Integrating Environmental Safeguards into Disaster Management: a field manual

Volume 1: Reference material

Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

Integrating Environmental Safeguards into Disaster Management: a field manual

Volume 1: Reference material

Integrating Environmental Safeguards into Disaster Management: a field manual

Volume 1: Reference material

Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

This document was produced under the project 'Rehabilitating coastal ecosystems in a post-tsunami context: Consolidation Phase' carried out with financial support from the Autonomous Organisation for National Parks (*Organismo Autónomo Parques Nacionales* - OAPN) of the Ministry of Environment of Spain. The designation of geographical entities in this technical report, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of IUCN or OAPN concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The views expressed in this publication do not necessarily reflect those of IUCN or OAPN.

Published by: Ecosystems and Livelihoods Group Asia, IUCN, International Union for Conservation of Nature and Natural Resources.

Citation: Miththapala. S (2008). Incorporating environmental safeguards into disaster risk management. Volume 1: Reference material. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii + 130 pp.

ISBN: 978-955-8177-86-0

Cover Photo: © Earthquake damage in Pakistan, 2005 © Karl Schuler/IUCN

Design: Sriyanie Miththapala

Produced by: Ecosystems and Livelihoods Group Asia, IUCN.

Printed by: Karunaratne & Sons (Pvt) Ltd.
67 UDA Industrial Estate
Katuwana Road
Homagama
karusons@sltnet.lk

Available from: Ecosystems and Livelihoods Group, Asia
IUCN
4/1, Adams Avenue
Colombo 4
Sri Lanka
Phone: +(9411) 255 9634-5
Fax: +(9411) 255 9637
email: coastalinfo@iucnsl.org
website: http://data.iucn.org/places/asia/coastalinfo/

Contents

Acknowledgments

Many people assisted with the preparation and production of this manual. The author expresses her grateful thanks to Saima Baig, Channa Bambaradeniya, Lucy Emerton, Janaki Galappatti, Ranjit Galappatti, Usman Ifthikar, Mikkel Kallesøe, Sanjeewa Lellwala, Maeve Nightingale, Thushara Ranasinghe, Ali Raza Rizvi, Rebecca Roberts and Devaka Weerakoon for content inputs and comments.

Yvanka de Soysa prepared most of the annexes in Volume 1 and Eric Wikramanayake generated some GIS maps used for illustration in Volume 2. Anouchka Wijenaike and Irushnie Wedage proof-read the document.

Many people generously provided photographs for use. They are credited individually at the end of each volume.

This document was produced and published with financial support through a grant made from the Autonomous Organisation for National Parks (*Organismo Autónomo Parques Nacionales* - OAPN) of the Ministry of Environment of Spain to IUCN.

List of Figures

List of Tables

Executive summary

Environmental facets are essential components of human well-being and contribute positively to human security, providing basic materials for good life, good health and good social relations. Yet, these are being damaged and overexploited, ultimately to the detriment of humans. In addition, increasing incidence and intensity of natural disasters and climate change are having over-arching impacts on the environment. Sustainable development, often of the most vulnerable sectors of society, is thus being undermined.

One of the key reasons why this damage continues is that an integrated approach is adopted rarely in disaster risk management. For example, relief organisations may focus on damage to life and property while others examine impacts on livelihoods. Very often, ecological services and their indirect economic values are omitted completely from assessments. Adaptation to climate change is ignored.

Mainstreaming ecosystem concerns – both ecological and economical – into the development agenda and integrating them into disaster management, therefore, becomes essential. This manual attempts to provide background information and guidance for integrating environmental concerns into disaster management.

Volume 1 of the manual describes briefly the framework of the Millennium Ecosystem Assessment (MA). The MA links clearly ecosystem well-being to human well-being, and presents the major threats imposed by human activities to the services that ecosystems provide. Volume 1 also gives snapshot views of ecosystem well-being and human well-being in Asia and a brief overview of selected ecosystems in the region. Clarification of the difference between natural hazards and natural disasters and a discussion on risk and vulnerability are presented. Climate change and its impacts on natural disasters is also discussed. At the end of Volume 1 is a series of annexes that detail ecosystem services of and threats to ecosystems described in the text.

Volume 2 describes the disaster management cycle and its phases: prevention, mitigation, preparedness, relief, recovery and rebuilding. It introduces an integrated approach to assessments that examines biodiversity, ecosystem services, economic valuation and livelihoods. Volume 2 deals with each of the phases of the disaster management cycle, lists steps and introduces questions that must be raised during each phase in order to integrate environmental concerns into disaster management. These steps and questions are designed around the framework of the Millennium Ecosystem Assessment and its identified threats.

Finally, in the third volume, an integrated summary worksheet is presented as a tool for use. Details of the techniques for each component of assessment are also presented in this volume, as well as a list of available web resources.

The Indian Ocean tsunami of December 2004 served to focus the world's attention on the fatalities, the damage and the destruction that natural disasters cause. Much is being done and said about the development of early warning systems, disaster management and emergency preparedness planning.

Less is being said about integrating environmental safeguards into disaster management and preparedness planning. Even less is understood about why environmental safeguards are so vital for disaster management and, indeed, for sustainable living.

Why is the environment necessary for sustainable living?

The benefits that we amass from the Earth are enormous. The natural environment (ecosystems[1] in a narrower sense) provides us with many services.

These ecosystem services[2] can be categorised broadly as:

- Provisioning services,
- Regulating services,
- Supporting services, and
- Cultural services (see figure on following page).

Provisioning services:
These services cover the natural resources and products – goods – obtained from ecosystems. Such goods include food, wood, medicines, fuel and fuelwood, fibre and non-timber forest products. Ecosystems, therefore, provide, the basis for many industries: agriculture, livestock, fisheries, lumber, and pharmaceuticals, to name a few. They also provide the basis for a multitude of livelihoods.

Regulating Services:
These are the benefits obtained from the regulation of ecosystem processes, such as, for example, climate and flood regulation.

Supporting services:
These are ecosystem services that are necessary for the production of all other ecosystem services. For example, the production of biomass, balancing gases in the atmosphere, formation of soil, degradation of waste, nutrient and water cycling and pollination.

