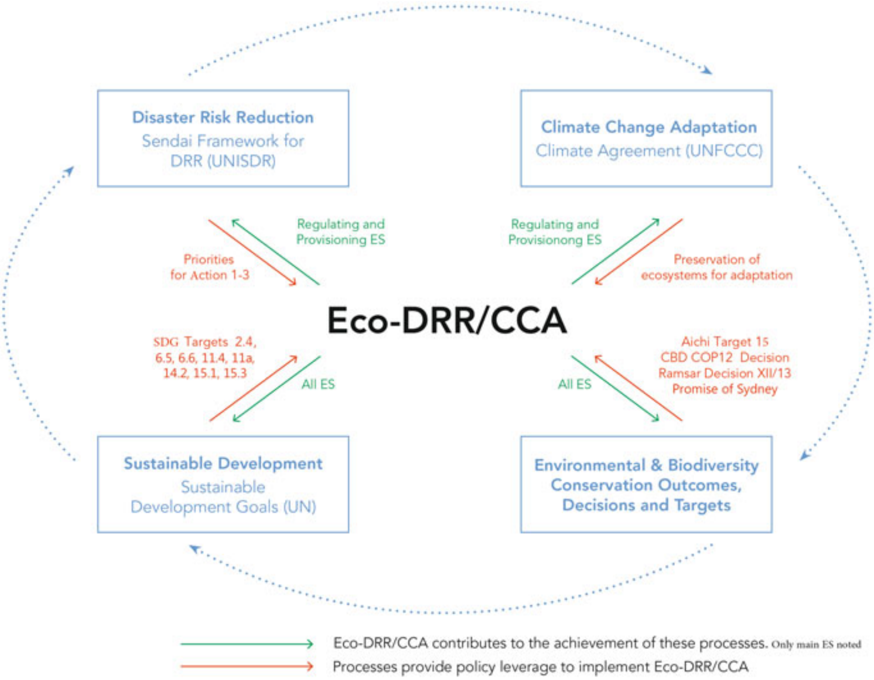

Fig. 1.1 Linkages between major international agreements and Eco-DRR/CCA. ES means ecosystem services

in disaster risk reduction and finally, present the structure and chapters of the book. Opportunities for the further development of Eco-DRR/CCA concepts and practice are discussed in more detail in the concluding chapter (Estrella et al. Chap. 24).

1.2 What Do We Mean by Eco-DRR/CCA?

Two key concepts feature in most of the chapters of this book: Eco-DRR and EbA. Definitions for each are given in Box 1.1. The two definitions are very similar (i.e. with a focus on ecosystem management, conservation and restoration for specific objectives and linking these to sustainable development), given that the Eco-DRR definition developed in 2013 drew on the existing definition of EbA which pre-dated it. One important difference is that one concept specifically addresses DRR and the other CCA. However, it can be easily argued that there are more similarities between the concepts than divergence, especially when addressing climate-related hazards (Doswald and Estrella 2015). Another key feature of both concepts, even if not spelled out explicitly in the definitions, is the fact that the approaches provide multiple benefits, beyond strictly DRR and CCA functions.

Box 1.1: Definitions of Eco-DRR and EbA
Ecosystem-based Disaster Risk Reduction (Eco-DRR) "is the sustainable management, conservation, and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development" (Estrella and Saalismaa 2013:30).
Ecosystem-based Adaptation (EbA) "is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies" (CBD 2009:41).

Although the definition of Eco-DRR does not include a reference to climate change, it was always considered that Eco-DRR could also contribute to climate change adaptation, as climate change is considered to be a risk amplifier now and in the future (Estrella and Saalismaa 2013). However, in this chapter, to be more explicit, we use the acronym Eco-DRR/CCA in order to emphasise that ecosystem-based approaches play a role for achieving *both* DRR and CCA. Therefore, we define Eco-DRR/CCA as: **"the sustainable management, conservation, and restoration of ecosystems to reduce disaster risk and adapt to the consequences of climate change, with the aim of achieving sustainable and resilient development"**. Although we use the term Eco-DRR/CCA in this chapter, authors of subsequent chapters have been given total freedom to elaborate on and use terminology that best describes their work.

