Chapter 8
Ecosystem-Based Disaster Risk Reduction: Experiences, Challenges, and Opportunities in the Post-2015 Development Agenda

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Abstract Ecosystems, climate change, and disaster risk reduction are among the cross-cutting issues highlighted in the Rio+20 Conference. In view of the post-2015 development agenda, the chapter discusses the important role of ecosystem-based disaster risk reduction in sustaining ecosystems and building disaster-resilient communities. It describes ecosystem management strategies that link ecosystem protection and disaster risk reduction, elucidates the challenges in advancing the use of ecosystem-based disaster risk reduction and linking it to policy, and identifies opportunities for scaling up.

Keywords Ecosystem-based disaster risk reduction • Ecosystem management • Post-2015 framework for disaster risk reduction • Post-2015 development agenda

8.1 Introduction

For the past few decades, the linkage between poverty, ecosystem degradation, and disaster risk has already been widely discussed in the science and policy arena. However, it was only during the UN Conference on Sustainable Development 2012 (Rio+20) that this relationship was given greater political attention (Beck et al. 2012). Additionally, scientists have only recently begun to systematically establish the influence of ecosystems on disaster risk. According to UNDP (2007), the

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attention given to these issues at this time may be attributed to major disasters, an active civil society to promote democratic political change, the engagement of particularly dynamic individuals, and a well-educated and participative population.

In the outcome document adopted at Rio+20, member states acknowledge planet Earth and its ecosystems as mankind's home and the rights of nature in the context of sustainable development (UN 2012). They recognize that it is necessary to promote harmony with nature to achieve a just balance among the economic, social, and environmental needs of present and future generations. There is, thus, a need to seize and create opportunities to achieve sustainable development through economic growth and diversification, social development, and environmental protection. With this in mind, ecosystems, climate change, and disaster risk reduction are among the thematic areas highlighted at Rio+20 and in the discussions on the post-2015 agenda on sustainable development, disaster risk reduction (DRR), and climate change.

8.1.1 Linking Ecosystem Management, Disaster Risk Reduction, and Sustainable Development

Ecosystem management has grown in theory and application from its ecological beginnings. This evolution is largely due to the changing views and processes within various scientific and social disciplines, technology, decision making, and policy. As shown in Table 8.1, many events in the environment, DRR, and climate change arena contributed to the growing link between these issues.

Environment, one of the pillars of sustainable development, figures highly in all discussions on sustainable development. As mentioned in the Millennium Assessment Report, attaining environmental sustainability requires an end to the current unsustainable uses of ecosystem services (e.g., fisheries and freshwater) as well as an end to the degradation of other services (e.g., water purification, natural hazard regulation, disease regulation, climate regulation, and cultural amenities) (MA 2005). An examination of selected key documents that advance sustainable development shows that environment has always been a main concern (Table 8.2).

The Hyogo Framework for Action (HFA), the first international plan to substantially reduce disaster losses by 2015, outlines five priorities for action. Sustainable ecosystem and environmental management are listed under Priority 4, to "reduce the underlying risk factors." Among the activities identified to achieve this priority are (i) encourage the sustainable use and management of ecosystems, including through better land use planning and development activities to reduce risk and vulnerabilities, and (ii) implement integrated environmental and natural resource management approaches that incorporate disaster risk reduction, including structural and non structural measures, such as integrated flood management and appropriate management of fragile ecosystems (UNISDR 2005).

In the following, the chapter discusses the important role of ecosystem-based disaster risk reduction (Eco-DRR) in sustaining ecosystems and building

Table 8.1 Timeline of selected events in environment, disaster risk reduction, and climate change

Period	Environment	Disaster risk reduction	Climate change
1960s–1970s	1962: Rachel Carson's *Silent Spring* (published by Houghton Mifflin) 1970: 1st Earth Day 1971: Greenpeace 1972: Stockholm Conference; UNEP; Meadows et al.'s *Limits to Growth* (published by Universe Books) 1974: *Chlorofluoromethanes Destroy the Ozone Layer* (Rowland and Molina, Nature 249, 810–812, 28 June 1974) 1975: Convention on International Trade in Endangered Species (CITES) 1976: UN Conference on Human Settlements 1977: UN Conference on Desertification 1979: Three Mile Island Nuclear Accident; Convention on Long-Range Transboundary Air Pollution	1971: UN Disaster Relief Office 1971–1985: Drought in Afghanistan, Ethiopia, and Other Countries in Africa	1974: *Chlorofluoromethanes Destroy the Ozone Layer* (Rowland and Molina, Nature 249, 810–812, 28 June 1974)
1980s–1990s	1980: IUCN's World Conservation Strategy 1982: UN Convention on the Law of the Sea; UN World Charter for Nature 1984: Bhopal Toxic Leak 1985: WMO Climate Change Meeting 1986: Chernobyl Nuclear Accident 1987: Montreal Protocol on Substances that Deplete the Ozone Layer 1987: Brundtland Report 1988: Intergovernmental Panel on Climate Change (IPCC) 1991: Global Environment Facility (GEF) 1992: Rio Summit 1995: World Trade Organization 1995: World Summit for Social Development 1996: ISO 14001	1990: International Decade for Natural Disaster Reduction 1991: Bangladesh Cyclone 1994: World Conference on Disaster Reduction; Yokohama Strategy 1995: Great Hanshin Earthquake	1985: Antarctic Ozone Hole Discovered; WMO Climate Change Meeting 1987: Montreal Protocol on Substances that Deplete the Ozone layer 1988: IPCC 1990: IPCC FAR 1992: UNFCCC 1995: IPCC SAR; COP1

(continued)