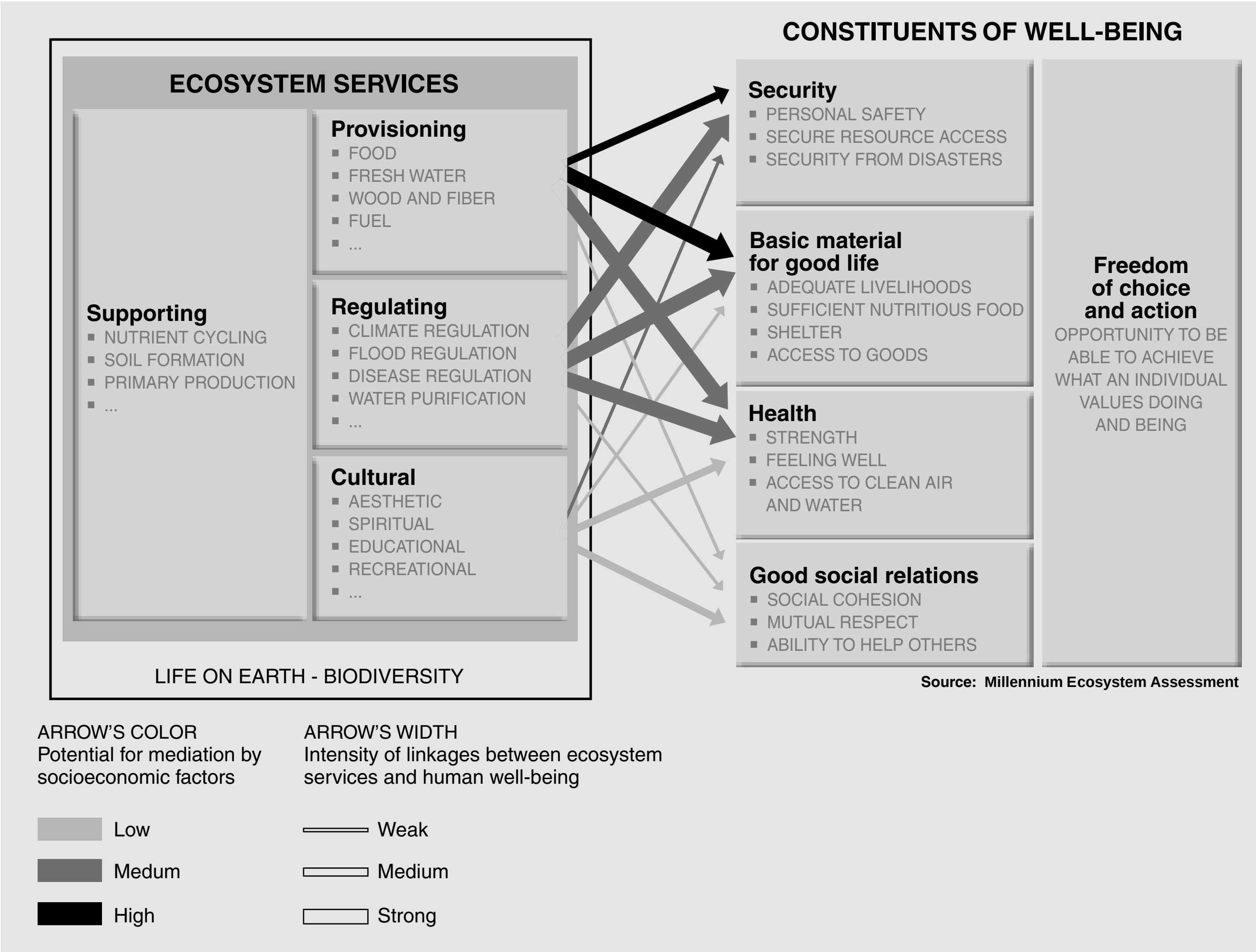
Cultural services:
These are non-material benefits people obtain from ecosystems through spiritual enrichment, development of learning, recreation and aesthetic experience.

All these ecosystem services are not only of direct value to humans, but they also offer indirect benefits by supporting and promoting the natural resource base upon which livelihood and economic activities are based. The Millennium Ecosystem Assessment framework examines and shows the relationships among biodiversity, ecosystems and ecosystem services, and also details the relationship between ecosystem services and human well-being (MA, 2005). (See Figure 1 on following page.)

> At the turn of this century, the then secretary of the United Nations, Kofi Anan, called for a global assessment of the state of the Earth. One thousand three hundred and sixty scientists from 95 countries participated in this assessment that was carried out between 2001 and 2005. It focussed on developing and presenting a framework that linked clearly all the services that ecosystems provided to human well-being. It examined relatively untouched ecosystems as well as intensively managed and highly modified systems. It examined how ecosystem well-being affects the services it provides and therefore, affects human well-being. This framework links clearly ecosystem well-being to human well-being, and shows explicitly that humans are integral parts of ecosystems. In its review, the Millennium Ecosystem Assessment (hereafter called the MA) also identifies major anthropogenic threats to ecosystems or drivers of ecosystem change (MA, 2005).

[1] Ecosystems are defined as dynamic complexes of flora, fauna and other living communities and their nonliving environment interacting as functional units (MA, 2005).
[2] Defined as the benefits that ecosystems provide for human well-being (MA, 2005).

Figure 1: The Millennium Ecosystem Assessment (MA) framework (Source MA, 2005)



The MA framework shows clearly that through different ecosystem services, biodiversity is an essential component of human well-being and contributes positively to human security, providing basic materials for good life, good health and good social relations.

The bottom line is that without ecosystems, humans can not live. In short, in order to achieve human well-being, it is essential that we also have ecosystem well-being.

This is the link that underpins sustainability of livelihoods and of development.

Yet this link is being threatened by various actions of humans and ecosystems and the services that are obtained from them are being damaged and degraded.

The five major drivers of biodiversity loss and change in ecosystem services are

- Over-exploitation,
- Habitat change,
- Climate change,
- Invasive Alien Species and
- Pollution.

Over-exploitation:

Humans are, simply, taking too much out of ecosystems, for food, medicines, as pets, as ornamentals and for other purposes. The demand for fish as food for people is increasing, resulting in major collapses of some fisheries industries. About 75% of the world's commercial marine fisheries are either exploited fully (50%) or over-exploited (25%) (MA, 2005).

Habitat Change:

Almost all of the world's ecosystems have been changed by humans. Changes in the last 50 years have been more than in any other time in recorded history.

More land was converted to cropland between 1950-1980 than in the 150 years between 1700 and 1850.

Twenty percent of coral reefs all over the world are already destroyed and another 20% are degraded.

Tropical rain forests are lost at the rate of one hectare per second (equivalent to the extent of two U.S. football fields).

Up to 80% of original mangrove ecosystems and 50% of the world's wetlands are already degraded and lost (MA, 2005).

