Environmental Guidance Note for Disaster Risk Reduction

Healthy Ecosystems for Human Security and Climate Change Adaptation

Karen Sudmeier-Rieux, Neville Ash and Radhika Murti

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Introduction: Human well-being, healthy ecosystems and disasters

This note was developed to provide guidance on the benefits of and ways **to integrate environmental concerns into disaster risk reduction strategies (DRR) at the local and national levels.** As recognised and outlined within the Hyogo Framework for Action priority 4: "Reduce the Underlying Risk Factors", healthy ecosystems and environmental management are considered key actions in DRR. Although the field of disaster risk management has evolved to recognize the need for addressing sustainable development issues for reducing risk, the environmental dimension has not to date received adequate attention and practical guidance.

The questions we would like to answer with this guidance note are:

- **What are healthy ecosystems and why do they matter to disaster risk reduction?**
- **How can ecosystems contribute to reducing disasters?**
- **What is ecosystem-based disaster risk reduction?**
- **How can we integrate ecosystem management and disaster risk management?**

The rise in number and intensity of many extreme hydro-meteorological events is increasingly recognized as being the result of global and regional climate change. More broadly and importantly, the underlying risk factors of disasters are increasing: more people are living in vulnerable areas, such as low lying coastal areas, steep hillsides, flood plains, near cliffs, or in forested areas on the outskirts of cities – most often out of necessity, but sometimes out of choice. Environmental degradation is reducing the capacity of ecosystems to meet the needs of people for food and other products, and to protect them from hazards. The people affected by reoccurring disasters are often the most dependent on natural resources for their livelihoods, and the appropriate management of ecosystems can play a critical role in their ability to prevent, cope with, and recover from disasters.

Investments in sustainable ecosystem management or sound environmental management can offer **cost-effective solutions to reducing community vulnerability** to disasters. Healthy ecosystems, such as intact forests, wetlands, mangroves, and coral reefs are beneficial to local populations for the many **livelihood benefits** and products that they provide: firewood, clean water, fibre, medicine and food, act as **natural buffers to hazard events** for flood abatement, slope stabilization, coastal protection and avalanche. Additionally, they can complement other structural and disaster preparedness measures, while acting as natural buffers to hazard events, e.g. for flood abatement, slope stabilization and coastal erosion protection. These natural buffers are often **less expensive to install or maintain, and often more effective than physical engineering structures**, such as dykes, levees, or concrete walls. The limited effectiveness of some physical engineering approaches has been dramatically demonstrated by disasters such as Hurricane Katrina in 2005 with the failure of the dyke system established to protect New Orleans. As a result, dams are being torn down and wetlands are being restored along the Mississippi basin to provide an ecosystem-based approach to DRR. The services provided by ecosystems are not an additional luxury, but rather a basic and multi-functional necessity to disaster risk reduction. We support shifting disaster risk management from reaction to prevention and placing sustainable ecosystem management for livelihoods at the center of disaster risk reduction strategies. **Balancing prevention with reaction requires political will**, donor willingness and new strategies, to which we hope this guidance note contributes.

What are healthy ecosystems…

Shelburne Bay,Great Barrier Reef Heritage Area, Australia

Ecosystems contribute to reducing the risk of disasters in multiple and varied ways. Well-managed ecosystems can reduce the impact of many natural hazards, such as landslides, flooding, avalanches and storm surges. The extent to which an ecosystem will buffer against extreme events will depend on an ecosystem's health and the intensity of the event. Degraded ecosystems can sometimes still play a buffering role, although to a much lesser extent than fully functioning ecosystems.

Ecosystems are defined as dynamic complexes of plants, animals and other living communities and their non-living environment interacting as functional units (Millennium Ecosystem Assessment, 2005). They are the basis of all life and livelihoods, and are systems upon which major industries are based, such as agriculture, fisheries, timber and other extractive industries. The range of goods and other benefits that people derive from ecosystems contributes to the ability of people and their communities to withstand and recover from disasters. The term "sustainable ecosystems" or **healthy ecosystems**, implies that ecosystems are largely intact and functioning, and that resource use, or demand for ecosystem services, does not exceed supply in consideration of future generations.

Healthy ecosystems are comprised of interacting and often diverse plant, animal and other species, and along with this, species and genetic diversity, constitute the broader array of biodiversity. **Biodiversity** is the combination of life forms and their interactions with one another, and with the physical environment, which has made Earth habitable for people. Ecosystems provide the basic necessities of life, offer protection from disasters and disease and are the foundation for human culture (Millennium Ecosystem Assessment, 2005) (Figure 1).

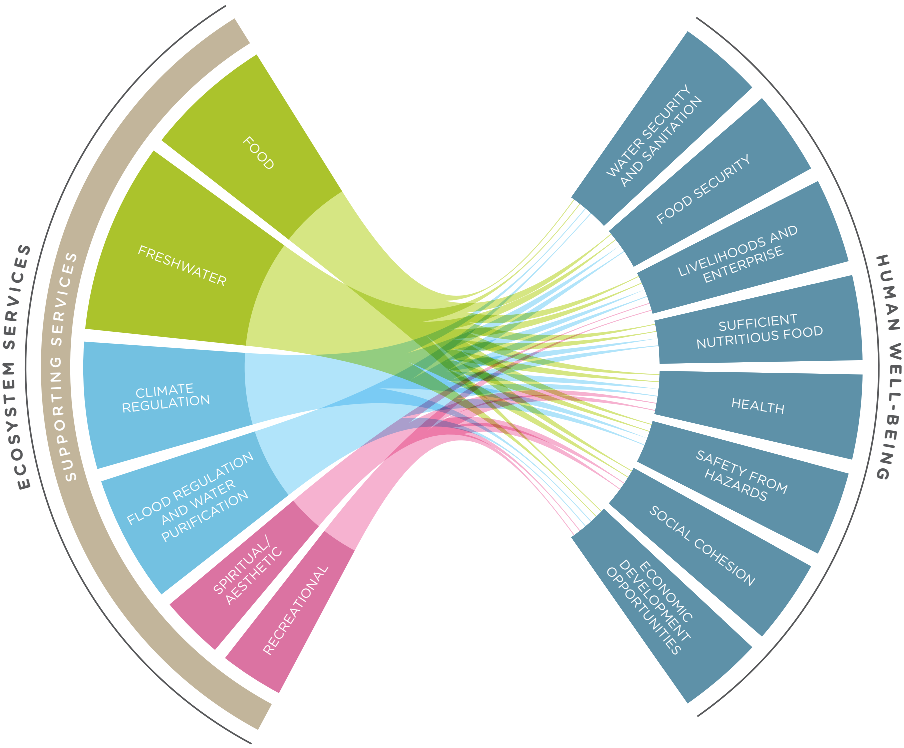

Figure 1. Ecosystem services and human well-being, modified from Millennium Ecosystem Assessment, 2005 © IUCN Water 2012

The benefits that people derive from ecosystems, or "ecosystem services", are often categorised into four types:

- **supporting services:** these are overarching services necessary for the production of all other ecosystem services such as production of biomass, nutrient cycling, water cycling and carbon sequestration;
- **provisioning services:** these are the services we often consider as "ecosystem goods" and products obtained from ecosystems to support livelihoods such as food, fibre, genetic resources, medicines, fresh water;
- **regulating services:** these are the services that offer protection and otherwise regulate the environment in which people live, such as flood regulation, water filtration, pollination, erosion control, disease regulation;
- **cultural services:** these are services supporting spiritual values, aesthetic, educational and recreational needs. (Millennium Ecosystem Assessment, 2005)

BOX 1

Degraded ecosystems reduce community resilience for sustainable development as well as disaster preparedness and recovery.