Table 8.1 (continued)

Period	Environment	Disaster risk reduction	Climate change
2000s –	2000: Millennium Development Goals (MDGs) 2002: Johannesburg Plan of Implementation 2005: Kyoto Protocol; Millennium Ecosystem Assessment 2006: Stern Review on the Economics of Climate Change 2007: Al Gore's "An Inconvenient Truth" 2008: Green Economy in the Mainstream 2010: The Economics of Ecosystems and Biodiversity (TEEB) 2012: Rio+20 Conference	2000: UNISDR 2004: Indian Ocean Tsunami 2005: Kashmir Earthquake 2005: HFA 2006: Global Platform on Disaster Reduction 2007: First Session of the Global Platform on Disaster reduction 2008: Sichuan Earthquake 2010: Haiti Earthquake 2011: Great East Japan Earthquake and Tsunami 2013: Typhoon Haiyan	2001: IPCC TAR 2005: Kyoto Protocol 2006: Nairobi Work Program 2006: Stern Review on the Economics of Climate Change 2007: AR4; Bali Action Plan 2009: Copenhagen Accord 2010: Cancun Agreements 2011: Durban Platform for enhanced action 2013/2014: AR5

Source: http://www.iisd.org/pdf/2012/sd_timeline_2012.pdf; http://www.unisdr.org/who-we-are/history; http://unfccc.int/essential_background/items/6031.php

Table 8.2 Issues in focus in selected documents on sustainable development

Document	Issues in focus	Summary
Stockholm declaration	Protection and improvement of 'Human Environment'	The declaration emphasizes that protection and improvement of natural and man-made environments is an urgent desire of people and a major duty of all governments and most environmental problems in developing countries were attributable to under development and natural disasters where poverty alleviation became an important step to improve environmental conditions
Rio declaration/ Agenda 21	Social and economic development; *conservation* and *management of resources*; strengthening the role of major groups; means of implementation	Key outcomes:
		The convention on biological diversity
		The framework convention on climate change
		The principles for the sustainable management of forests
		Rio declaration
		Agenda 21
		Key commitments:
		Integration of environment and development in decision making
		Recognition of common but differentiated responsibilities
		Application of the precautionary approach to decision making
		Provision for polluters to pay for costs of pollution
Brundtland Report	*Environmental degradation*; social and economic development	The report sought for solutions to parallel problems of global environmental degradation and global lack of social and economic development by asking for these challenges to be addressed in an integrated way in the interests of present and future generations
MDGs	Poverty; education; gender equality; health; *environmental sustainability*; partnership	The MDGs are time-bound goals and targets to improve human well-being
Johannesburg Plan of Implementation	Poverty eradication; changing unsustainable patterns of consumption and production; *protecting and managing the natural resource base* of economic and social development	Designed as a framework for action to implement the commitments originally agreed at the Earth Summit
		Set out specific timetable to address some issues
	Globalization; health; small island developing states; Africa; regional initiatives; means of implementation	Strengthened the role of the commission on sustainable development in continuing international oversight monitoring progress on sustainability agreements
	Institutional framework for sustainable development	

disaster-resilient communities in view of the post-2015 development agenda. It describes ecosystem management strategies that link ecosystem protection and disaster risk reduction, elucidates the challenges in advancing the use of Eco-DRR and linking it to policy, and identifies opportunities for increased uptake in the post-2015 development agenda.

8.2 Disaster Risk Reduction, Sustainable Development, and Ecosystem Management in the Post-2015 Development Agenda

Global consultation processes have taken place to guide and support deliberations on a post-2015 framework for DRR. In parallel, the post-2015 sustainable development agenda and goals have been discussed. The consideration of ecosystem management in these international frameworks is examined in the following.

8.2.1 Post-2015 Framework for DRR

According to the HFA's mid term review, Priority 4 made the least progress so far (UNISDR 2011). The Rio+20 Outcome document has called for the acceleration of the implementation of the HFA and emphasizes the imperative of reducing risk and building disaster resilience for poverty eradication, addressing the impacts of climate change, and achieving sustainable development. Despite its direct impact on each of the HFA's priority areas, ecosystems are not prominently highlighted as a crosscutting issue. At the 2013 Global Platform consultations, discussions revolved around issues and proposals on:

(i) the importance of community-level involvement,
(ii) targeting and including the most vulnerable populations,
(iii) women as leaders,
(iv) children and youth,
(v) health,
(vi) integrating climate change adaptation, development, and disaster risk reduction,
(vii) the role of science,
(viii) knowledge sharing and education,
(ix) capacity building: financing, risk assessment, preparedness, and early warning,
(x) private sector involvement in disaster risk reduction,
(xi) political will and leadership,
(xii) governance, accountability, transparency, and inclusiveness (UNISDR 2013b).

Environmental degradation (such as deforestation, erosion, and loss of biodiversity) was mentioned only because it will be affected by climate change and will

have far-reaching consequences for food and water security. Moreover, environmental risk assessments were proposed to be integrated to risk assessments.

Similarly, the key issues and proposals that came out at the Asia Pacific consultations include (i) building on the HFA for a new framework for DRR; (ii) integrating DRR, climate change, and sustainable development; (iii) local-level action; (iv) turning vulnerability into resilience; (v) multi-stakeholder engagement; (vi) risk governance and accountability; (vii) knowledge-based decision making; and (viii) what kind of new framework (UNISDR 2013a). Again environment was not highlighted.

Despite the low emphasis on environment during consultations, environment is included in Priority 3 (investing in economic, social, cultural, and environmental resilience) of the zero draft of the post-2015 framework for DRR. Ecosystem management is identified as a key development area which requires strengthened sustainable use and management of ecosystems and DRR-integrated environmental and natural resource management approaches (UN 2014).