Climate Change:

The result of excessive greenhouse gas emissions and an increased greenhouse effect is a distinct warming of the earth. This global warming is causing climate change: melting ice caps, changing weather patterns and ocean currents, increasing extreme weather events and spreading disease. Climate change, therefore, is causing overwhelming changes to ecosystems and their services. (See later section on climate change for a more detailed description.)

Invasive Alien Species:

Invasive Alien Species are introduced species that do not stay confined to the area into which they were introduced, compete vigorously with native species, become established in natural ecosystems, threaten native species and have the potential of eradicating them. When they eradicate native species and disrupt ecosystem interactions, they damage ecosystem services and cause severe economic damage (IUCN, 2000).

Pollution:

Ecosystem degradation and loss have had serious impacts on human well-being in the Asian region.

Since 1950, increases in nitrogen, phosphorus, sulphur, and other nutrient-associated pollutants (often fertilisers) have become one of the most important drivers of ecosystem change.

Other forms of water pollution such as domestic, industrial and marine pollution are further degrading ecosystems and damaging their services. The accumulation of non-degradable solid waste (which attracts disease carriers, pollutes groundwater and rivers and generates methane) is also adding considerably to the problem of ecosystem degradation.

In all, the Millennium Ecosystem Assessment reveals that 15 ecosystem services - including provisioning services such as fisheries, timber production and regulating services such as water supply, waste treatment and detoxification, water purification, natural hazard protection, regulation of air quality, regulation of regional and local climate, regulation of erosion, and many cultural benefits - have been degraded.

Ecosystem well-being in Asia

Asia contains some of the richest ecosystems and livelihoods. More than half the world's biodiversity is found in the region (Sodhi et al., 2004). South and Southeast Asia house about 15.5 % of the world's fauna and 12% of the world's flora. Five out of 17 mega diverse countries (which contain, within their borders, more than two thirds of the world's biodiversity) of the world are Asian (China, India, Indonesia, Malaysia and the Philippines) (Mittermeier et al., 1997). Of the 25 'biodiversity hotspots' (areas richest in biodiversity but also the most highly threatened) identified in the world, six hotspots (Indo-Malaya, the Philippines, the Himalayan region, the mountains of southwest China, the Sundalands, and the Western Ghats and Sri Lanka) are found in this region (Conservation International, 2008). Together, the region has a biological diversity that is not found elsewhere in the world, and this biodiversity sustains human life by providing essential provisioning services such as food, medicines, wood and firewood and regulating and supporting services such as storm protection, climate regulation, balancing gases in the atmosphere, water regulation, soil engineering, nutrient cycling, degradation of wastes and pollination.

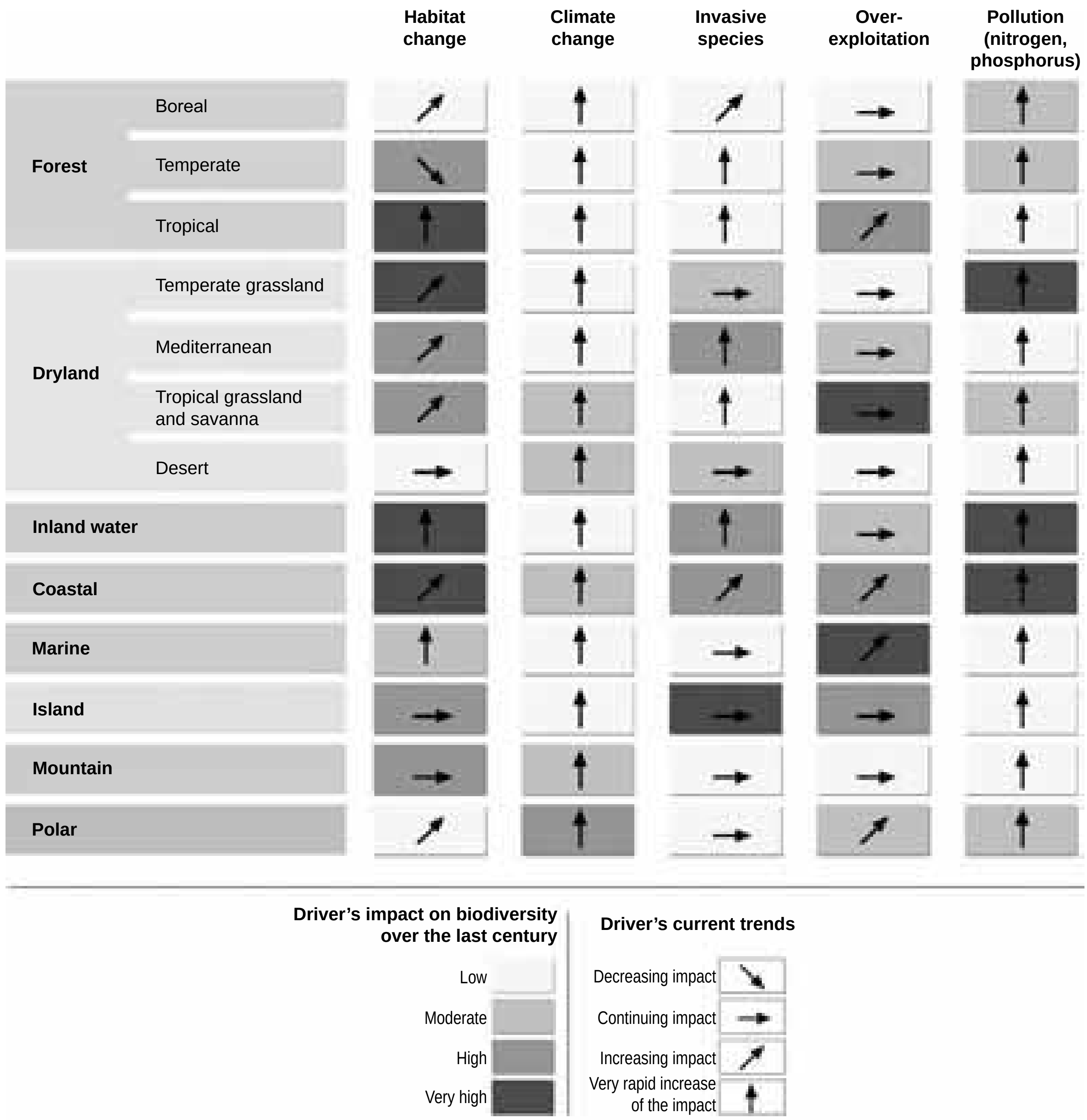
The results of the Millennium Ecosystem Assessment released in 2005 were alarming.