Pakistan earthquake and landslides, 2007

The Millennium Ecosystem Assessment (MA), a five-year international assessment initiative, clearly demonstrated the strong and varied links between human well-being, human security, livelihoods, health and intangible benefits such as equality and freedom of choice, with ecosystem services. The MA also highlighted that ecosystem degradation is undermining this link due to a number of human activities, mainly:

- **over-exploitation of resources** or higher demand for ecosystem goods than can be sustained, such as overfishing;
- **land use and land cover changes,** or changes to habitats due to conversion to croplands and urbanization;
- **climate change impacts** are affecting ecosystems and exacerbating environmental degradation;
- **invasive alien species** are introduced species that compete and encroach vigorously upon native species, with the potential to degrade ecosystem services and cause severe economic damage;
- **pollution,** from chemical waste and agricultural inputs, has severely degraded many ecosystem services, and continues to act as a major driver of change.
(Modified from Miththapala, 2008)

Ecosystem degradation and loss have led to serious impacts on human well-being: these include reduced availability of goods and services to local communities, increased spread of diseases and reduced economic opportunities. This, in turn, is leading to loss of livelihoods, and reduced food security (Miththapala, 2008).

Healthy ecosystems both reduce vulnerability to hazards by supporting livelihoods, while acting as physical buffers to reduce the impact of hazard events. As such, this “natural infrastructure” is in many cases equally effective in reducing the impact of hazard events, and is often less expensive than human-built infrastructure. Disasters also hamper development goals, and yet few governments, donors and development organizations adopt a precautionary approach in the design and management of development projects, and fewer still recognize the role and value of ecosystem management for reducing disaster risk (UNEP, 2007).

Four reasons why ecosystems matter to disaster risk reduction:

- **Human well-being depends on ecosystems** that also enable people to withstand, cope with, and recover from disasters. There is a two-way relationship between poverty and disasters, with poor communities being subject to greater numbers of disasters, especially in areas where ecosystems are degraded.

- **Ecosystems, such as wetlands, forests, and coastal systems, can provide cost-effective natural buffers** against hazard events and the impacts of climate change.

- **Healthy and diverse ecosystems are more resilient to extreme weather events.** Intact ecosystems are less likely to be affected by, and more likely to recover from, the impacts of extreme events. However, disasters can affect ecosystems through habitat loss and species mortality. Poorly designed post-disaster clean-up efforts can also negatively impact on ecosystems, with negative consequences on progress toward achieving the objectives of the UN Convention on Biological Diversity[1] and Millennium Development Goals.

- **Ecosystem degradation, especially of forests and peatlands, reduces the ability of natural systems to sequester carbon,** increasing the incidence and impact of climate change, and climate change related disasters.

BOX 2

The Hyogo Framework for Action (HFA) Priority for Action 4 on 'reducing the underlying risk factors' advocates the 'sustainable use and management of ecosystems, including through better land-use planning and development activities to reduce risk and vulnerabilities' (UNISDR, 2005). A mid-term review on the progress countries are making for the implementation of HFA was conducted during 2010-2011. The review states that Priority for Action 4 reported the least progress. Moreover it reports that 'there was little mention of' sustainably managing natural resources to successfully reduce risks, by countries.

[1] The Convention on Biological Diversity (CBD) has three objectives: the conservation of biodiversity, the sustainable use of its components and the equitable sharing of benefits from the use of biodiversity. In 2002, the CBD adopted the 2010 Biodiversity Target, to reduce the rate of loss of biodiversity by 2010. The 2010 target was subsequently endorsed at the World Summit on Sustainable Development, and has been incorporated into the Millennium Development Goals, as a target under MDG7 on environmental sustainability.

How can ecosystems contribute to reducing disasters?

Mamberamo River, Papua Indonesia

The negative impacts of climate change and disaster events are more severe on vulnerable people and, at the same time, they are creating greater population vulnerability for those living in the conditions of socio-economic exclusion, including women and children. This is due to increasing **environmental degradation**, populations living in **more exposed areas**, more **extreme weather events** and the **social and governance factors** that affect livelihoods.

Disasters are mainly **social constructs**: they are largely determined by how a **society manages its environment**, how prepared it is to face adversity and what resources are available for recovery. As pointed out by Moser and Satterthwaite (2008), the more assets people have, the less vulnerable they are and the greater the erosion of people's assets the greater their insecurity. Such assets also include the access to healthy ecosystems.

Vulnerable populations are more at risk to disasters – poverty exacerbates vulnerabilities, especially for poor communities that are heavily dependent on ecosystem services for their livelihoods and for physical protection. Therefore, mainstreaming disaster risk and ecosystem management in development planning is likely to make a major contribution to the goal of achieving sustainable and secure livelihoods for the poor.

BOX 3

Broadly defined, the total economic value of ecosystems includes:
Use values

- **Direct values: benefits derived from the use of environmental goods either for direct consumption or production of other commodities**
- **Indirect values: benefits provided by ecosystem functions and services that maintain and protect natural and human systems such as maintenance of water quality and flow, flood control and storm protection**
- **Option values: the premium placed on maintaining an ecosystem service (i.e. a pool of species, genetic resources and landscapes) for future uses**
- **Bequest values: the willingness to pay to ensure that future generations inherit a particular environmental asset.**

Non-use values

- **Intrinsic values: i.e. the value of biodiversity in its own right independent of value placed on it by people.**

(Modified from Emerton and Bos, 2004)

Examples and values of protective ecosystem services:

Regulating flood waters

Wetlands and peatlands provide storage space for flood waters, and there is growing evidence that maintaining vegetation and associated soil structure in local watersheds regulates the flow of rain water into streams and rivers, although this service can be overwhelmed with large-scale rainfall and flooding events (Bradshaw et al., 2007). Sri Lanka's Muturajawla marsh is a coastal peat bog covering over 3,100 hectares and an important part of local flood control as the marsh buffers and regulates flood water discharge into the sea. The annual value of this service was estimated at more than US$ 5 million, or US$ 1,750 per hectare (Emerton and Bos, 2004). Riparian and coastal vegetation also stabilizes shorelines and riverbanks. The costs of losing vegetation along riverbanks has been estimated at up to US$ 425 per meter of bank (Ramsar Convention on Wetlands, 2005).

> BOX 4
>
> **Declining ecosystems are increasing the vulnerability of people to disasters and their inability to absorb related shocks and stresses.** (Emerton, 2006)

Reducing landslides, avalanches and rockfalls

The management of protection forests in the Swiss Alps is approximately 5 to 10 times less expensive than the construction and maintenance of technical measures and studies have demonstrated that along some roads at risk from rock fall, forests can reduce risks for roads considerably (Wehrli and Dorren, 2013). In monetary terms, this risk reduction corresponds to approximately 1,000 USD per ha per year (Wehrli and Dorren, 2013).