According to UNISDR (2013c), it is essential that the post-2015 framework for DRR considers enhancing current risk management practices in development planning and investment in order to manage risks inherent to development which manifests through disasters, climate change and variability, financial and economic crises, and other consequences for the economy, society, and the environment. Disaster risk management should aim for development that manages risks, sustainably seizes opportunities, and strengthens resilience to ensure sustainable development. It should not focus on the reduction of disaster loss but on encouraging sustainable development and human welfare and well-being (Lavell and Maskrey n.d.). A new framework for DRR would ideally be composed of (i) the post-2015 framework for disaster risk reduction and its monitoring system and period review process; (ii) the voluntary commitments of stakeholders, as leading examples of assumption of responsibility, vision, and readiness to act; and (iii) the political declaration (UNISDR 2013c).

8.2.2 Sustainable Development Goals

The process to develop a set of Sustainable Development Goals (SDGs) was agreed at the Rio+20 Conference. The SDG consultation process consists of two tracks which will converge in September 2014 into one intergovernmental process: a member state-led (UN General Assembly) intergovernmental process to develop SDGs and the UN secretary-general-led discussions on what should replace the MDGs, supported by global stakeholder consultations. In the Rio+20 Outcome Document, member states agreed that SDGs must:

- Be based on Agenda 21 and the Johannesburg Plan of Implementation.
- Fully respect all the Rio Principles.
- Be consistent with international law.
- Build upon commitments already made.

- Contribute to the full implementation of the outcomes of all major summits in the economic, social, and environmental fields.
- Focus on priority areas for the achievement of sustainable development, being guided by the outcome document.
- Address and incorporate in a balanced way all three dimensions of sustainable development and their interlinkages.
- Be coherent with and integrated into the United Nations development agenda beyond 2015.
- Do not divert focus or effort from the achievement of the Millennium Development Goals.
- Include active involvement of all relevant stakeholders, as appropriate, in the process.

Additionally, it was agreed that the SDGs should be (i) action oriented, (ii) concise, (iii) easy to communicate, (iv) limited in number, (v) aspirational, and (vi) global in nature and universally applicable to all countries. A 30-member Open Working Group (OWG) of the General Assembly, tasked with preparing a proposal on the SDGs, released a zero draft of the proposed Sustainable Development Goals to be attained by 2030. Selected proposed indicators related to DRR and ecosystem management are listed in Table 8.3.

Integrating DRR into the post-2015 development agenda has been a priority issue in the consultations as they are so closely aligned. To synchronize the post-2015 Framework for DRR with the Post-2015 Sustainable Development Framework, Lavell and Maskrey (n.d.) suggest that the new HFA should be inside the SDGs and disaster risk management be made implicit in all the SDGs.

8.3 Ecosystem-Based Disaster Risk Reduction

Sudmeier-Rieux and Ash (2009) provide a definition of ecosystem-based disaster risk reduction (Eco-DRR) in the following:

> Ecosystem-based disaster risk reduction refers to decision-making activities that take into consideration current and future human livelihood needs and biophysical requirements of ecosystems, and recognize the role of ecosystems in supporting communities to prepare for, cope with, and recover from disaster situations.

In arguing for Eco-DRR, Sudmeier-Rieux et al. (2006) cite several reasons to integrate ecosystem-based management in DRR and development planning such as:

1. It can decrease vulnerability to natural disasters.
2. Natural disasters have a high cost.
3. It costs less to prevent disasters than it does to fix the damage they cause.
4. At-risk populations depend on ecosystems for their livelihoods.
5. Natural disasters and the responses to them have a negative impact on biodiversity.

Table 8.3 Proposed SDGs and indicators related to DRR and ecosystem management

Proposed SDG	Indicators
11. Build inclusive, safe, and sustainable cities and human settlements	By 2030, reduce the environmental impacts of cities and improve the quality of environment in cities
	By 2020, increase by x% the number of human settlements adopting and implementing policies and plans towards resilience and adaptation to climate change and natural disasters
13. Promote actions at all levels to address climate change	Build resilience and adaptive capacity to climate induced hazards in all vulnerable countries
	By 20xx, integrate climate change adaptation and mitigation strategies into development plans and poverty reduction strategies
	Improve education, awareness raising and human and institutional capacity on climate change impact reduction and early warning
14. Attain conservation and sustainable use of marine resources, oceans, and seas	By 2030, reduce by x% marine pollution of all kinds, including from land-based activities
	By 2020, sustainably manage, restore and protect marine ecosystems from destruction, including by strengthening their resilience, and support relevant scientific research address and prevent further ocean acidification; ensure the full implementation of existing regional and international regimes for managing oceans and seas by their state parties
	By 2020, eliminate illegal, unreported and unregulated (IUU) fishing and destructive fishing practices
	By 2020, conserve at least 10 % of coastal and marine areas, including through establishing effectively managed marine protected areas, consistent with international law and based on best available scientific information; implement integrated and participatory coastal management to increase resilience of coastal ecosystems
15. Protect and restore terrestrial ecosystems and halt all biodiversity loss	By 2020 halt the loss of all biodiversity, and protect and prevent the extinction of threatened species
	By 2020 ensure conservation and sustainable use of ecosystems, with particular attention to wetlands, including through restoration of at least 15 % of degraded ecosystems
	Maintain genetic diversity of both cultivated plants, farmed and domesticated animals and their wild relatives including through effective cooperation of national institutions
	By 2030, ensure the implementation of sustainable management of all types of forests and of mountain ecosystems
	By 2030 reverse the loss of and enhance forest cover worldwide, increase reforestation by x%, including by providing adequate incentives for developing countries
	By 2030, halt and prevent land degradation, reclaim land affected by desertification and drought, and improve land productivity and soil quality
	Introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems
	By 2020 control or eliminate the priority invasive species; ensure free prior informed consent of indigenous peoples and local communities in decision making and natural resources management, and promote the use of their traditional knowledge
	Integrate natural resources and biodiversity values into national and local planning, development processes, and accounts

Source: http://sustainabledevelopment.un.org/focussdgs.html

Despite these reasons, there are still relatively very few concrete examples of Eco-DRR. This section reviews the link between ecosystems and DRR; examines the tools, approaches, and strategies applied in Eco-DRR; and describes the common elements present in Eco-DRR initiatives.