- Of 24 evaluated ecosystems, 15 are being damaged. Twenty percent of the world's coral reefs (the centre of diversity of which is in Asia) were lost and 20% degraded in the last several decades. Thirty five percent of mangroves have been lost in the last several decades. (Forty percent of the world's mangroves are found in Asia).
- Other significant changes include the conversion of forests and grasslands for agriculture, diversion and storage (through dams) of freshwater.
- Other ecosystems affected seriously by human activity include temperate broad-leaved forests, temperate grasslands, Mediterranean forests, and tropical dry forests.
- The most rapid changes are taking place currently in developing countries, 17 of which are in Asia (BMBF 2002).
- Sixty percent of the world's ecosystem services have been degraded.
- The most important change in the world has been the conversion of natural ecosystems to cultivated land - 24% of the terrestrial extent of the earth is now agricultural.

(Source MA, 2005).

This ecosystem degradation and loss has had serious impacts on human well-being in the Asian region. '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 issues associated with environmental security through the loss of livelihoods and food security. Declining ecosystems have also increased the vulnerability of the people to natural disasters and their inability to absorb related shocks and stresses' (Emerton, 2006).

Figure 2: Impacts of the main drivers of ecosystem change (Source: MA, 2005)



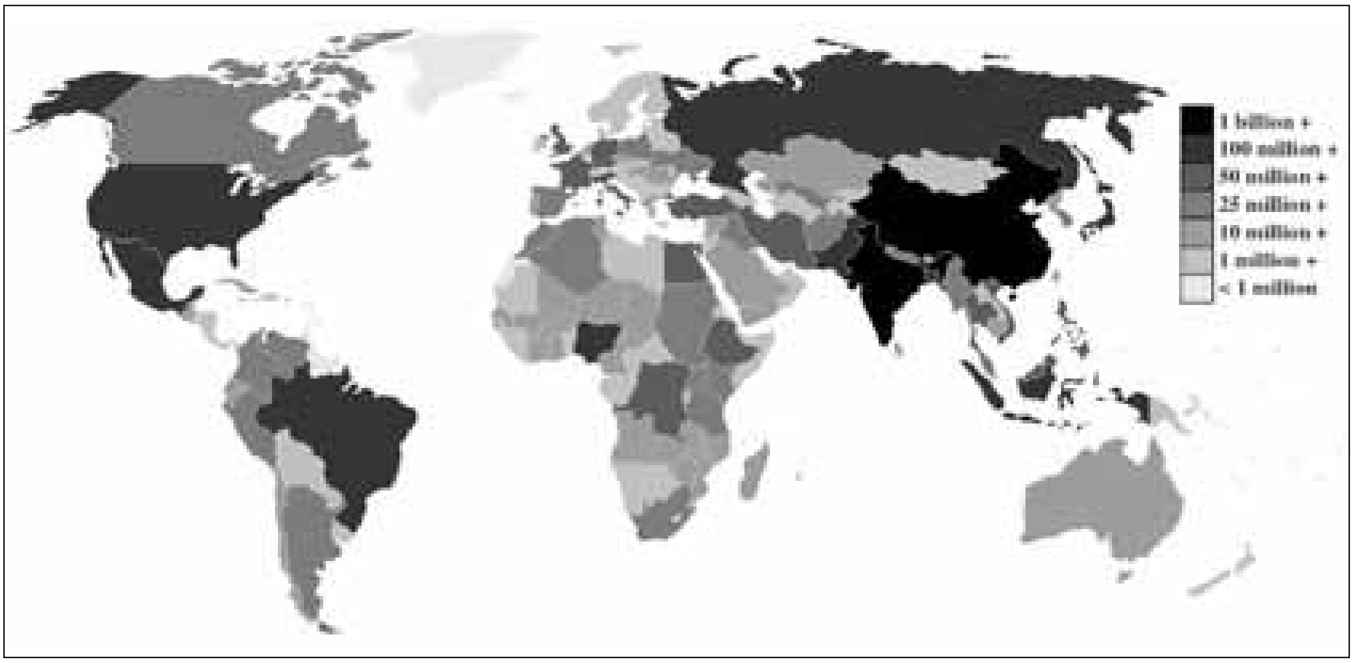




Human well-being in Asia

The current world population stands at just over 6,660,000,000 (U.S. Census Bureau, 2008). Of this, the Asian region accounts for 56.5% or 3,733,783,474 people (U.S. Census Bureau, 2008).

Figure 3: Current world population
(Source: http://upload.wikimedia.org/wikipedia/commons/b/b1/World_population.PNG)



The two most populous countries in the world – China and India - are found in the Asian region. In addition, of the top ten most populous countries in the world in 2002, six (China, India, Indonesia, Pakistan, Bangladesh and Japan) are Asian (U.S. Census Bureau, 2008).

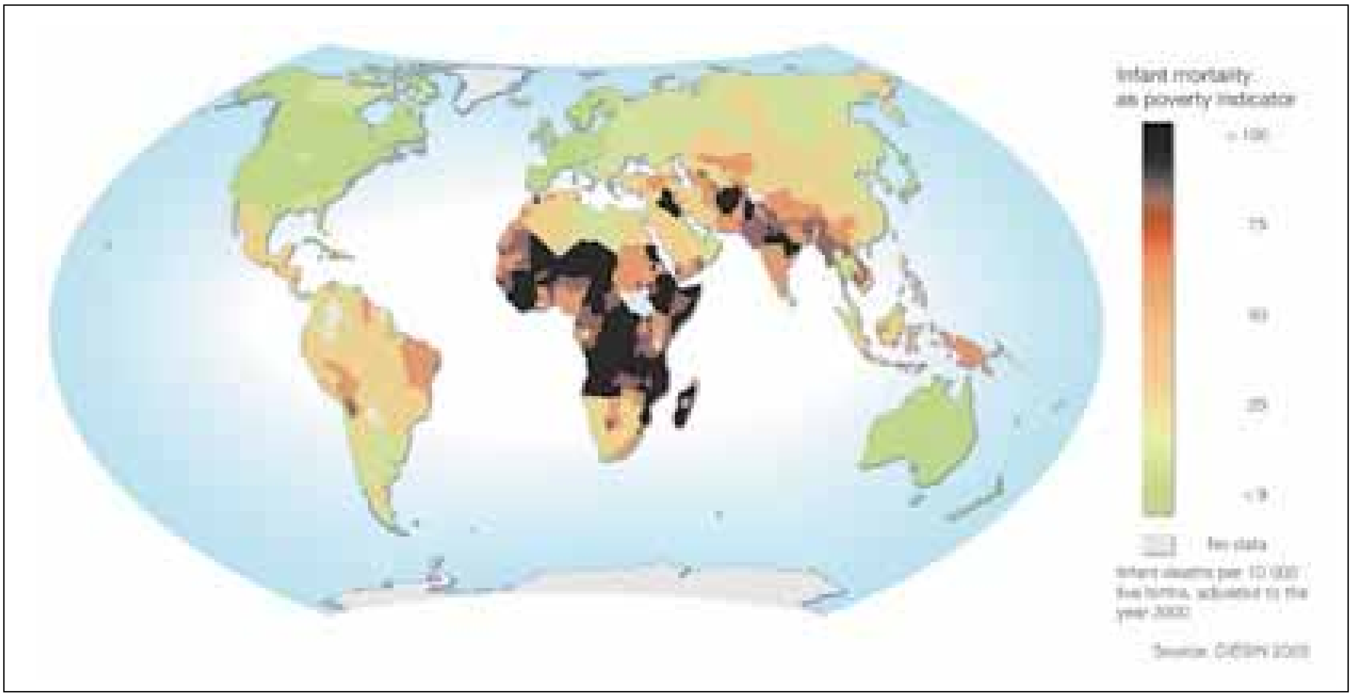
Asia is also the home to over 70% of the world's poor, most of whom live in rural areas and many of whom live in coastal areas and depend on an easily disturbed natural resource base for their survival.