Improving coastal management and flood risk reduction

Intact coastal ecosystems - in particular mature, stabilized sand dunes, coral reefs, lagoons, salt marshes and mangroves - play an important role in reducing flood damage during coastal storms (UNEP-WCMC, 2006). As with all forms of flood protection, ecosystems have limits in their capacity to absorb large events, thus healthy coastal ecosystems can be particularly effective in reducing flooding from small- to medium-scale events. In addition to reducing coastal flooding, mangroves provide many other services, such as nursery habitat for fish and other marine species, firewood, building materials and medicine which support the needs of communities for both disaster risk reduction and development (van Eijk et al., 2013).

Drought, sand storm and fire regulation

Wildfires, wind erosion, severe drought are expected to increase worldwide as a result of climate change-induced weather changes. Wind erosion causes severe loss of topsoil, estimated at 161 tons of lost soil annually in Canada alone, and causing significant economic losses (ProAct Network, 2008). Ecosystems can act to buffer the processes of drought and desertification through shelterbelts, greenbelts, hedges and other "living fences". These buffers help break the force of winds, provide shade, stabilize dunes, maintain soil structures, trap water and restore organic material, rendering soil more favorable to agricultural practices. Fire is a natural part of many ecosystems, and can enhance vegetation by controlling invasive plants and enhancing regenerative processes, especially in grazing lands. Where a reoccurring feature, fire is best managed as a part of agro-ecosystems, creating firebreaks and controlling understory vegetation (Goldammer, 1988; ProAct Network, 2008; Stolten et al., 2008).

BOX 5

An analysis of 141 countries in the period 1981 to 2002 found that disasters (and their subsequent impacts) on average killed more women than men, or they killed women at a younger age than men in societies where women's economic and social rights are not protected.
(Neumayer and Plumper, 2007)

BOX 6

On the cost effectiveness of ecosystems as natural buffers to coastal protection in Indonesia

Along Indonesia's coastlines, the value of marine and coastal ecosystems in decreasing vulnerability to risks and disasters accrue mainly through damage costs avoided – and these averted losses are typically substantial. A study in Bintuni Bay, West Papua, valued mangroves at US$ 600 per household per year based on their ability to control erosion.

A variety of values have been calculated for the coastal protection functions of coral reefs in Indonesia, depending on their location: reefs adjacent to sparsely populated areas where agriculture is the main activity have been valued at US$ 829/km (based on the value of agricultural production that would be lost), reefs adjacent to areas of high population densities at US$ 50,000/km (based on the cost of replacing housing and roads) and reefs in areas where tourism is the main use at US$ 1 million/km (based on the cost of maintaining sandy beaches). In total, Indonesia's coral reefs are estimated to have a value of some US$ 314 million for coastal erosion prevention.

When marine and coastal ecosystems are degraded and these important coastal defense functions are lost, high economic costs arise. The value of coastline protection by coral reefs in Wakatobi National Park has been estimated to be worth US$ 473/km. The damage caused to reefs as a result of coral mining in Lombok is calculated to incur net present costs of between US$ 12,000–260,000/km^2 in terms of the resulting increase in coastal erosion. One hotel in West Lombok has spent US$ 880,000 over a seven-year period to restore a 250 m stretch of beach which had been damaged by past coral mining, and more than US$ 1 million has been spent in Bali to protect 500 metres of coastline that is no longer protected by coral reefs.
(Emerton, 2009)

What is ecosystem-based disaster risk reduction?

Ecosystem management is central to building resilience of communities and nations under the Hyogo Framework for Action (HFA), especially HFA priority 4.

Therefore, ecosystem-based disaster management policies, practices and guidelines need to be an integral part of national disaster risk reduction. **Ecosystem-based disaster management refers to decision-making activities that take into consideration current and future human livelihood needs and bio-physical requirements of ecosystems, and recognize the role of ecosystems in supporting communities to prepare for, cope with, and recover from disaster situations.**

Mangroves, providing spawning grounds for numerous fish species, Sri Lanka

Sprats, Sri Lanka

This is of particular relevance to the field of disaster risk management as it is a meeting point for enhanced livelihood security for the poor and long-term management of ecosystems. It is a strategy consistent with the Ecosystem Approach of the Convention on Biological Diversity, for the integrated management of land, water and living resources for human benefits as well as conservation goals (See Annex 1). Ecosystem-based DRR recognizes that ecosystems are not isolated but connected through the biodiversity, water, land, air and people that they constitute and support (Shepherd, 2008). Sustainable ecosystem management is based on equitable stakeholder involvement in land management decisions, land-use trade-offs and long-term goal setting. These are central elements to reducing underlying risk factors for disasters and climate change impacts[2].

[2] *See "Ecosystem-based DRR" (www.iirr.org)*

BOX 7

Indonesia takes steps to integrate environmental and disaster risk reduction policies

Recognizing Indonesia's vulnerability to hazard events and disasters, the 2006-2009 National Action Plan for Disaster Risk Reduction was launched. This important document (also backed up by legislation via the Disaster Management Law No. 24 of 2007) makes repeated mention of the importance of ecosystems and a healthy environment in disaster risk management and reduction. Ecosystem degradation is recognized as one of the major factors, which interact to cause disasters, and the Plan itself includes a series of actions to encourage the sustainable use and management of ecosystems. It demands that "Regions that depend themselves on extractive industry and exploitation of natural and environmental resources are expected to equally invest on the efforts of mitigation, preparedness, response and recovery from disaster impacts that have been or may be caused by those activities". The plan specifically calls for natural resource protection and zoning in coastal and marine areas.
(Emerton, 2009)

How can we integrate ecosystem management and disaster risk management?

Although disaster risk management, ecosystem management, development planning and climate change adaptation (CCA) institutions each have their own specific set of stakeholders, goals and actions, a number of these are interrelated (see Figure 2). They each seek the overarching goal of sustainable development, human well-being and human security. Improved dialogue and specific coordinating mechanisms are being created amongst these spheres, although more effort is needed to achieve greater convergence. Likewise, conservation programmes can benefit by including risk and climate change considerations into project planning and monitoring, for the longer term security of conservation investments.