1.3 Eco-DRR/CCA Gaining Steam Globally

Ecosystems for DRR and/or CCA have been advocated in many "commentaries" and "perspectives" of leading journals, particularly for coastal systems. For example, Barbier (2015) discussed in the journal *Nature* the feasibility of having three lines of coastal defenses: green and grey infrastructure as well as local stakeholders' engagement with a potential for application globally. This builds on an earlier perspective in *Science* where restoration of coastal ecosystems was considered a necessary step for long-term coastal adaptation (Barbier 2014). Again in *Science*, the case for "nature-based engineering solutions" in delta environments was made by Timmerman and Kirwan (2015), building on an earlier perspective in *Nature* encouraging a broader consideration of ecosystem-based, coastal defenses (Timmerman et al. 2013).

In *Nature Climate Change*, Cheong et al. (2013) discussed the role of ecological engineering for coastal adaptation. Finally, Martin and Watson (2016) made a general plea in *Nature Climate Change* for the consideration of ecosystems in adaptation to climate change. Furthermore, many scientific papers have been published on the topic during the last few years, some of them are reviewed in Sect. 1.4 of this chapter.

In addition to articles in scientific journals, many other publications related to ecosystem-based approaches have recently been published. Without intending to be exhaustive, a few can be mentioned. A recent example is a technical report by the European Environment Agency on Green Infrastructures as an option to mitigate climate change-related hazards, with a specific focus on landslides, avalanches, floods, and storm surges (EEA 2015). On the occasion of the 2014 World Parks Congress, the International Union for the Conservation of Nature (IUCN) published 18 case studies illustrating the interlinkages between protected areas and DRR and CCA (Murti and Buyck 2014). Ecoshape also showcased other examples such as oyster reefs to mitigate erosion, seabed landscaping to boost biodiversity, and more generally, the multiple benefits provided by Nature-based Solutions (De Vriend and Van Koningsveld 2012).

Technical and general guidelines are also increasingly being published. Examples include the role of protected areas for DRR (Dudley et al. 2015) which was released during the World Conference on Disaster Risk Reduction; the development of hybrid solutions for large scale coastal erosion control (Winterwerp et al. 2014); the use of mangroves (Spalding et al. 2014a) or natural and nature-based features (Bridges et al. 2015) for coastal protection and resilience; and comparisons of ecosystem-based and engineering solutions for coastal protection in Fiji (Rao et al. 2012).

In addition, and linked to the work leading to some of the publications above, many initiatives around the world have been developed that consider ecosystems as stand-alone solutions or as a component of hybrid solutions for DRR and/or CCA. Naming just a few and in no particular order: Living shorelines to restore America's estuaries[2]; the Building with Nature programme in Indonesia[3]; and the Coastal Resilience programme[4] (Beck et al. 2013).

As noted in the introduction, many positive developments have also taken place on the policy front. Ecosystems are mentioned as playing a critical role for DRR and CCA, a fact highlighted or reinforced in many recent international agreements. The role of ecosystems or of the environment features in numerous places in the Sendai Framework for Disaster Risk Reduction (SFDRR) (UN 2015a); they also play a critical role for many of the Sustainable Development Goals (SDGs) (UN 2015b); environmental or ecosystem integrity is mentioned in several places of the Paris Agreement (UNFCCC 2015); the Convention on Biological Diversity also puts an important emphasis on ecosystem-based solutions for CCA and DRR in

[2] https://www.estuaries.org/living-shorelines (accessed Oct 2015)

[3] http://www.ecoshape.nl/overview-bwn.html (accessed Oct 2015)

[4] http://coastalresilience.org/ (accessed Oct 2015)

a decision reached during the 12th Conference of the Parties (CBD 2014); and the Ramsar Convention on Wetlands adopted resolution XII.13 on "wetlands and disaster risk reduction" at its last Conference of the Parties in 2015 (Ramsar 2015). Figure 1.1 shows the possible linkages (the list is not exhaustive) between major international agreements and Eco-DRR/CCA.