8.3.1 Ecosystems and Disaster Risk Reduction: A Review

It seems logical that healthy ecosystems can protect communities from the impacts of disasters. Ecosystems increase resilience levels and help deliver development benefits which can help vulnerable people cope with the impacts of more frequent and intense disasters. Ecosystems contribute to increasing resilience through its provisioning and regulating functions (Munang et al. 2009; Saikia et al. 2013). The decline of these protective and regulatory functions can exacerbate and magnify the impacts of hazards. Conversely, ecosystem degradation can be exacerbated by disturbances caused by natural disasters. Thus, any loss or damage in ecosystem reduces its capacity to carry out these functions, reducing the resilience of both human communities and the ecosystem itself (Saikia et al. 2013). Losses from disasters contribute to the decline in ecosystems, social welfare, and economic growth and, thus, undermine local development and national economic growth (UNISDR 2013d).

Literature on the important role of ecosystems in DRR has grown substantially over the years. MA (2005) concludes that 60 % of the ecosystems are not being sustainably used or are in a state of ongoing degradation. It stressed the link between environmental degradation and increased impacts of disasters and the role of ecosystems in reducing risk from disasters such as flooding and forest fires. A study by Danielsen et al. (2005) also shows that the deterioration and clearing of mangroves and other types of coastal vegetation along many coastlines have increased their vulnerability to storm and tsunami damage. Recognizing this, the 2009 and 2011 Global Assessment Reports identify ecosystem decline as one of the underlying drivers of risk (UNISDR 2009, 2011). Land degradation, for instance, increases agricultural drought risk (UNISDR 2013d). Similarly, Beck et al. (2012) point to environmental degradation as a significant risk factor that reduces the capacity of societies especially vulnerable populations to deal with disaster risk.

Healthy ecosystems matter to disaster risk management because (i) human well-being depends on ecosystems that enable people to withstand, cope with, and recover from disasters; (ii) ecosystems, such as wetlands, forests, and coastal systems, can provide cost-effective natural buffers against hazard events and the impacts of climate change; (iii) there are clear links between resource degradation and disaster risk; (iv) healthy and diverse ecosystems are more robust to extreme weather events; and (v) ecosystem degradation reduces the ability of natural systems to sequester carbon, exacerbating climate change impacted disasters (Sudmeier-Rieux and Ash 2009). As presented in Table 8.4, numerous studies have shown the many benefits of healthy and well-managed ecosystems for DRR. Beck et al. (2012)

Table 8.4 Selected studies demonstrating the role of ecosystems in DRR

Hazard	Finding of study	References
Tsunami	Coastal forests and trees (e.g., mangroves) protected lives, resources, and infrastructure during the 2004 Indian Ocean Tsunami	Braatz et al. (2007), Chang et al. (2006), Danielsen et al. (2005), Forbes and Broadhead (2007), and Yanagisawa et al. (2009)
	In Thailand, poorly planned tourist developments and fishing communities built close to the shore on flat, low-lying land and in wide, exposed bays with no coral reefs were the worst hit during the 2004 Indian Ocean Tsunami	UNEP-WCMC (2006)
	Tsunami damage reached only 50 m inland and waves were only 2–3 m high compared to other areas in Hikkaduwa, Sri Lanka, due to coral reefs in a marine park	World Bank and United Nations (2010)
Cyclone/storm/ hurricane	Statistical evidence from a sample of 409 villages demonstrated how mangroves reduced death toll during the 1999 super cyclone in Orissa	Das and Vincent (2009)
	Wetlands reduce flooding associated with hurricanes in the United States to an average of USD 8,240 per hectare per year, with coastal wetlands estimated to provide USD 23.2 billion a year in storm protective services	Costanza et al. (2008)
	A combination of infrastructure and relatively well-preserved natural ecosystems (semi-altered ecosystems) offer a good protection service against the impact of hurricanes in terms of human lives	Perez-Maqueo et al. (2007)
Flood	Sri Lanka's Muturajawia marsh, a 3,100 ha coastal peat bog that buffers and regulates flood water discharge into the sea, is estimated to provide protective services at more than USD 5 million or USD 1,750 per hectare	Emerson and Bos (2004)
Avalanche	Forests have an estimated economic value in preventing avalanches ranging from less than USD 100 per hectare per year for some of the landscapes in the Swiss Alps to more than USD 170,000 per year for tourist venues and towns	ProAct Network (2008)

and Renaud et al. (2013) identify benefits such as (i) serving as natural infrastructure to prevent hazards or buffer hazard impacts; (ii) helping reduce the exposure of people and their productive assets to hazards; (iii) sustaining human livelihoods and providing for basic needs, such as food, shelter, and water, before, during, and after hazard events; and (iv) supporting better the post-disaster recovery needs of communities. In addition, these natural protection structures can (i) enhance community

ownership of DRR; (ii) adapt to changing conditions, including recovery after a major damage-causing event; (iii) be more readily applied in poor countries as they are more cost-effective; (iv) be maintained with less external assistance; and (v) prevent and reverse environmental degradation. Finally, ecosystems provide many co-benefits such as increased areas for recreation, aesthetic improvements, habitat protection, reduction of human and technological errors or failures associated with structural works, or the spurring of economic growth (Kousky 2010). Recognizing the various benefits provided by ecosystems in risk reduction, IPCC (2012) cites investing in ecosystems as a "low-regrets" measure. In addition, ecosystem-based approaches have been recognized as a key climate change adaptation strategy in the UNFCCC negotiations since the Conference of Parties (COP) in Copenhagen in 2009.