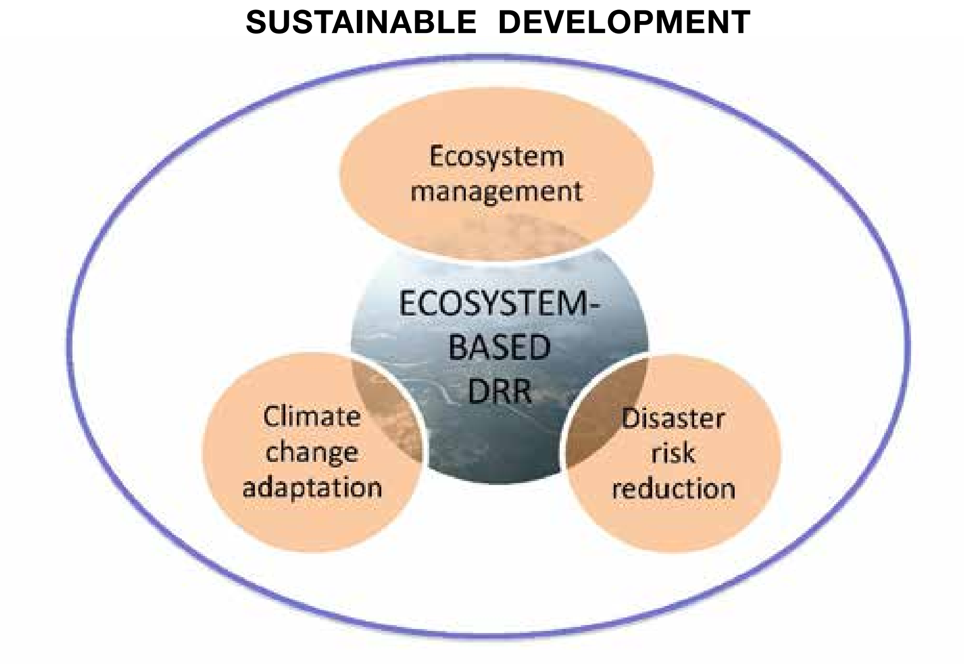

Fig. 2 Ecosystem-based disaster risk reduction, a more sustainable approach to DRR and climate change adaptation (source PEDRR, 2010)

Below are examples of specific actions that can be taken toward bridging the gap between ecosystem-based management and disaster risk management.

Jointly advocating for ecosystem-based DRR and CCA

Ecosystem management for disaster risk reduction (DRR) is increasingly recognized by the international community as a critical approach for enhancing human security. In 2005, the Hyogo Framework for Action (HFA), the first global agreement on disaster reduction, recognized the importance of sustainable ecosystems and environmental management in reducing disaster risk. The 2009 and 2011 Global Assessment Reports on Disaster Reduction (UNISDR) identified ecosystems decline as one of four major drivers of risk and called for greater protection and enhancement of ecosystem services, a message that was further reinforced by the recent IPCC Special Report on Extreme Events, summary for policy makers (IPCC, 2011). Moreover, during the course of UNFCCC negotiations for a global climate agreement and in particular since the Conference of Parties (COP) in Copenhagen in 2009, ecosystem-based approaches have been recognized as a key climate change adaptation strategy. Sustainable ecosystem management is therefore increasingly viewed as an effective approach for achieving both DRR and climate change adaptation (CCA) priorities. The World Bank, for example, recommends that adaptation programmes integrate an ecosystem-based approach into vulnerability and disaster risk reduction strategies.

Giving explicit consideration to ecosystem-based DRR

Many countries have already recognized the need for legislation and zoning regulations that support sustainable development and environmental principles. However, where legislation often fails is in the implementation and enforcement, leading the way for unsustainable and risk-building practices, such as locating housing in dangerous places. Policies and financial incentives can be offered for investing in ecosystem protection, such as "Payments for Ecosystem Services", or through new carbon market and other schemes such as REDD[3], which aim to reduce environmental degradation. Incorporating environmental concerns into contingency plans for disaster response is intended to follow the principles of "do no harm" to long-term recovery (i.e. improper waste management practices that pollute waterways, or locating transitional shelters and settlements in floodplains or elephant pathways) and aim to rebuild back better.

Appropriate national and local governance and policies:

- **Recognize the value of ecosystems** as necessary for disaster risk reduction;
- **Grant relevant legal authority** to environmental, planning and disaster management agencies to coordinate and enforce sustainable environmental DRR policies and procedures;
- **Seek to integrate national adaptation processes**, such as NAPAs with DRR and environmental national strategies, including through encouraging the establishment of cross sectoral coordination mechanisms or platforms;
- **Encourage new financial incentives** for investments in sustainable ecosystem management that emphasize ecosystems as part of disaster risk planning, possibly financed through payments for ecosystem services.

[3] *REDD: Reducing Emissions from Deforestation and Degradation in Developing Countries*

Implementing environmental monitoring and enforcing sustainable land use planning

Progress can be made by integrating land use planning and environmental monitoring into disaster management such as maintaining wetlands for flood risk reduction. Environmental monitoring implies maintaining baseline data on ecosystem health and tracking trends in environmental degradation, such as deforestation and drought, and restoration. Integrated risk assessments can be designed as a useful tool to couple physical risk, vulnerability and environmental assessments. They go beyond the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) processes, which are conducted for new development projects.

BOX 8

Payments for ecosystem services
These financial mechanisms are increasingly being used successfully to finance ecosystem conservation and restoration. Examples include payments to a community to maintain forest cover in sensitive water recharge areas, or on steep slopes to reduce the occurrence of landslides or downstream flooding.

The beneficiary community or other third party would pay for the benefits generated.
(IUCN-UNEP, 2007)

Integrated mechanisms and procedures are useful to:

- **Promote and enforce integrated land use (spatial and temporal) planning and zoning** that include protection of ecosystems (e.g. Integrated Coastal Zone Management, Integrated Water Resources Management, and forest management plans) and risk assessments;
- **Conduct environmental monitoring and assessments** (ecosystem baseline data, EIAs, SEAs for new development projects and programmes);
- **Conduct integrated risk assessments** (coupling physical risk, vulnerability and environmental assessments);
- **Implement ecosystem restoration and rehabilitation** that follow clear technical guidance and match local needs and priorities;
- **Incorporate environmental safeguards** into disaster emergency response plans, such as Rapid Environmental Assessments (see checklist below).
  (Modified from UNEP, 2009)

Engaging with stakeholders

Ecosystem management practices are the most successful when they involve communities as stakeholders and land stewards, such as community-managed marine protected areas, or community forest user groups. These environmental management mechanisms can become especially relevant and effective for disaster risk reduction if they incorporate disaster risk assessments. To achieve this, there is a need to put into place mechanisms for consultations between environmental, planning and disaster management authorities. It is important to:

- **Build dialogues and mechanisms** for collaboration between environmental, planning and disaster risk management authorities and people affected by the decisions;

- **Include communities**, especially women, minorities and people with disabilities in designing and implementing the above procedures.

Knowledge creation and exchanges

Capacity-building through awareness-raising, education and training are critical to changing attitudes and behaviors toward more sustainable environmental practices. As an example, ecosystem rehabilitation and restoration can be options in the aftermath of a disaster or to safeguard against new ones. However, successful ecosystem rehabilitation requires time, knowledge, resources, appropriate technical advice and should be conducted in consultation with communities, and based on local needs and priorities especially when natural restoration may be the most effective option.

Awareness raising, education, training and knowledge exchange can help to:

- **Promote new knowledge** creation and sharing among scientists, practitioners and communities;
- **Recognize, support and preserve the value of local practices and knowledge**, much of which promotes ecosystem based approaches;
- **Recognize the special role that women play** as agents of change and stewards of natural resources and as being highly affected by extreme events.