There is clearly increasing interest in ecosystem-based solutions for DRR and CCA globally. In the next section, some recent scientific advances are further described for coastal protection, flood protection, and landslide risk reduction.

1.4 Progress on the Science Front

1.4.1 Coastal Ecosystems for Coastline Protection

Coastal social-ecological systems are exposed to various types of hazards (e.g. tropical cyclones, storm surges, tsunamis, flooding, erosion, sea-level rise) and are relatively vulnerable because of a variety of factors such as increasing population densities linked to urban expansion, and high levels of economic activities (e.g. Nicholls et al. 2008). As can be inferred from Sect. 1.3 of this chapter and in Chaps. 13, 14, 18, 19 and 20, many Eco-DRR/CCA activities have taken place or are being planned in coastal environments, particularly linked to the rehabilitation or conservation of coastal ecosystems, such as mangroves and sand dunes (Cunniff and Schwartz 2015; Gedan et al. 2011; Temmerman et al. 2013). Lacambra et al. (2013) provided a comprehensive review of the multiple roles of mangroves in terms of coastal protection. In the span of several years, many additional publications on the subject have emerged addressing the multiple dimensions regarding the role of coastal vegetation in buffering populations and infrastructures against hazards but also in providing other ecosystem services. Examples include reviews highlighting:

- the multiple benefits coastal ecosystems provide in the context of DRR such as reducing flooding and erosion, the ability of many ecosystems to self-repair or adapt to changing environmental factors, and the cost-effectiveness of ecosystem-based solutions (e.g. Spalding et al. 2014b);
- the critical role of coastal vegetation (e.g. mangroves, salt marshes, seagrasses) in terms of climate change mitigation (carbon sequestration) and adaptation (e.g. dissipation of wave energy, elevation of the land or the sea floor, sediment trapping, protection against coastal flooding and erosion) (Duarte et al. 2013). Mangroves, in particular, can store large amounts of carbon (Wicaksono et al. 2016), particularly below ground (Donato et al. 2011), and their destruction can lead to large emissions of carbon to the atmosphere (e.g. Murdiyarso et al. 2015);
- the reduction in height of wind and swell waves by mangroves (McIvor et al. 2012a, 2015);

- the linkages between mangrove presence and their ability to reduce storm surge peak water levels, flow speed and surge damage behind mangroves (McIvor et al. 2012b);
- the ability of mangroves, in many circumstances, to keep pace with local sea level rise (Duarte et al. 2013; McIvor et al. 2013) as long as there is a sustainable supply of sediment and organic matter (see also Alongi 2008). In addition, mangroves can migrate landward when facing e.g. rising sea levels but only if there are no obstacles behind them such as natural features or human infrastructure (Alongi 2008; Lovelock et al. 2015).

All these studies emphasise the fact that the cause-effect relationship between ecosystems and disaster risk reduction can be highly localised as multiple factors are at play when considering wave attenuation effects or increases in elevation of the land. Regarding the latter, Lovelock et al. (2015) noted that in 70 % of sites surveyed in the Indo-Pacific region, sea-level rise exceeded soil surface elevation gains. Nevertheless, based on these new insights and an increasing body of empirical evidence not reviewed here, several technical guidelines for experts and policymakers have been and are currently being developed (e.g. Spalding et al. 2014a; Dudley et al. 2015). Five chapters in this book discuss in varying details the role of coastal vegetation for DRR: Friess and Thompson (Chap. 4); van Wesenbeeck et al. (Chap. 8); Furuta and Seino (Chap. 13); Takeuchi et al. (Chap. 14); and David et al. (Chap. 20).