Table 1. Population and poverty in Asia (Sources: as listed individually)

Country	Population 2005 (millions)[3]	Population living on less than 2 USD/day[4]	GNI[5] per capita 2005 (Atlas method, USD)[3]
Bangladesh	141.8	83.0%	470
Cambodia	141.0	77.7%	430
China	1,300.0	47.0%	1,740
India	1,100.0	80.0%	730
Indonesia	220.6	52.0%	1,280
Lao PDR	5.9	74.0%	430
Malaysia	25.3	9.3%	4,970
Maldives	0.3	NA	2,320
Nepal	27.1	69.0%	270
Pakistan	141.5	74.0%	690
Sri Lanka	19.6	41.6%	1,160
Thailand	64.2	25.2%	2,720
Vietnam	83.1	NA	620

[3] World Bank Country tables, 2005.
[4] Poverty Database World Bank.
[5] GNI is Gross National Income - the sum of all income earned in a county within one year.

Figure 4: World poverty distribution - using infant mortality as a poverty indicator
(Source: UNEP/GRID-Arendal, 2008)

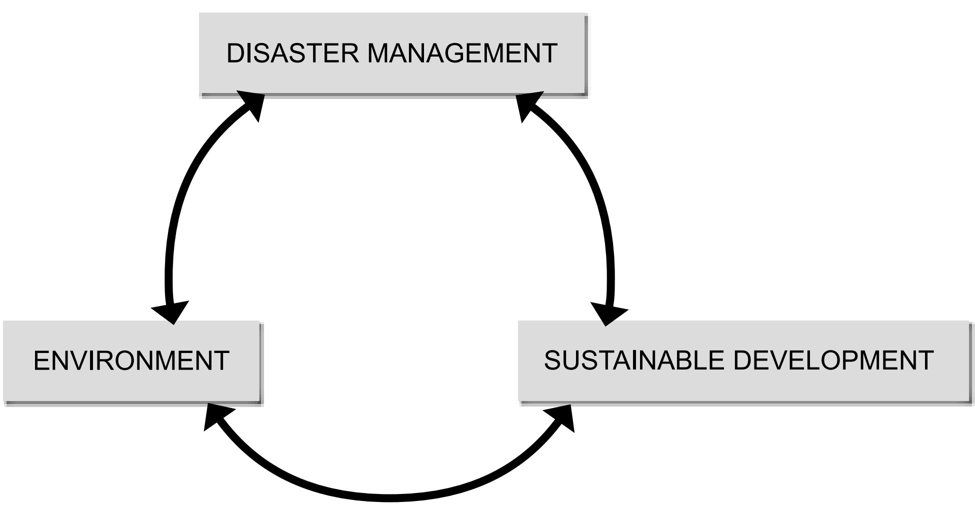


Along with rapid urbanisation and growth, a great proportion of the population in Asia remains vulnerable, and faces uncertain and insecure livelihoods. In many countries, there have been worsening levels of corruption, ethnic and religious tensions, gender inequalities, excessive consumption by the rich, and trafficking in drugs and people.

What should be done?

One of the key reasons why biodiversity and ecosystems continue to be degraded and lost is that the impacts of their loss are not assessed together. Assessments are often made in a fragmented manner, with the result that only part of the true picture is revealed. For example, relief organisations may focus on damage to life and property while others examine impacts on livelihoods. Very often, ecological and their indirect economic values are omitted completely from assessments.

Mainstreaming ecosystem concerns – both ecological and economical – into disaster management and integrating them into development agendas, therefore, becomes essential. It is only then that, in the long term, disaster management becomes effective and development sustainable. In turn, good practices in disaster management and development will protect the environment.



This manual attempts to provide background information and guidance for integrating environmental concerns into disaster management and to provide direction for carrying out integrated assessments.

The manual is structured in three parts. Volume 1 gives background information on ecosystems and their value, and also clarifies the difference between natural hazards and natural disasters. It discusses risk and vulnerability. Climate change and its impacts on natural disasters are also discussed. Volume 1 also presents a series of annexes detailing ecosystem services of and threats to ecosystems described in the text.

Volume 2 describes the disaster management cycle and its phases: prevention, mitigation, preparedness, relief, recovery and rebuilding. It deals with each of the components of the disaster management cycle, lists steps and raises questions that must be asked at each step in order to integrate environmental concerns into disaster management. The steps and questions are designed round the framework of the Millennium Ecosystem Assessment and its identified threats.

Finally, in the third volume, an integrated summary worksheet is presented as a tool for use. Details of the techniques for each component of assessment are also presented in this volume, as well as a list of available web resources.

An overview of main Asian ecosystems and their status

The World Wide Fund (WWF) for Nature recognises 142 terrestrial, 53 freshwater, and 43 marine ecoregions (WWF, 2007). A detailed description of each of these ecoregions is beyond the scope of this manual, but a broad-brush overview of a select cross-section of ecosystems found in the Asian region is presented here.