BOX 9

Ten years after the Indian Ocean tsunami - lessons learned from Sri Lanka

- **Beach clean-up efforts led to the spread of invasive species, notably prickly pear *(Opuntia humifusa)*;**
- **Dumping of debris from the cleanup into waterways and wetlands created pollution and drainage problems that hampered long-term recovery;**
- **Several transitional settlements were located in elephant pathways and near waterways, creating animal-human conflict and pollution of drinking water;**
- **In some instances, sand dunes and coral reefs that protected coastal communities from the tsunami's full impact were used for building materials, thereby reducing coastal protection;**
- **Better coordination and information flow between environmental authorities, NGOs and disaster management authorities could have avoided several of these pitfalls;**
- **Women died and were affected in much larger numbers, likely due to restricted clothing and lack of swimming skills;**
- **Boats were improperly distributed post-tsunami, creating social tension and lasting development problems;**
- **Mangrove restoration efforts have largely failed due to improper planting procedures, lack of community involvement and planting in the wrong places;**
- **A positive outcome of lessons from the tsunami is the "Sri Lanka Road Map" for disaster risk management, which includes several provisions for integrating environmental considerations into disaster risk reduction planning and operations.**

(Modified from Miththapala, 2008)

Pre-disaster:

- Prevention, mitigation and preparedness stages should ensure that proper **environmental practices are followed that value and restore ecosystems**, especially wetlands, coastal ecosystems and forests on steep slopes as natural buffers. Specific projects may include wetland restoration, tree planting, and restoring coastal open spaces.

- Disaster risk reduction planning should include **coordination with environmental ministries**, in addition to disaster management and land use planning authorities.

Bururi Province, Burundi

- Ensure that existing legislation is being followed and enforced, especially related to **zoning and land-use planning**, for example respecting coastal buffer zones and proper road building in mountainous areas to avoid landslides; and ensure that land use planning **is not damaging to ecosystems and human well-being**.

- **Conduct education and training about the role of ecosystems** and their multiple benefits for protection and human well-being.

Post-disaster:

- Response, recovery and rebuilding stages progress from quick relief for saving lives to short and medium-term planning of housing and livelihood solutions. Basic **environmental concerns must already be integrated into each of these stages** while planning, following the goal of "reducing the underlying risk factors". Basic environmental considerations can be included in contingency plans and standard disaster response procedures in order to avoid potential damage that can be incurred and impede long-term recovery.

- **Minimize pollution and make waste management effective**; ensure that waste does not contaminate waterways or wetlands areas and hazardous waste materials is secured.

- **Locate transitional shelters and settlements[4] away from sensitive ecosystems** and from areas that may put people in harms way (such as floodplains, wetlands and animal habitats) while providing adequate sanitation facilities.

- **Take care that building material is sustainably sourced** and does not lead to further degradation of critical ecosystem functions. (e.g. not mining coastal sand dunes, mangroves, or coral reefs to rebuild houses).

[4] *For more information see: (www.sheltercentre.org)*

- **Rehabilitate damaged ecosystems with native species when suitable and prevent the spread of invasive alien species**; these are non-native species that can invade habitats and agricultural land.

- Special provisions should be made for women, children and other vulnerable populations, according to Sphere Handbook Charter[5].

- **Rapid Environmental Assessments**[6] are useful to assessing the environmental situation post-disaster in a quick and low cost manner for more effective immediate and long-term recovery planning.
  (Modified from Miththapala, 2008)

BOX 10

Key actions for ecosystem-based DRR

Watersheds, forests and coastal zones are naturally linked – for example without adequate upstream forest cover, sedimentation can create severe downstream pollution and damage to coastal vegetation and coral reefs.

Watershed management
Watershed management is necessary for agricultural, environmental and socioeconomic development. The physical and biological resources of watersheds provide goods and services to people, including water protection, attenuation of disasters by regulating runoff, protection of coastal resources and fisheries, protection of the environment and protection of productive lowlands. Watershed management programs need to build on existing environmental initiatives.

- **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;**
- **Intensive agricultural activity should not to be permitted on slopes greater than a specified percentage reflecting land stability;**
- **Clear cutting of forests should be limited with forest conservation and sustainable forest management prioritised;**
- **Institutional bodies, such as River Basin Organizations should be formally established to address land use conflicts, and staff trained in conflict-resolution;**
- **Public participation of both men and women should be increased in management decisions;**
- **Effective management plans and enforcement of environmental and zoning regulation are critical;**
- **Regional environmental impact assessments are needed to ensure that cumulative impacts of economic activities are sustainable.**

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[5] *(www.sphereproject.org)*
[5] *(www.abuhrc.org)*

Forest management

Forest management is required to balance 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. Although listed separately here, forest management is often integrated into watershed management.

- **Protect and improve the forest environment through increased vegetation;**
- **Help alleviate poverty by generating income through increased tree cover and related activities;**
- **Increase forest resources;**
- **Establish community-driven economic activities based on forest plantation;**
- **Increase multiple uses for land;**
- **Create popular awareness about sustainable forest management.**

Coastal zone management

Ecosystems such as coral reefs and coastal mangrove forests can adapt to change and recover from storms and floods and still provide services of protecting the coast and absorbing pollution. But once these ecosystems are put under pressure by coastal development, they may lose their resilience. Coastal zone management strategies being considered in the Asia-Pacific region after the 2004 tsunami highlighted the continuum of inland areas, coasts, and oceans. Below are some key entry points.

- **Replant coastal forests and restore mangroves, which have been taken up as a part of the environmental recovery process;**
- **Restore and maintain the health of the coral reefs and seagrass beds, through reducing pressure from pollution, overfishing, sedimentation, etc.;**
- **Maintain and/or develop mangrove belts as buffer zones for coasts and coral reefs;**
- **Protect wetlands and watersheds to minimize sedimentation.**

(Modified from DEWGA, 2008)

An island village, Fiji

Case study: Protection forests in Switzerland

Alpine protection forest

Mountain hazards: landslides, debris flow, rock fall and avalanches

Hazardous processes such as rockfall, snow avalanches, erosion, landslides, debris flows and flooding are frequent in the Alps. Many forests in the Alps protect people and their assets from mountain hazards which explains the relatively high proportion of protection forests in many alpine regions (Brang et al., 2001). Protection forests play a key role in integrated risk management, as they have the capacity to reduce risks to acceptable levels at relatively lower costs (Wehrli and Dorren, 2013). The management of protection forests is approximately 5 to 10 times less expensive than the construction and maintenance of technical measures and studies have demonstrated that along some roads at risk from rock fall, forests can reduce risks for roads considerably (Wehrli and Dorren, 2013). In monetary terms, this risk reduction corresponds to approximately 1,000 Swiss francs per ha per year (Wehrli and Dorren, 2013).

The goal of protection forest management is to ensure that a forest is as effective as possible in reducing potential damage due to hazards. Currently, Switzerland invests approximately 160 million Swiss Francs per year in protection forest management (FOEN, 2012). The measures taken include nationwide delimitation of protection forests, silvicultural interventions and subsequent success monitoring. In many Alpine countries, the silvicultural interventions in protection forests are carried out following specific guidelines (Wehrli and Dorren, 2013).

Lessons learned:

- Protection forests are a key factor in integrated risk management in the Alps, since they provide effective prevention and mitigation at relatively low cost;
- Political support is key for ensuring the financial support needed for an effective and efficient nationwide protection forest management program;
- Protection forests need to be identified and subsequently managed in a sustainable way, based on guidelines. These guidelines have to be based on the current state of knowledge and need to be conceptually sound. Consequently, they should continuously be subjected to critical review and revision.