Another important type of ecosystem in the context of DRR are coastal dune systems (CDS) which provide a variety of ecosystem services, and in particular the physical buffer function that protects inland areas from coastal hazards such as tropical cyclones, storm surges, and coastal floods (Hettiarachchi et al. 2013). Coastal dunes can even prevent or at least mitigate tsunami impacts depending on the circumstances (Liu et al. 2005; Bhalla 2007; Mascarenhas and Jayakumar 2008). Furthermore, intact CDS control geomorphological processes such as coastal erosion (Prasetya 2007; Barbier et al. 2011) and mitigate effects of sea level rise and saltwater intrusion (Heslenfeld et al. 2004; Saye and Pye 2007). The effectiveness for hazard mitigation and long-term adaptation to climate change depends on the integrity of the protective ecosystem services. These are composed of the physical conditions, in particular height, width, shape and continuity (Gómez-Pina 2002; Takle et al. 2007; Thao et al. 2014), the ecological status (Nehren et al. in Chap. 18), and the dynamics of the CDS.

Despite their importance for coastal protection and CCA, losses and degradation of CDS are widespread phenomena around the globe, mainly triggered by urbanisation processes, overexploitation, mining, and tourism (Martínez et al. 2004). The growing global demand for sand and gravel (Peduzzi 2014) will most probably lead to intensified sand mining activities along beaches and shorelines in the near future, and further accelerate degradation processes in many coastal regions of the world – with severe consequences for biodiversity and the livelihoods and vulnerability of coastal communities.

In many mid-latitude countries, particularly in Europe and the USA, the problem has been recognized, and conservation and restoration measures for CDS have been established or are underway (Doody 2013). In these countries, current research related to DRR, CCA and ecosystem management of CDS focuses among others on mid- to long-term effects of climate change – in particular sea level rise and storm intensities – on morphology, species composition, and habitat losses of CDS (e.g. Feagin et al. 2005; Psuty and Silveira 2010; Prisco et al. 2013; Seabloom et al. 2013; Pakeman et al. 2015). Another research line deals with the protective services of CDS as well as conservation and restoration measures to maintain or restore these services (e.g. Feagin et al. 2010; Hanley et al. 2014; Sigren et al. 2014).

In tropical and subtropical countries, the databases on CDS and their role in coastal protection and adaptation are often very limited. Even though CDS of tropical and subtropical regions are frequently described as degraded (Moreno-Casasola et al. 2008), these assessments are often based on geographically restricted field studies and observations, so that inferences to larger areas are not possible. Due to the lack of ground-based data particularly in tropical and subtropical countries, there is as yet no global overview on the ecological status and change patterns of CDS. Considering the significance of CDS for coastal protection, climate change adaptation and biodiversity conservation, there is an urgent need to foster research and action with respect to the status and management of CDS in developing and emerging countries, where livelihoods of coastal dwellers are most affected. Furthermore, in-depth research on the protective and other ecosystem services of CDS are needed for a more targeted implementation of conservation, restoration and sustainable use measures. Finally, policymakers need to be convinced that in many cases the short-term benefits of sand dune exploitation are associated with higher costs for coastal protection in the long run. This requires an improved database on the socio-ecological system including the valuation of ecosystem services of CDS.