Disasters not only affect people but also ecosystems producing negative consequences to the ecosystem services that they provide. Some of the environmental impacts include (i) direct damage to the natural resources and infrastructure, affecting ecosystem functions; (ii) acute emergencies from the uncontrolled, unplanned, or accidental release of hazardous substances, especially from industries; and (iii) indirect damage as a result of post-disaster relief and recovery operations that fail to take ecosystems and ecosystem services into account (PEDRR 2010). With climate change and the new risks posed by extreme climate events, ecosystems' critical role in reducing the impacts of climate extremes and disasters is lessened. Table 8.5 describes the impacts of climate extremes on ecosystems.

8.3.2 Experiences of Eco-DRR

8.3.2.1 Tools and Approaches in Eco-DRR

PEDRR (2010) identifies the following core elements on implementing Eco-DRR: (i) recognize the multiple functions and services provided by ecosystems, including natural hazard protection or mitigation; (ii) link Eco-DRR with sustainable livelihoods and development; (iii) combine investment in ecosystems with other effective DRR strategies, including hard engineering options; (iv) address risks associated with climate change and extreme events and reduce their impact on ecosystem services; (v) enhance governance capacities for Eco-DRR through multi-sector, multidisciplinary platforms; (vi) involve local stakeholders in decision making; and (vii) utilize existing instruments and tools in ecosystems management and enhance their DRR value. As an example of existing instruments and tools which can be enhanced for their DRR value, the convention on biological diversity (CBD) adopts the ecosystem approach as a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. Five points of operational guidance, which can be applied to Eco-DRR, were

Table 8.5 Consequences of climate extremes on ecosystems

Extreme climate event	Consequences on ecosystems
Drought	Affect forestry and terrestrial and aquatic ecosystems
Heatwave	Can directly impact by constraining carbon and nitrogen cycling and reducing water availability, potentially decreasing production or even causing species mortality
	Extreme temperature conditions can also shift forest ecosystems from being a net carbon sink to a net carbon source
Dzud	Puts heavy pressure on ecosystem services and infrastructure and social services. It lasts all year round and causes dramatic socioeconomic impacts, including significant loss of livestock, unemployment, poverty, and mass migration from rural to urban areas
Flood	Impact ecosystems, including species populations
Hurricane and storm	Can impact forest ecosystems, particularly in pre-alpine and alpine areas. Saltmarshes, mangroves, and coral reefs can also be vulnerable to such climate extremes
Oceanic warming and acidification	Have a negative impact on marine ecosystems particularly for coral reef ecosystems. Anthropogenic oceanic changes may contribute indirectly to damage to coral atolls, by affecting the health of the surrounding reef system
Permafrost	Melting of massive ground ice and thawing of ice-rich permafrost can lead to landslides, slope instabilities, subsidence of the ground surface, and the formation of uneven topography known as thermokarst. Such changes have implications for ecosystems, landscape stability, and infrastructure performance

Source: Seneviratne et al. (2012)

developed following the 12 principles of the ecosystem approach to aid implementation and facilitate wider adoption. Table 8.6 shows lists of CBD's points of operational guidance for ecosystem approach and shows how this guidance has been adopted by the International Union for the Conservation of Nature (IUCN), Wetlands International, and the Department for Environment, Food and Rural Affairs (DEFRA) of the United Kingdom. These steps for implementation of the ecosystem approach place emphasis on holistic approach, structure and function of the ecosystem, spatial scale; risks and vulnerabilities, land and natural resource use, economic issues, stakeholder involvement, and engagement of multiple sectors.

Moreover, Sudmeier-Rieux (2013) lists available tools that can be used in Eco-DRR including (i) environmental assessment tools (e.g., environmental impact assessment (EIA)), strategic environmental assessment (SEA), and rapid environmental assessment (REA), (ii) integrated risk and vulnerability assessments, (iii) spatial planning at regional and local scales, and (iv) integrated ecosystems management (e.g., integrated water resources management, integrated coastal zone management, integrated fire management, protected area management and community-based ecosystem, and disaster risk management. In harmonizing