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http://www.bafu.admin.ch/org/organisation/00180/00193/index.html?lang=en

http://www.foresteurope.org/sfm_criteria/criteria/protective-functions

Integrating Wetland Ecosystem Values into Urban Planning: The Case of That Luang Marsh, Vientiane, Lao PDR

That Luang Marsh, Lao PDR

Situated on the outskirts of Vientiane City, the That Luang Marsh is one of the largest urban wetlands of the city, providing a wide range of economically valuable goods and services, including fisheries, farming and natural resource collection activities, flood attenuation, maintenance of water quality and supply, and treatment of domestic, agricultural and industrial wastes.

Although there have been considerable improvements to the drainage system since it was initially assessed by JICA in 1990, the city of Vientiane still experiences substantial urban drainage problems. Drainage of storm water from the urban area is restricted to gravitational flow and by downstream flow conditions. There are currently 175 flood prone areas within the city limits, 70 of which are located in the city's core area. Flooding occurs at least 6 times a year but in many cases flood prone areas will flood every time it rains.

According to the current system for drainage in Vientiane, That Luang Marsh acts as a regulating basin for drainage, with a projected annual value of flood damages avoided by the year 2020 amounting to $US 2,842,000, while the estimated annual value of water sanitation services provided by That Luang Marsh is $US 70,088 (Gerrard, 2004). Future damage was estimated on the basis of land use projections and the unit value of damage potential, while the unit value of damage potential in each year was calculated by adopting the growth rate of the Gross Regional Domestic Product of Vientiane Municipality (GRDP).

Lessons learned:

- The goods and services associated with That Luang Marsh, both direct and indirect, are worth just under $US 5 million to people living around the marsh and in Vientiane City, with direct benefits of estimated at 40% of the total value of the wetland.
- The loss of these resources would have large implications for local communities, and in particular poorer households relying on wetland products.
- The high value of the wetland services provided by That Luang Marsh demonstrate the importance of incorporating these functions into urban planning and capitalizing on wetland services.

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Case study Netherlands

1995 flood in Netherlands

Room for the River programme, Netherlands

Being located in a river delta, The Netherlands is one of the most experienced countries in flood-protection measures. However extensive flooding in 1993 and 1995, compounded by implications of the centuries old “command-and-control” environmental management approaches, instigated a shift in water management policy. The Room for the River Programme, established in 2007, aims to bring back the natural river flood plains and wetlands to act as buffer capacities in case of increased river water levels.

Measures undertaken include: relocating dykes further inland to widen floodplains, modifying dykes in certain areas to allow for flooding, reducing the height of groynes to allow water to flow more quickly, creating side channels as alternate routes for high water, deepening the river bed, removing obstacles from the river that obstruct flow, creating temporary water storage areas and strengthening dikes in densely populated areas.

The estimated cost of the overall programme including planning stages is 2163 million euros, of which 472,1 million is allocated to the modification of existing infrastructure and compensations to farmers for water storage - either annual compensation for damage to crops or a single benefit for the decrease of the value of the land. Retention areas can additionally create additional income for farmers, e.g. by deploying these areas for recreation, nature development and management, and as water stocks for the fruit growing sector to combat night frost in spring.

Lessons learned:

- ´Room for the River´ programme is considered an effective response to accommodating the uncertainties of climate change in relation to flooding as it provides more adaptive and sustainable risk management solutions;
- ‘Room for the River’ requires a watershed or river basin approach where the river is allowed space for excess water retention;
- Such programmes are likely to be most successful where a favourable legal and political environment approves the high cost of measures and compensation payments required.

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Coastal hazards: sandstorms, windstorms, tsunami, storm surges
Case Study: Forests of Japan


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Coastal forests of Sendai, Japan.

Since in the 17th century, Japan's coastal forests were established to protect coastal communities and infrastructure from sand storms, winds, salt damage, storm surges and tsunamis (Shaw et al., 2012). Today, Japan's coastal forests, mostly Japanese black pine cover a total of 1,640 km2 across country's coastline. These forests are also of great significance to the coastal communities' cultural heritage and identity. Japan's Forest Law specifically states that Disaster Risk Management (DRM) forests should be planted along the coast to prevent damages from coastal hazards. Furthermore, the Government of Japan has prioritized replanting of coastal forests as ecosystem-based measures to complement other engineered and soft solutions (Renaud and Murti, 2013).

Lessons learned from the Great East Japan Earthquake (GEJE) and tsunami of March 2011:

- Coastal forests cannot mitigate disasters of extreme magnitudes yet can be effective for frequently occurring smaller events such as windstorms and sand storms.
- Uprooted pine trees from the coastal forests increased wave impacts and caused more damage as they were the first debris to hit houses. Many of these trees were planted in areas (such as shallow mounds) where they could not establish comprehensive root systems. Therefore proper planting and management of trees as well as species selection are critical factors.
- However, coastal forests acted as filters for secondary debris (such as fishing boats) and also helped in saving lives (people were able to hold on to the trees).
- The rice paddies that were protected by the coastal forests were less damaged when compared to exposed paddies.
- In specific cases the forests, hills and rocky cliffs contributed to changing the tsunami path, redirecting waves and reducing wave energy.
- In combination with land use planning/zoning, higher seawalls, water channels and deeper river beds (to hold more water), coastal forests can provide an effective option for multiple defenses to tsunamis. (Renaud and Murti 2013)

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How can we measure the implementation of ecosystem management for disaster risk reduction and climate change adaptation?

Flood in Shagarab, Eastern Sudan

What are indicators?
The term "indicators" refers to data of a quantitative or qualitative nature which can provide and communicate scientifically robust measures of the status or change in condition. They indicate the current status and any changes in a process or a system with respect to a given aspect of interest. An indicator is a pointer. It can be a measurement, a number, a fact, an opinion or a perception that points to a specific condition or situation, and measures changes in that condition or situation over time. Indicators facilitate a close observation about the results of initiatives or actions, and help to simplify the presentation of complex situations. They are very important tools to evaluate and follow up DRR processes, and are valuable tools to help achieve better results in projects or initiatives. A good indicator is considered SMART (Specific, Measureable, Achievable, Relevant and Timely), in addition to being clearly understandable.

Several types of indicators
Qualitative indicators are measures that refer to qualities. They deal with aspects that are not directly quantifiable, opinions, perceptions or judgments from people about something, such as people's reliance on their boats as an instrument of economic independence. On the other hand, **quantitative** indicators are measures that directly refer to numbers or amounts, such as the number of women who own boats in a community. Each type of indicator - qualitative and quantitative - expresses different, complementary, needed dimensions about the situation of interest (modified from Aguilar, 2009).

Progress or results indicators convey whether tangible results are being achieved, and **process indicators** indicate about the state of a process, such as stakeholder dialogue. The difference between the two may be time dependent. For example, a training workshop on environmental legislation and DRR in the short term may lead to attitude changes among participants and a process toward new legislation may be undertaken. Real progress resulting in new legislation and implementation mechanisms may take much longer and is dependent on other factors although the impetus may have come from the initial workshop.