1.4.2 Riverine Ecosystems for Floods Protection

Flooding is the hazard that causes the majority of disasters and economic losses. Between 1994 and 2013, floods accounted for 43 % of all recorded events and affected nearly 2.5 billion people (EM-DAT 2015). In addition to higher concentrations of populations in flood plains, more extreme precipitation is one of the hazards likely to become more frequent due to climate change (IPCC 2014). Reducing flooding can be very costly, and mitigation measures range from high-technology structural engineered flood defenses around densely populated areas, to non-structural measures such as early warning systems or floodplain zoning (Senhoury et al. Chap. 19). Along with increasing numbers of flooding events, high economic losses and the uncertainty that flood defenses are inadequate to protect against increasing flood risk, a shift is occurring to consider more integrated flood risk management, including natural flood defenses (Bubeck et al. 2015; Day et al. 2007; van Wesenbeeck et al. 2014; van Staveren et al. 2013, van Wesenbeeck, Chap. 8). These include wetlands, lakes and rivers which have been restored to make "room for water" and can retain water in upper catchments and provide space for excess water (Bubeck et al. 2015). The importance of Integrated Water Resources Management (IWRM) which considers water management issues in watersheds and river basins was especially highlighted in the SFDRR.

However, the uptake of integrated approaches varies considerably among countries, depending on the frequency of flooding events and the public demand and support for certain types of flood risk management (Bubeck et al. 2015). The major floods which struck Europe between 1998 and 2004 led to several important European Union directives, including the Water Framework Directive (EC 2000) and the Flood Directive (EC 2007). The Water Framework Directive, in particular, is one of the few directives with a dual ecological and DRR component while promoting an integrated approach to water and drought risk management. It points to the need to achieve a balance between ecological requirements and the need for drought measures and flood defense based on good ecological science (Sudmeier-Rieux 2013). As a result of these two directives, a number of countries, notably the Netherlands, U.K., Germany, Belgium and France developed programmes, which promoted the use of wetlands, rivers and other natural spaces as reservoirs for excess water. One example is the Netherlands' "Room for the River", a €2.3 billion programme which was conceived to create more space for the rivers while improving flood protection, recreation possibilities and improved environmental quality of rivers in the country. According to the main government agency overseeing the project, in addition to flood protection, any extra space created for the rivers will also remain permanently available for this purpose and for other recreational and ecological functions (Dutch Ministry of Water Management, Transport and Public Works 2012). Although not part of the EU but following this paradigm shift in flood management, the Government of Switzerland's third Rhone River Correction programme is a 30-year initiative which will allow to control potential flood damages, re-establish and strengthen biological functions of the river and maintain social and economic priorities along the upper catchment of the Rhone River (between the town of Brig and the mouth of river in the Canton of Vallis) (Pahl-Wostl et al. 2006).

Global estimates of inland (freshwater) wetlands vary between 5.3 and 9.5 million km^2 but are also considered underestimated (Russi et al. 2013). The Economics of Ecosystem and Biodiversity (TEEB) report on water and wetlands (Russi et al. 2013) has estimated that inland wetlands (floodplains, swamps, marshes and peatlands) provided regulating services of 23,018 USD/hectare/year and a total of 44,597 USD/hectare/year. This value does not consider the many non-monetary values that wetlands provide, such as aesthetics, rich biodiversity, educational, cultural and recreational ecosystem services.

The core of the new flood risk management paradigm is a recognition of ecosystem services in attenuating flooding, which needs to be based on a careful scientific analysis of the linkages between wetlands and flooding (Janssen et al. 2014; van Wesenbeeck et al. 2014). According to van Eijk et al. (2013), river basins are highly dynamic systems, and the periodic rise and fall of floodwaters is a normal pulsing feature in the river landscape. The role of wetlands in regulating floods is far from universal and will depend on the scale of the flood event, the size and health status of the wetlands, its location in a river basin and local climate. Depending on the study, wetlands can both contribute to flood reduction and increase it (van Eijk et al. 2013). This points to a wide heterogeneity of ecosystem services related to flood attenuation, which requires more localised expertise and study. Thus according to the situation:

- Peatlands, wet grasslands and other wetlands can store water and release it slowly, reducing the speed and volume of runoff after heavy rainfall or snowmelt in springtime (Brouwer and van Elk 2004; Javaheri and Babbar-Sebens 2014)
- Marshes, lakes and floodplains release wet season flows slowly during drought periods and can contribute to recharging ground water (Maltby 2009; Wilson et al. 2010)

However despite their many benefits, wetlands face severe pressures especially due to land conversion, development of dams, eutrophication and pollution due to intensification of agriculture. In Europe, 80 % of wetlands have disappeared over the past 75 years, as compared to 50 % in North America (van Verhoeven 2013). In 2012, 28 % of 127 governments reporting to the Ramsar Convention stated that their wetlands had deteriorated, while only 19 % reported any improvements (Russi et al. 2013).