Terrestrial inland ecosystems

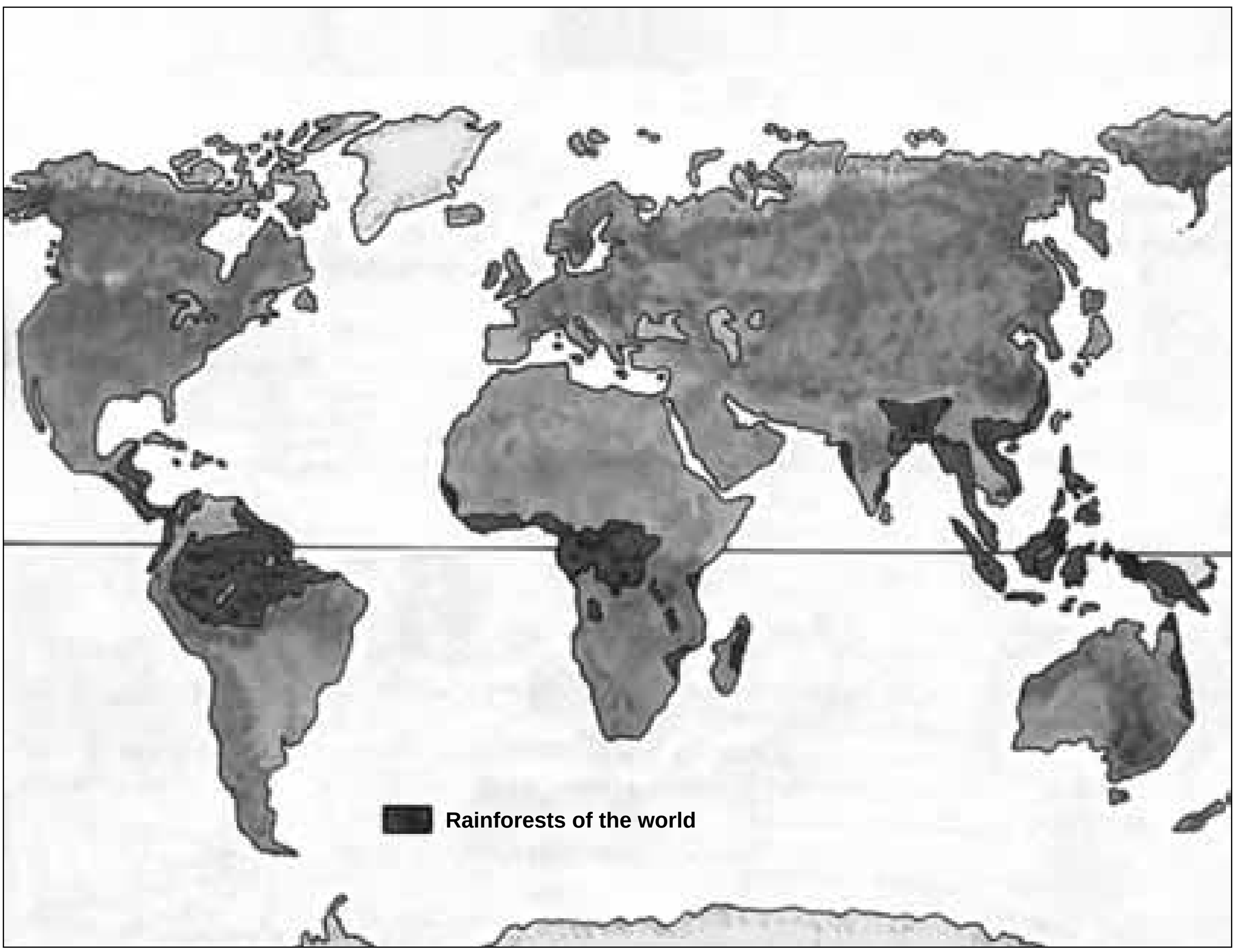
Tropical lowland rain forests (Moist broad-leaved forests)

Tropical lowland rain forests are found at elevations below 1000m near the equator between the Tropic of Cancer and the Tropic of Capricorn. This means that the temperature in tropical lowland rain forests does not vary and ranges only between about 20-28°C. Tropical lowland rain forests, as their name implies, receive high annual rainfall - at least 254cm and, on average, between 1.25 – 6.5m of rain annually, distributed evenly through the year. The soils of lowland rain forests are impoverished.

These forests are concentrated in Africa, Asia, Australia and Central and South America.

> The Amazon is the world's largest rainforest. It covers areas in Brazil, Peru, Venezuela, Colombia and Ecuador and is estimated to represent half of the world's remaining rainforests (UNEP, 2001).

Figure 5: Global distribution of tropical rainforests
(Source: http://en.wikipedia.org/wiki/Rainforests)



Tropical lowland rainforests are famous for their incredible diversity and species richness. It is reported that one square kilometre of Amazonian forest may contain over 75,000 types of trees and 150,000 species of higher plants (Lewinsohn et al., 2005).

Tropical lowland rainforests are extremely important as they provide many goods to humans. Many fruits consumed today (such as bananas, papayas, citrus fruits), vegetables (such as legumes, cassava, peppers, okra) flavourings (such as cocoa, vanilla, sugar), spices (such as nutmeg, cinnamon), nuts (such as peanuts and cashew nuts) originated in the rainforest. It is reported that a staggering 80% of the foods eaten in the developed world originated in rainforests (http://www.andrew.com).

Over a quarter of the world's allopathic medicines also originated in rainforests. The US National Cancer institute has identified over 3,000 plants that have chemicals active against cancer cells; of these 70% are found in rainforests. Many familiar medications - such as quinine (used to treat malaria), curare (used as a muscle relaxant) vincristine and vinblastine (used to treat some forms of leukaemia) - had their origins in rainforest plants (http://www.andrew.com).

Apart from their amazing provisioning services, lowland tropical rainforests provide a wide range of other services, such as climate and flood regulation, water purification, nutrient cycling, primary production, carbon sequestration as well as aesthetic and educational services – all essential for human well-being (Condit et al, 1996; Ross et al., 1990).

Tropical rain forests are being threatened very rapidly by habitat destruction and climate change, increasingly by invasive alien species and have continued over-exploitation of species. (See Annexe 1 for a detailed description of the services provided by and threats to tropical lowland rainforests.)