Table 8.6 CBD's ecosystem approach as adopted by selected organizations

CBD's five points of operational guidance	IUCN's five steps (Shepherd 2004)	Wetlands International's five steps (Wetlands International 2013)	DEFRA's six principles (DEFRA 2010)
1. Focus on the functional relationships and processes within ecosystems	1. Determining the main stakeholders, defining the ecosystem area, and developing the relationship between them	1. Assessing risks and vulnerabilities, including the (environmental) root causes of risk	1. Taking a more holistic approach to policy-making and delivery, with focus on maintaining healthy ecosystems and ecosystem services
2. Enhance benefit sharing	2. Characterizing the structure and function of the ecosystem, and setting in place mechanisms to manage and monitor it	2. Identifying risk reduction scenarios and related costs and benefits	2. Ensuring that the value of ecosystem services is fully reflected in decision making
3. Use adaptive management practices	3. Identifying the important economic issues that will affect the ecosystem and its inhabitants	3. Ensuring that risk reduction measures are planned at multiple spatial scales – locally at the community level but also across wider areas (river basins, landscapes)	3. Ensuring environmental limits are respected in the context of sustainable development, taking into account ecosystem functioning
4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to lowest level, as appropriate	4. Determining the likely impact of the ecosystem on adjacent ecosystems	4. Designing and implementing ecosystem-inclusive risk reduction measures in partnership with multiple sectors	4. Taking decisions at the appropriate spatial scale recognizing the cumulative impacts of decisions
5. Ensure intersectoral cooperation	5. Deciding on long-term goals and flexible ways of reaching them	5. Addressing the root causes of risk by ensuring sound land use and natural resource use policies, ensuring that ecosystem services are sustained	5. Applying adaptive management of the natural environment to respond to changing pressures, including climate change
			6. Identifying and involving all relevant stakeholders in the decision and plan-making process

environmental and disaster reduction policies, Sudmeier-Rieux et al. (2006) recommend these actions:

(i) assess the environmental causes of vulnerability;
(ii) assess environmental actions that reduce vulnerability;
(iii) monitor natural processes (e.g., drought and flood) and establish early warning systems;
(iv) consider the effects on ecosystem services (e.g., the impacts of draining wetlands on flood regimes) in decision-making processes;
(v) establish partnerships for and regional approaches to land use and nature conservation;
(vi) establish alternatives to conflicts over the alternative uses of resources;
(vii) provide advice and information to involve people in enhancing ecosystem protection (e.g., community stewardship of mangrove forests);
(viii) consider the economic benefits of the services that ecosystems provide to disaster risk reduction (e.g., the benefits of investing in wetland restoration as a buffer for floods);
(ix) create economic and legal incentives to include ecosystem services in disaster risk reduction (e.g., incentives or disincentives to avoid exploitation of resources from protective sand dunes, mangrove forests, and coral reefs);
(x) enforce environmental regulations, particularly those that may reduce population vulnerability (e.g., zoning laws, protection of key ecosystems, solid waste management); and
(xi) strengthen ecosystem management to include disaster risk reduction (e.g., watershed management, integrated coastal management, protected area management).

In addressing climate-related risks, UNEP (n.d.b) mentions four complementary strategies that are required in implementing an ecosystem approach: (i) political commitment to raise the profile of ecosystems in climate change policy setting at local, national, and international levels; (ii) investment related to ecosystem management and protection, especially as part of a global climate change fund; (iii) incentives to reduce emissions, ease existing pressures on ecosystems, and support changes that increase environmental resilience and resource sustainability; and (iv) comprehensive information that foster closer links between ecosystem management, CCA, and disaster risk reduction communities as well as between science, economics, politics, and policy.

8.3.2.2 Eco-DRR Strategies

There is a wide range of ecosystem management strategies and actions that can be applied for DRR in different ecosystems at local, national, and regional levels. The following describes some of the Eco-DRR strategies that are widely utilized. Table 8.7 provides a summary of these strategies and examples of initiatives undertaken.

Table 8.7 Examples of Eco-DRR initiatives in different ecosystems and levels

	Ecosystem-based DRR initiatives		
Ecosystem	Local	National	Regional
Forest	Community-based forest management; community-based DRR/adaptation	DRR plans and programs	REDD+
		Under the Amazon protected areas program, Brazil has created a mosaic of over 30 million hectares of biodiversity-rich forests reserve of state, provincial, private, and indigenous land, resulting in potential reduction in emissions estimated at 1.8 billion tons of carbon, through avoided deforestation	
		In Muminabad, Tajikistan a Swiss Development Cooperation project adopted an integrated approach to risk through reforestation and integrated watershed management	
Watershed/deltas	River basin management	Vietnam's strategic environmental assessment in land use planning projects and hydropower development for the Vu Gia-Thu Bon river basin, including climatic disaster risks	Transboundary/river delta initiatives (Mekong River)
		European countries affected by severe flooding, notably the United Kingdom, the Netherlands, and Germany, have made policy shifts to make space for water by applying more holistic river basin management plans and integrated coastal zone management	
Coastal (mangrove, beach, reef, sea grass, salt marsh)	Coastal zone management; mangrove restoration and rehabilitation; coral restoration; protected area management	Philippines' National Greening program; programs after Indian Ocean tsunami	Coral triangle initiative; mangroves for the future

Forest Management

Forest management balances demand for forest products with the ecological requirements of forests, while ensuring other key benefits for livelihoods, notably by stabilizing steep slopes and reducing soil erosion. DEWGA (2008) identifies these actions for sustainable forest management: (i) protect and improve the forest environment through increased vegetation; (ii) help alleviate poverty by generating income through increased tree cover and related activities, (iii) increase forest resources, (iv) establish community-driven economic activities based on forest plantation, (v) increase multiple uses for land, and (vi) create popular awareness about sustainable forest management. In addition, forests in potential avalanche release areas can reduce the risk of avalanches because trees break up snow cover, prevent wind-blown snow drifts, and keep snow under shade and therefore colder and firmer and their fallen boles and boughs tend to anchor snow and prevent it from moving (ProAct Network 2008).

Protected Area Management

Stolton et al. (2008) identify three direct roles that protected areas can play in preventing or mitigating disasters arising out of natural hazards such as (i) maintaining natural ecosystems (e.g., coastal mangroves, coral reefs, floodplains, and forest) that may help buffer against natural hazards, (ii) maintaining traditional cultural ecosystems that have an important role in mitigating extreme weather events (e.g., agroforestry systems, terraced crop growing, and fruit tree forest in arid lands), and (iii) providing an opportunity for active or passive restoration of such systems where they have been degraded or lost.