1.4.3 Protection Forests for Landslide Risk Reduction

From the geological and geomorphological viewpoint, landslides can be principally considered natural phenomena, which are usually triggered by rainfall or earthquakes. However, human interference, such as road construction, quarrying, deforestation, agricultural practices in mountainous terrain, can contribute to or aggravate their destructive forces (Dolidon et al. 2009; Walker and Shiels 2013). Another important root cause for landslides is the change of the vegetation cover (Papathoma-Koehle and Glade 2013). To mitigate in particular the risk of shallow landslides (i.e. with a depth of 2–10 m), conservation and restoration of vegetation (e.g. from grasses with deep roots to mountain forests) are recommended, often combined with engineered structures such as fences and debris flow barriers (Dietrich et al. 1998; Wehrli and Dorren 2013).

The effectiveness of protection forest depends on various factors, such as the hazard type, the geological and topographical setting, the location of the forest, its tree composition and dynamics, as well as management aspects (Wehrli and Dorren 2013). There are many experiences with respect to the creation and maintenance of protection forests particularly in Europe and the US, where protection forests are not only used for landslide risk reduction, but also as buffers against rockfall, avalanches, debris flows, flooding and erosion (Brang et al. 2006). A prominent example is found in the Swiss Alps, where protection forests are a main component of the national disaster risk reduction programme, and the Government spends over USD 120 million per year on the management of its protective forests (Wehrli and Dorren 2013). However, the planning process takes a time span of 50–100 years and requires public willingness to contribute to the forests' maintenance. On the other hand, Wehrli and Dorren (2013) point out that the creation and maintenance of protection forest cost 5–10 times less than structurally engineered structures over time.

Current research on protection forests is concentrated in Europe, North America, Australasia, and Japan and focuses among others on the ideal composition of tree species to maximise the degree of protection. Models that take into account the structural diversity and species composition include parameters that have a major impact on slope stabilisation, such as root density, root tensile strength, and root orientation (Danjon et al. 2008; Mao et al. 2012; Preti 2013). These models build on studies on root systems of different tree species in various environments (e.g. Schmid and Kazda 2001, 2002; Roering et al. 2003; Bischetti et al. 2005, 2009; Mattia et al. 2005; De Baets et al. 2008; Abdi et al. 2009) and works on root characteristics (Stokes et al. 2009). Other models include the effects of vegetation, reinforcement and hydrological changes (Greenwood 2006), forest structure (Kokutse et al. 2006) and hydro-mechanical effects of different vegetation types (González-Ollauri and Mickovski 2014). Important research along these lines include the impact of successional stages and plant density for landslide control (Cammeraat et al. 2005; Pohl et al. 2009; Loades et al. 2010), management aspects of protection forests (Dorren et al. 2004; Schönenberger et al. 2005; Brang et al. 2006; Runyan and D'Odorico 2014; Basher et al. 2015), and geomorphologically-controlled variations of ecological conditions on root reinforcement (Hales et al. 2009). A quantitative tool developed to determine the slope stabilising effect of protection forests in Switzerland is presented by Dorren and Schwarz (Chap. 11).

Within the last years, the potential of protection forests for landslide risk reduction has also been recognised in developing countries and emerging economies, and several projects have been implemented, often together with local communities. In this context, Anderson et al. (2014: 128) stress the implementation challenges of community-based landslide risk reduction measures in developing countries and point out "the need for disaster risk reduction researchers and practitioners to develop future environmental scenarios as the basis for modeling landslide triggers in vulnerable communities."