Tropical montane and submontane rain forests

Tropical montane rainforests, as their name suggests, grow in the tropics above 2,500-3,000m. The temperatures in tropical montane forests are generally cooler than that of lowland rainforests. A particular type of montane forests are cloud forests in which clouds hang low near the tree canopy and provide plentiful moisture. Typically, trees in montane and cloud forests are shorter as an adaptation to high winds at high elevations. Submontane forests are found at intermediate elevations - lower than montane forests, but higher than lowland forests. Their structure is in-between that of montane and lowland rain forests (WWF, 2007).

Like tropical lowland rain forests, montane, cloud and submontane forests support a high diversity of species, often with a high degree of endemicity. Montane and cloud forests, in particular, support a rich diversity of epiphytes such as orchids. Many montane and sumontane forests provide watershed protection and prevent soil erosion.

These forests are subject to many of the same threats as lowland rain forests. (See Annexe 2 for details.)

Cloud forests are found at lower elevations of the Andes in Ecuador, Peru, Colombia, and Venezuela, Costa Rica, Borneo and Africa.

Monsoon forests (Dry/semi evergreen broad-leaved forests)

Monsoon forests are found in tropical areas that have a long dry season followed by a season of heavy rainfall. The seasonal dry season has a huge impact on these forests, whose species are adapted to deal with times of water stress. For example, many trees shed their leaves during the dry season. Hence, these forests are also called tropical deciduous forests.

Monsoon forests provide a range of ecosystem services but are under threat from selective over-exploitation, habitat destruction – for example, from shifting cultivation - pollution, climate change and invasive alien species. (See Annexe 3 for details.)

Monsoon forests are found just north and south of the rainforest belt. The most diverse dry forests in the world are found in southern Mexico. There are also monsoon forests in India, Sri Lanka and Indochina, and these forests support many large vertebrates (WWF, 2007).

Scrub forests

Scrub forests also grow in areas that are water stressed, but tend to be found in more arid regions than monsoon forests, where the dry season is prolonged. Here, plants show xeromorphic[6] adaptations to conserve water. Animals too are able to survive water stress and many are vagile[7].

When monsoon forests are destroyed, often, thorn scrubs regenerate in their place.

Scrub forests are threatened particularly by slash and burn cultivation and invasive alien species, such as Prickly Pear (*Opuntia dillenii*) and Mesquite (*Prosopis juliflora*). (See Annexe 4 for details.)

In Asia, scrub forests are found in India and Sri Lanka (the Deccan thorn forests) and in north western India.

[6] Xeromorphic characters are adaptations that allow plants to conserve water.
[7] Vagile animals range widely.

Tropical coniferous forests

Tropical coniferous forests experience low rainfall and moderate temperature variability. Vegetation is adapted to deal with this variability, and leaves are needle-shaped to reduce water loss during cold periods. Animals migrate to warmer areas during the cold season.

These forests are characterised by many species of conifers and large ungulates.

Because these forests are found in Asia on mountain slopes they provide regulating services in flood and erosion prevention. Their streams provide fresh water for humans at lower elevations.

Tropical coniferous forests are threatened by habitat destruction through wildfires and logging, forest fragmentation and over-exploitation by hunting. (See Annexe 5 for details.)

The most diverse tropical coniferous forests are found in Mexico. In Asia, they are found at high elevations where the temperature is lower, in Lao PDR, Vietnam, the Philippines and the lower ranges of the Himalayas (WWF, 2007).

Temperate broad-leaved and mixed forests

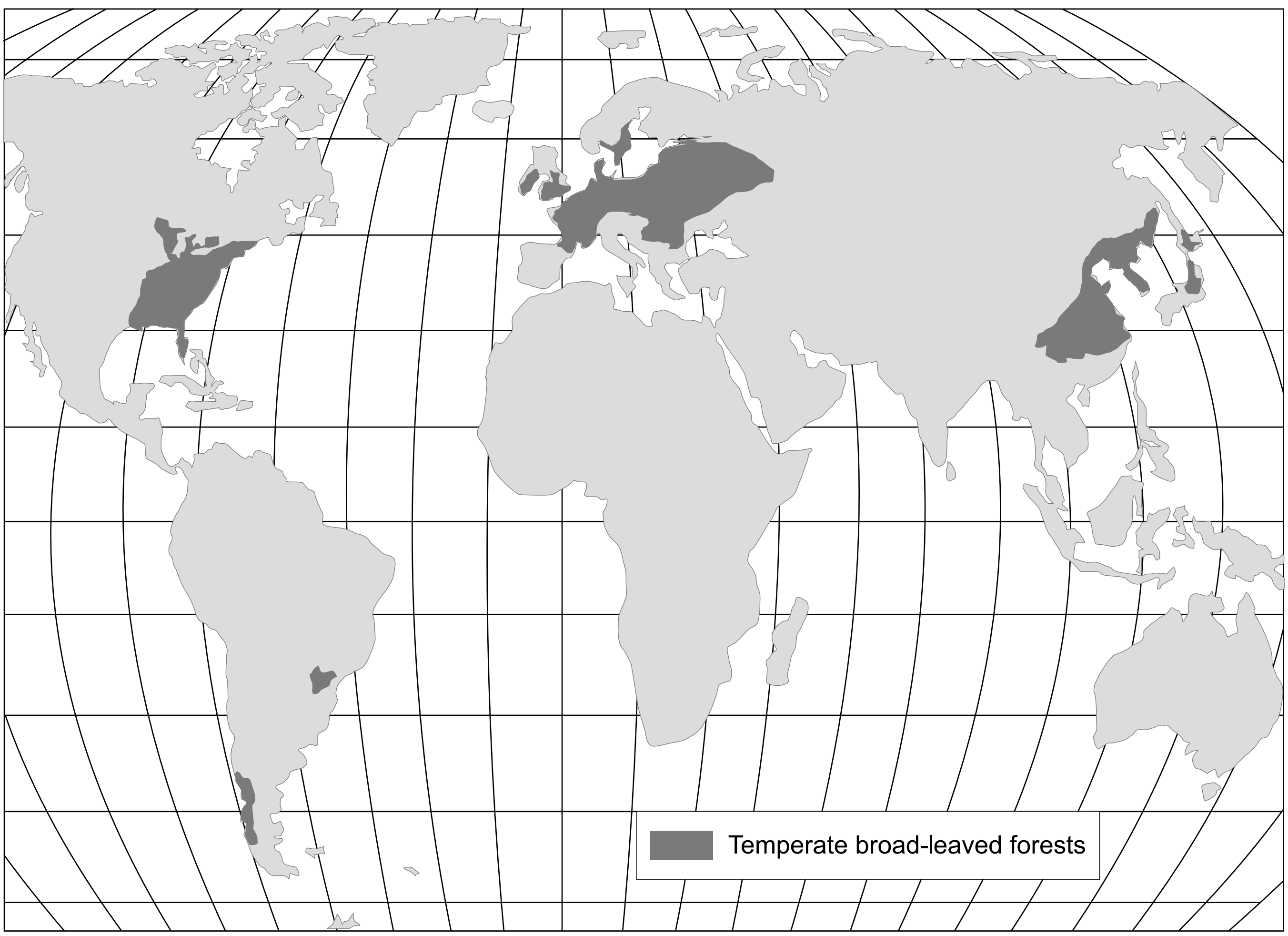
Temperate broad-leaved forests have marked seasonal changes in temperatures: with distinct seasons of moderately cold winters, springs, warm summers and autumns. Throughout the year, they also have marked changes in the length of day: during the summer, daylight hours are long; while during the winter, they are short. There is good precipitation throughout the year but some of it becomes unavailable when it is too cold. The soils of rain forests are nutrient rich.