Watershed Management

The physical and biological resources of watersheds provide a wide range of ecosystem goods and services to people such as water protection, attenuation of disasters by regulating runoff, protection of coastal resources and fisheries, protection of the environment, and protection of productive lowlands. For these reasons, watershed management is important for agricultural, environmental, and socioeconomic development. Actions for effective management of the watershed include:

(i) when located in floodplains, structures should be built to withstand flood damage, to prevent floodwater contamination, and to avoid disruption to river courses, river banks and vegetation;
(ii) intensive agricultural activity should not to be permitted on slopes greater than a specified percentage reflecting land stability;
(iii) clear-cutting of forests should be limited with forest conservation and sustainable forest management prioritized;
(iv) institutional bodies, such as River Basin Organizations, should be formally established to address land use conflicts and staff trained in conflict-resolution;

(v) public participation of both men and women should be increased in management decisions;
(vi) effective management plans and enforcement of environmental and zoning regulation are critical; and
(vii) regional environmental impact assessments are needed to ensure that cumulative impacts of economic activities are sustainable (DEWGA 2008).

Coastal Zone Management

Coastal ecosystems such as mangroves, salt marshes, beach vegetation, seagrass beds, and coral reefs are effective buffers against many coastal natural hazards while providing significant social and economic benefits (MA 2005). Barrier islands formed by offshore drift and sedimentation buffer storm surges and waves as well (ProAct Network 2008). These ecosystems are under pressure by coastal development, and thus, coastal zone management actions must consider the continuum of inland areas, coasts, and oceans through actions such as (i) replanting coastal forests and restoration of mangroves, which have been taken up as a part of the environmental recovery process, (ii) restoring and maintaining the health of the coral reefs and seagrass beds, (iii) maintaining and/or developing mangrove belts as buffer zones for coasts and coral reefs, and (iv) protecting wetlands and watersheds to minimize sedimentation (DEWGA 2008).

Mangrove Restoration and Rehabilitation

Mangroves generally slow the flow of water as the surge moves inland and reduce the waves riding on top of the surge, lowering water levels and reducing damage behind the mangroves. They reduce the magnitude of storm surges and related inundation by absorbing storm energy, reducing flow depths and velocities, and holding sediments in place within root systems (ProAct Network 2008). As with coastal zone management, coastal protection against hazards is recognized as one of the benefits that restored mangroves will provide resulting in the increasing interest in the use of mangroves as coastal defense against hazards such as storm surges (McIvor et al. 2012; Gedan et al. 2011; Shepard et al. 2011; Zhang et al. 2012).

Coral Restoration

Healthy reef systems provide a buffer zone for the shoreline during extreme surge and wave events thus mitigating erosion and inundation. They are also a source of carbonate sand and gravel for atolls, which are delivered to shore by storms and swell (CDKN 2012). Beck et al. (2012) estimate that there are 200 million people who benefit from risk reduction from coral reefs alone or may have to bear higher costs of disasters if the reefs are degraded. This population lives in low, risk-prone coastal areas (below 10 m elevation) and within 50 km of coral reefs in villages, towns, and cities.

8.3.2.3 Common Elements in Eco-DRR Initiatives

Slocombe (1998) explains that, in general, an ecosystem approach (i) describes parts, systems, environments, and their interactions; (ii) is holistic, comprehensive, and trans disciplinary; (iii) includes people and their activities in the ecosystem; (iv) describes system dynamics; (v) defines the ecosystem naturally; (vi) looks at different levels/scales of system structure, process, and function; (vii) recognizes goals and takes an active management orientation; (viii) incorporates actor-system dynamics and institutional factors in the analysis; (ix) uses an anticipatory and flexible research and planning process; (x) entails an implicit or explicit ethics of quality, well-being, and integrity; and (xi) recognizes systemic limits to action.

In addition, seven core elements associated with implementing Eco-DRR are outlined in PEDRR (2010), namely:

1. Recognize the multiple functions and services provided by ecosystems, including natural hazard protection or mitigation.
2. Link ecosystem-based risk reduction with sustainable livelihoods and development.
3. Combine investments in ecosystems with other effective DRR strategies, including hard engineering options.
4. Address risks associated with climate change and extreme events and reduce their impact on ecosystem services.
5. Enhance governance capacities for ecosystem-based DRR through multi-sector, multi disciplinary platforms.
6. Involve local stakeholders in decision making.
7. Utilize existing instruments and tools in ecosystem management and enhance their DRR value.

Other common elements mentioned in the literature include (i) integration of ecological, sociocultural, economic, and institutional factors; (ii) consideration of ecosystem integrity; (iii) use of environmental planning and management tool, strategy, or system, (iv) practice of adaptive management (Uy and Shaw 2012); (v) cost-effectiveness (Kousky 2010); and (vi) local accessibility (PEDRR 2010).

8.4 Challenges and Limits to Implementing Eco-DRR

While ecosystem management is not a new concept, further evidence is needed to build the case and demonstrate how ecosystem management can be maximized for DRR and thus facilitate uptake (PEDRR 2010). The main challenge at present is improving the evidence base for Eco-DRR. To respond to this, the challenges on knowledge and research and institutions and policy, in particular, need to be addressed to increase appreciation of Eco-DRR and guide implementation especially at the local level.