For landslide-affected areas in Asia and the Pacific, the FAO (2013) published a report that provides a good overview of the affected regions and shows strategies for effective risk management, with a focus on protection forests and land management practices. For Dolakha District in central-eastern Nepal, Jaquet et al. (2013) analysed landslides trends and demonstrated that proper management of community forests significantly contributes to slope stabilisation and thereby reduces the risk of shallow landslides. For China, there are also some studies that focus on floristic and vegetational aspects, in particular the root systems of different forest types (Genet et al. 2010; Ji et al. 2012).

Also in Latin America as well as in Sub-Saharan Africa, the role of forests and good agricultural management including slope terracing, agroforestry, and silvopastoral systems for landslide and flood prevention has become increasingly recognised. However, the number of scientific publications, in particular with respect to ground-based data, is still limited. Among the few publications that exist are those by Anderson et al. (2011) on community-based landslide risk reduction in the Eastern Caribbean; Lange et al. (Chap. 21 in this book) on risk perception for participatory ecosystem-based adaptation to climate change in the Atlantic Forest of Rio de Janeiro State; Lange et al. (2016) on the potential of ecosystem-based measures for landslide risk reduction in the city of Rio de Janeiro; and some studies that have been conducted on landslides in the Mt. Elgon area (Bintoora 2015).

The Eco-DRR/CCA advances reviewed above for coastal, floodplain and mountain environments show the increase interests of the scientific and practitioner communities on the concept. However, much more knowledge remains to be generated to fully understand the role ecosystems can play in mitigating hazards of different magnitudes and frequencies and in helping societies adapt to climate change. This could be further facilitated in the future by the recognition of the role of ecosystems for DRR, CCA and development in major international agreements (Fig. 1.1). Further advances, practical examples, and suggestions for the way forward for Eco-DRR/CCA are presented in the following chapters of the book.

1.5 Structure of the Book

This book comprises 24 chapters divided into four main sections as well as an overall introduction (this Chapter) and an overall conclusion by Estrella et al. (Chap. 24) which summarizes the main points developed throughout the book, and discusses emerging issues related to the four themes mentioned earlier in this chapter.

Part I, entitled “Economic approaches and tools for Eco-DRR/CCA” is composed of four chapters, which examine how best to capture, from an economic perspective, the multiple benefits generated by Eco-DRR approaches. Emerton et al. (Chap. 2) present and discuss a conceptual framework for the integration of ecosystem values in development planning in the context of climate change. Applications of the framework are presented for coastal areas in Kenya and Sri Lanka. Vicarelli et al. (Chap. 3) make the case for the consideration of cost-benefit analyses for Eco-DRR and EbA projects, by providing a detailed review of best practices and providing examples from case studies. Friess and Thompson (Chap. 4) discuss the concept of Payment for Ecosystem Services for mangroves in the context of DRR, outlining some of the pre-requisites that are necessary for these types of schemes to work efficiently. Finally, Harmáčková et al. (Chap. 5) present a case study in the Czech Republic where participatory scenario building, GIS modelling and economic evaluation were used to analyze economic costs and benefits of adaptation scenarios.