Purpose and caveats of the suggested "Indicators for Ecosystem-based DRR"
We have suggested these indicators to offer guidance on example areas to focus policy and resources in order to make progress on achieving HFA priority 4, "Reduce underlying risk factors" and in particular, "Sustainable ecosystems and environmental management". The indicators are both qualitative and quantitative, and mainly process-oriented. Caveats of the proposed (and any) indicators are multiple. They need to be configured to the local context in order to become SMART; they are not universal; they will not always apply to

all countries, at all scales; they may not adequately reflect cultural considerations and specific contexts. However, the following list of indicators is intended to provide guidance for integrating ecosystem management into disaster risk reduction policies and practices, a dimension that has not received adequate attention and practical guidance to date.

The suggested indicators can be used for further defining and refining nationally and locally relevant indicators. They have also been classified according to disaster risk management, vulnerability related, policies, operational mechanisms, knowledge and education, human well-being, ecosystem services, drivers of threats to ecosystem services and characteristics of disaster-resilient communities.

Important work has already been conducted in developing and testing relevant indicators for sustainable development and human well-being, ecosystem health, ecosystem services and disaster management. We have drawn on many of these sources (see section "Resources") to develop this list of indicators relevant to ecosystem-based disaster risk reduction.

Examples of indicators for use in ecosystem-based disaster risk reduction	
1.	Risk identification indicators
1.1	Systematic inventory of disasters and losses, including small events
1.2	Hazard monitoring and mapping
1.3	Vulnerability and risk assessments take into account monitoring of ecosystem conditions, ecosystem services and threats to ecosystems
2.	Policy indicators linking ecosystem-based management to DRR
2.1	National platforms for DRR, HFA focal point and other national disaster risk institutions include environmental and planning ministries in decision-making and implementation
2.2	Legislative mechanisms effectively incorporate sustainable land use planning into DRR legislation
2.3	Zoning regulations take into account specific ecosystem considerations and enforcement
2.4	Cross-sectoral mechanisms effectively incorporate sustainable land use planning into DRR legislation
2.5	NAPAs and National Adaptation plans include DRR and sustainable environmental management actions
2.6	National Biodiversity Strategies and Action Plans include DRR considerations

2.7 National resources-related policies and environmental legislation (forestry plans, integrated coastal zoning management plans, etc) include and implement risk assessments
2.8 National Sustainable Development Strategies include and implement risk assessments
2.9 Public and private infrastructure investments that include enforceable EIAs and risk assessments
2.10 Financial incentives in the form of tax rebates, subsidies and other monetary and non-monetary rewards are for investments in ecosystem restoration and sustainable environmental management that emphasize ecosystems as part of disaster risk planning
2.10 Renewable energy policies are enacted and financial incentives are developed

3. Ecosystem-based management and DRR

Risk assessments are integrated into:

3.1 Integrated Water Resources Management programmes
3.2 Integrated Coastal Zone Management programmes
3.3 Protected Areas Management
3.4 Community Conservation Areas – these include local communities in ownership of conservation projects
3.5 Community-managed Marine Protected areas
3.6 Forest management plans
3.7 Integrated Forest Fire Management
3.8 Forest landscape restoration areas
3.9 River basin organizations for improved river management through stakeholder involvement
3.10 Livestock management – establishment of grazing practices
3.11 Fisheries management – establishment of quotas and regulations
3.12 Water management – equitable pricing and distribution schemes

4. Knowledge, participation and education

4.1 Public information and community participation are part of risk assessments
4.2 Non-state actors are involved in dialogue and implementation of DRR at the national and local levels, including civic groups, environmental, humanitarian and development agencies
4.3 Disaster practitioners and environmental managers are trained in integrated risk assessment, which include ecosystem management
4.4 Primary school children are educated in disaster preparedness and environmental stewardship

5. Human well-being and human security: reducing exposure to disasters and vulnerability

Many excellent human well-being and human security indicators have already been developed, including from the following sources:

U.N. Commission on Sustainable Development indicators
Human Development Index
Human Poverty Index
Gender-related Development Index
Governance Index (Kaufmann)
Prevalent Vulnerability Index (Inter-American Development Bank)

6. Ecosystem health indicators by ecosystem type

6.1 General
6.1.1 Changes in native species richness
6.1.2 Abundance of selected key species
6.1.3 Number of threatened species
6.1.4 Number and area of protected areas
6.1.5 Number and spread of invasive alien species
6.2 Agro-ecosystems/forests
6.2.1 Percent of land use changes
6.2.2 Proportion of land area covered by forest and vegetation
6.2.3 Percent of land degradation
6.2.4 Arable and permanent cropland area
6.2.5 Reduced dependency on fertilizer and pesticide use
6.2.6 Proportion of land area covered by forest
6.2.7 Percent of area under sustainable forest management
6.3 Wetlands/rivers
6.3.1 Percent of area maintained as wetlands
6.3.2 Riverbank vegetation maintained
6.3.3 Water quality and turbidity
6.4.4 River fragmentation
6.4 Water
6.4.1 Drinking water quality
6.4.2 Bathing water quality
6.4.3 Proportion of total water resources used
6.4.4 Water use intensity by economic activity
6.4.5 Wastewater treatment
6.5 Coastal/Marine
6.5.1 Area of healthy seagrass beds and marine algae
6.5.2 Proportion of marine area protected
6.5.3 Health of marine ecosystems, as measured by marine trophic index

6.5.4 Coverage of live coral reef ecosystems
6.5.5 Area of healthy mangroves as buffer zones as measured by area, density and width

7. Threats to ecosystems are monitored

7.1 Climate change impacts
7.2 Conversion of ecosystems for urbanization and agriculture
7.3 Fragmentation of habitats
7.4 Slash and burn agriculture
7.5 Over-harvesting of forest products
7.6 Desertification
7.7 Industrial logging/illegal logging
7.8 Over-grazing/cattle ranching
7.9 Invasive alien species
7.10 Soil erosion
7.11 Eutrophication: overuse of fertilizers

Sources:
IUCN internal review (2009)
U.U. Commision on Sustainable Development (2007)
Cardona, Inter-American Development Bank (2005)
Millennium Ecosystem Assessment (2005)
Convention on Biological Diversity
Environmental Vulnerability Index (2004)

El Cangrecal river, Honduras

Conclusions and future perspectives

Increasing numbers of extreme events causing casualties and affecting populations are climate change-related. As highlighted by several influential policy documents, climate change is exacerbating already existing risk factors, including ecosystem decline. "If the underlying drivers of risk are addressed then climate change impacts could also be addressed" (UNISDR, 2009; IPCC, 2012). Thus, the risk of suffering from any particular disaster depends on the size and frequency of the hazard event but even more on the **vulnerability of people, often linked to environmental degradation and governance issues.** Disasters are not caused by extreme events themselves, but occur when a society's capacity to cope with an extreme event is overwhelmed or mismanaged. For these reasons, the term "natural disaster" is now considered a misnomer (Hewitt, 1997; Wisner et al., 2004; Abramovitz et al., 2002).

Unfortunately, available economic statistics on disasters do not reflect lost agricultural land and livelihoods in developing countries. While in recent years studies such as FAO (2012) have attempted to address this information gap, the more common and chronic disasters - shallow landslides, recurring flooding, rising seawaters, drought and impacts of invasive species - have the greatest impact on poor populations. These small, cumulative disasters are commonly those grounded in land use and pressure on natural resources, and are therefore most easily addressed through appropriate ecosystem management.