8.4.1 Knowledge and Research

Essentially, there is a need for additional research due to lack of understanding of the potential of natural buffers (ProAct Network 2008; Kousky 2010). Challenges exist in developing understanding of an ecosystem; identifying appropriate spatial and temporal scales for analysis, planning, and management; and governance and institutional jurisdiction which determine the issues and opportunities to address and the different information and management tools required. Among the gaps in knowledge and research on Eco-DRR include (i) ecology on multiple scales, (ii) monitoring and evaluation, (iii) "benchmarks" of ecosystem condition, (iv) human dimensions of natural resource use, (v) ecological restoration technology development, (vi) quantifying uncertainty and assessing risk, and (vii) adaptive management process. In addition, insufficient recognition of the economic and social benefits of ecosystem services under current risk situations, let alone under potential changes in climate extremes and disaster risks, lack of interdisciplinary science and implementation capacity for making informed decisions associated with complex and dynamic systems, inability to estimate economic values of different ecosystem services, and lack of capacity to undertake careful cost and benefit assessments of alternative strategies to inform choices at the local level are challenges to increasing investments in ecosystem-based solutions (CDKN 2012).

8.4.2 Institutions and Policy

Kousky (2010) identifies uninterested decision makers and political opposition as potential challenges to increasing adoption of the use of natural capital to reduce risks. Linking Eco-DRR to policy and institutional mandates is necessary to facilitate implementation. Also, having a champion advocating for Eco-DRR would ensure that it is prioritized (UNEP 2009). In this light, institutional barriers need to be addressed such as (i) fragmentation and specialization in administration and research [e.g., data and monitoring on ecosystem status and risk are often dispersed across agencies at various scales and are not always accessible at the sub national or municipal level, where land use planning decisions are made (CDKN 2012)], (ii) competition within and between agencies and governments, (iii) overlapping efforts, (iv) narrow focus, (v) lack of standardization, (vi) politically defined management units, (vii) short-term and self-interested politics, and (viii) economic determinism.

Lastly, it needs to be understood that there are many factors that may limit the ecosystem's ability to provide protection against hazards. It is important to note that the nature of the relationship between ecosystems and disaster risk reduction depends strongly on the characteristic of hazard and the type and state of ecosystem – that ecosystem functions are very complex and disaster risk is influenced by many factors (IPCC 2012). It would be necessary, therefore, to consider hybrid solutions such as combining hard engineering with soft ecosystem approaches. As Feagin et al. (2010) note, the use of ecosystems as bioshields is not a panacea for decreasing vulnerability and must be combined with other measures.

8.5 Way Forward and Opportunities in the Post-2015 Development Agenda

The discussion and elaboration of three international frameworks and instruments (i.e., post-2015 framework on DRR, SDGs, and post-Kyoto global climate agreement) provide a unique opportunity to integrate ecosystem approaches to disaster risk reduction into a harmonized post-2015 paradigm. Eco-DRR brings together three distinct communities, environment, DRR, and climate change adaptation, along with their knowledge, expertise, experience, and resources subsequently contributing to multiple development priorities (Renaud et al. 2013). Many groups are starting to recognize the merits of Eco-DRR as a way to link ecosystem management, disaster risk reduction, and sustainable development to achieving environmental, social, and economic goals. To this end, the post-2015 development agenda offers important opportunities for Eco-DRR as discussed below.

Increasing Focus on Environmental and Ecosystem Service Degradation and Climate Change as Underlying Drivers of Risk in DRR Activities. Given the risks posed by climate change and increasing disaster losses globally, Eco-DRR provides an integrated solution for reducing disaster risk through ecosystem management and climate change adaptation. UNEP (n.d.a) summarizes the opportunities for a renewed focus on environment by:

(i) engaging environmental managers fully in national disaster risk management mechanisms;
(ii) including risk reduction criteria in environmental regulatory frameworks;
(iii) assessing environmental change as a parameter of risk;
(iv) utilizing local knowledge in community-based disaster risk management;
(v) engaging the scientific community to promote environmental research and innovation;
(vi) protecting and valuing ecosystem services;
(vii) considering environmental technologies and designs for structural defenses;
(viii) integrating environmental and disaster risk considerations in spatial planning;
(ix) preparing for environmental emergencies; and
(x) strengthening capacities for environmental recovery.

Increasing Understanding of Eco-DRR Through Documentation, Dissemination, and Capacity Development. The lack of awareness and capacity on Eco-DRR often presents a barrier to its uptake. Improving understanding of Eco-DRR requires proper documentation, dissemination, and capacity development. Evidence of Eco-DRR needs to be documented particularly for monitoring and evaluation. To aid the effective implementation, replication, and scaling up of Eco-DRR, information that are well understood and tools that are user friendly need to be developed and disseminated for practitioners and decision makers to learn the value added of ecosystem approaches.

Integration of Eco-DRR into Development Planning. The post-2015 framework for disaster risk reduction is in a strong position to introduce the necessary

changes to enhance current risk management practices in development planning and investment (UNISDR 2013c). Risks to natural capital compromise future wealth (UNISDR 2013d). Achieving well-being and sustained prosperity will require development pathways that respect ecological limits and restore ecosystem health while optimizing the contribution of the environment to economic progress (IRF 2013). One way of doing this is to integrate DRR into existing development instruments and mechanisms and protect ecosystems through employing participatory valuation and management of ecosystem services and mainstreaming of ecosystem approaches in DRR (UNISDR 2013d).

More efforts would be required in building a case for Eco-DRR, improving its evidence base, and linking it to policy. The post-2015 development agenda is expected to put back environment into the limelight along with its multidisciplinary and intersectoral linkages. It would be important for stakeholders especially decision makers to be able to appreciate Eco-DRR for its many benefits as well as its importance in sustainable development.

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