Part II of the book entitled "Decision-making tools for Eco-DRR/CCA" comprises seven chapters. Whelchel and Beck (Chap. 6) provide, through the analysis of case studies, lessons learned and recommendations related to decision support tools and approaches for Eco-DRR and EbA. In Chap. 7, Krol et al. provide an overview of the use of geo-information tools for Eco-DRR and how they can be used to compare different DRR options. The decision support tool RiskChanges is also presented. Van Wesenbeeck et al. (Chap. 8) present approaches which could better integrate the role of ecosystems in coastal flood risk management engineering projects and, by doing so, provide additional incentives for coastal engineers to consider ecosystem-based solutions for coastal flood management. Kloos and Renaud (Chap. 9) review ecosystem-based approaches for drought risk reduction, with a focus on Sub-Saharan Africa. The chapter also presents some criteria to determine when approaches can be considered ecosystem-based. In Chap. 10, Bayani and Barthélemy show how the Integrated Valuation of Ecosystem Services and Tradeoff (InVEST) tool can be used to assess ecosystems and disaster risk in data-scarce environments, with examples from Haiti and the Democratic Republic of the Congo. In their chapter, Dorren and Schwarz (Chap. 11) present a quantitative tool called SlideforNET which was developed to determine the slope stabilising effect of protection forests in Switzerland. In the last chapter of Part II, Kumar et al. (Chap. 12) describe a cluster approach used for disaster risk reduction planning in the Mahanadi Delta, India.

Part III of the book entitled "Innovative institutional arrangements and policies for Eco-DRR/CAA" is composed of five chapters. The first two chapters (Furuta and Seino; Takeuchi et al.) address the integration (or lack thereof) of ecosystem-based approaches in the rebuilding process in the aftermath of the 2011 Great East Japan Earthquake (GEJE). In both chapters, the debates and policies enacted after this disaster are discussed in detail. Furuta and Seino (Chap. 13) also describe the role that ecosystems played during the GEJE. In addition to the GEJE case study, Takeuchi et al. (Chap. 14) showcase the multiple benefits of Eco-DRR activities in two other regions of the world, Ghana and Myanmar. Sandholz (Chap. 15) addresses urban disaster risk reduction through the example of Kathmandu Valley in Nepal and illustrates how unplanned urban development, political instability and the non-enforcement of existing policies and laws constitute hurdles to the integration of ecosystem-based approaches in DRR. Kieft et al. (Chap. 16) discuss anticipatory management of peat fires in Indonesia and the integration of the concept into existing procedures of fire prevention and into spatial and development planning. The early warning system "Fire Risk System" is also presented. Finally, McNeely (Chap. 17) argues for the greater consideration of protected areas in national strategies linked to CCA and DRR and proposes various management approaches for protected areas in this context.

Part IV "Research and Innovation" has six chapters. Nehren et al. (Chap. 18) highlight the importance of coastal dune systems for DRR through case studies from three countries: Vietnam, Indonesia, and Chile. They also suggest indicators for assessing the degradation of coastal dune systems and for assessing ecosystem services. In Chap. 20, David et al. elaborate on the perspectives of coastal engineers on ecosystem-based coastal protection measures and highlight the multiple benefits as well as the limitations of "low-regret measures", such as green belts, coir fibers, and porous submerged structures. Senhoury et al. (Chap. 19) present an assessment of flood risk for Nouakchott, Mauritania, and highlight, among other things, the importance of preserving and restoring the coastal dune belt that can protect the city. Lange et al. (Chap. 21) present research results from a case study area in Brazil that focused on perception analysis to determine how to more effectively promote local community participation in Eco-DRR and EbA activities; the hazards considered in this chapter are landslides, mudslides and floods. Dhyani and Dhyani (Chap. 22) also address land degradation, but this time from the Indian Himalayas' perspective, and discuss the important role of forests for DRR, and critically, for improving local livelihoods. They show in detail the complex interactions between society and their natural environment and discuss the role that fodder banks can play in supporting livelihoods and ecosystems. Last but not least, Fedele et al. (-Chap. 23) discuss the role of forest ecosystems for livelihoods when disasters strike in Indonesia. Through an analysis of ecosystem services, they emphasise the roles that forests play in reducing the vulnerability of communities exposed to various hazards.

With this second book volume, we hope to spark ongoing dialogue, research and practice that advance global understanding and, most importantly, applications of ecosystem-based solutions for disaster risk reduction and climate change adaptation.

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