Even if the number and frequency of extreme events increases, the magnitude of disasters can be reduced through adopting **integrated approaches that combine development processes, disaster risk reduction measures, and ecosystem management**. Sustainable disaster risk reduction needs to combine risk-sensitive land use planning with ecosystem management as a cost-effective alternative and complement to physical engineering structures. We consider this guidance note to be one contribution of practical ideas and indicators for how to shape an integrated approach to disaster risk reduction. The *Environmental Guidance Note for Disaster Risk Reduction* is work in progress that will evolve with new experiences, success stories, lessons learned and good practices. However we are convinced that rather than controlling nature, which has all too often been the approach in the past, we have learned that we must work with nature if we are to keep ourselves safe while facing increasingly hazardous times.

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Annex 1

International environmental frameworks, conventions and agreements relevant to DRR Risk Management Indicators

UNESCO World Heritage Convention (Paris, 1972)

Convention Concerning the Protection of the World Cultural and Natural Heritage. Established **by parties to protect cultural heritage and natural heritage from damage and destruction**, including those caused by disasters.

Agenda 21 (1992)

Adopted by 168 countries in 1992, establishes sustainable development as a main policy goal. Especially relevant to disaster risk reduction is Chapter 7: Promoting Sustainable Human Settlement Development, which refers to developing a "**culture of safety**" in all **countries, especially those that are disaster-prone** (paragraph 7.60).

Convention on Biological Diversity (1992)

The Convention on Biological Diversity (CBD) was ratified by 190 Parties. In decision VI/26 (2002), the COP adopted the Strategic Plan for the CBD. This so-called 2010 Biodiversity Target was subsequently endorsed by the World Summit on Sustainable Development and the United Nations General Assembly at the 2005 World Summit. The Summit also highlighted the essential role of biodiversity in meeting the Millennium Development Goals (MDG), and the 2010 Biodiversity Target has been incorporated into the MDGs. Of relevance here is the focal area within the 2010 target of: **maintaining ecosystem integrity, and the provision of goods and services provided by biodiversity in ecosystems, in support of human well-being.**

Convention to Combat Desertification (1994)

Relating specifically to drought, Part II of the Convention (on General provisions), paragraph 2, states that: "In pursuing the objective of this Convention, the Parties shall: (d) promote cooperation among affected country Parties in the fields of **environmental protection and the conservation of land and water resources**, as they relate to desertification and drought."

UNFCCC (1994) and Kyoto Protocol (1997)

The Convention notes that Parties should take whatever actions are necessary, i.e. funding, insurance and the transfer of technology, to meet the specific needs and concerns of developing countries, which will have to cope with the adverse effects of climate change **especially countries with areas prone to natural disasters** (article 4: Commitments, paragraph 8).

Hyogo Framework for Action (2005)

Since its adoption the "Hyogo Framework for Action 2005-2015: Building the resilience of Nations and Communities to Disasters", has led to many countries revising their policies to put disaster risk reduction at the top of their political and development agendas. The Hyogo Framework includes in section B (Priorities for action), section (4) on reducing underlying risk factors, which states: "(i) Environmental and natural resource management (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**."

Ramsar convention (1971)

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Resolution IX.9 (COP 9, Kampala, Uganda, 2005): The role of the Ramsar Convention in the prevention and mitigation of impacts associated with natural phenomena, including those induced or exacerbated by human activities Para 14: "ENCOURAGES Contracting Parties and River Basin Authorities to ensure that **wetland ecosystems are managed and restored, as part of contingency planning, in order to mitigate the impacts of natural phenomena such as floods, provide resilience against drought in arid and semi-arid areas**, and contribute to wider strategies aimed at mitigating climate change and desertification and thus reduce the incidence or magnitude of natural phenomena induced or enhanced by such change."
(Modified from Stolten et al., 2008)

Annex 2

Selected tools and resources related to environment and DRR

Asian Disaster Preparedness Center
- Community based DRM tool

(http://www.adpc.net/2012/)

CARE International
- Community Vulnerability Capacity Assessment Tool

(www.care-international.org)

Center for International Climate and Environment Change – Oslo *(www.cicero.uio.no)*

Global Fire Management Center *(www.fire.uni-freiburg.de)*

International Institute for Sustainable Development/ Intercooperation/IUCN/SEI
- CRiSTAL (Community Risk identification Screening Tool for Adaptation and Livelihoods)

(*www.cristaltool.org*)

International Federation of Red Cross and Red Crescent Societies
- Vulnerability and Capacity Analysis

(www.ifrc.org/what/disasters/resources/publications.asp)

Intergovernmental Panel on Climate Change, Special Report on Extreme Events (http:ipcc-wg2.gov/SREX/)

International Union for Conservation of Nature
- Integrating Environmental Safeguards into Disaster Management, Vol. 1 and Vol. 2 and Training module

(http://cmsdata.iucn.org/downloads/integrating_environmental_safeguards_into_disaster__management__vol_1.pdf)
(http://cmsdata.iucn.org/downloads/integrating_environmental__safeguards__into_disaster_management_vol_2.pdf)
(http://cmsdata.iucn.org/downloads/integrating_environmental_safeguards_into_disaster_management_vol_3.pdf)

- Ecosystems, Disasters and Livelihoods: An Integrated Approach to Disaster Risk Reduction
(www.iucn.org/about/union/commissions/cem/cem_resources/?340/Ecosystems-Livelihoods-and-Disasters)
- Strengthening Decision-Making Tools for Disaster Risk Reduction, a case study from Northern Pakistan
(www.iucn.org/about/union/commissions/cem/cem_resources/?1663/Disaster-Risk-Livelihoods-and-Natural-Barriers-Strengthening-Decision-Making-Tools-for-Disaster-Risk-Reduction)

Island issues *(www.islandvulnerability.org)*

La Red *(www.desenredando.org)*

Partnership for Environment and Disaster Risk Reduction (PEDRR)
(www.pedrr.net)

Pro Act Network *(proactnetwork.org)*

Risk RED *(www.riskred.org)*

Stockholm Environment Institute *(www.sei.se)*

United Nations Environment Programme *(www.unep.org/conflictsanddisasters)*

United Nations University-Environment and Human Security *(www.ehs.unu.edu)*

United Nations International Strategy for Disaster Reduction
(www.preventionweb.org)

World Wildlife Fund

- Natural Security, Protected Areas and Hazard Mitigation, 2008

(www.panda.org/what_we_do/how_we_work/conservation/forests/news/?uNewsID=133901)

Indicators and indices

Characteristics of disaster resilient communities
(www.proventionconsortium.org/?pageid=90)

Convention on Biological Diversity (www.cbd.int)

Environmental Vulnerability Index, UNEP/SOPAC
(www.vulnerabilityindex.net/Files/EVI%20Descriptions%202005.pdf)

European Union Habitats Directive
(http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm)

Inter-American Development Bank
(http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1481595)

Millennium Ecosystem Assessment *(www.millenniumassessment.org)*

OECD Key Environmental Indicators
(www.oecd.org/dataoecd/32/20/31558547.pdf)

U.N Commission on Sustainable Development
(www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf)

Open-air school, post-earthquake Pakistan

Women bringing cabbages to market, Nepal

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