These forests are characterised by a mix of deciduous vegetation with evergreen species. Both flora and fauna are adapted to survive changes in temperature and daylight hours, and many animals migrate to warmer areas to feed during winter months.

Because soils are nutrient rich, much of these forests have been cleared for agriculture. They are affected by habitat fragmentation and invasive alien species. (See Annexe 6 for details.)

Temperate broad-leaved and mixed forests are found at varying elevations. In Asia, they are found in the Himalayas - above elevations that support tropical coniferous forests and in south west China.

Figure 6: Global distribution of temperate broad-leaved forests
(Source: http://www.runet.edu/~swoodwar/CLASSES/GEOG235/biomes/rainforest/rainfrst.html)



Tropical grasslands

Tropical grasslands are found in both wet and dry areas at low altitudes.

Savannahs

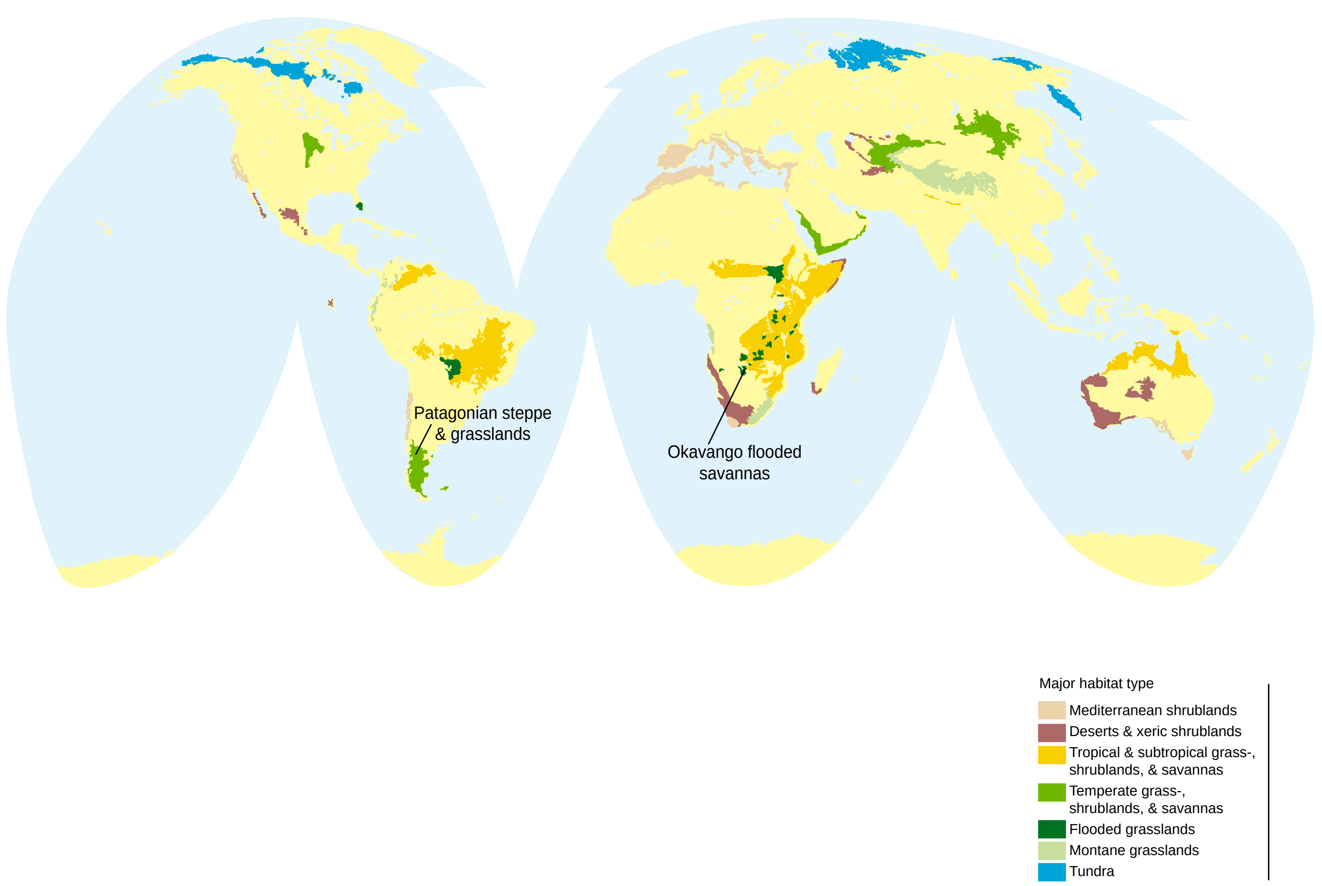
Tropical dry grasslands of low altitude are called savannahs and are characterised by so little rainfall per annum that there is insufficient moisture to sustain much tree life. Instead, savannahs support a multitude of grasses, some shrubs and a few scattered trees, all adapted to conserving precious water. Because of the diversity of grass species, the fauna of savannahs is dominated by grazing herbivores, as well as many carnivores who feed on the herbivores (WWF, 2007).

Grasslands, therefore, support high species richness. In addition, they sequester carbon, prevent soil erosion, provide fertile soils and regulate floods.

Although seasonal fires - when conditions become very dry - play a vital role in the savannah's biodiversity, grasslands are threatened as a result of excessive burning by humans and also by over-grazing by domestic livestock that alters the ecosystem balance as well as water balance, leading to desertification. (See Annexe 7 for details.)

Savannahs are found in east and central Africa and in India.

Figure 7: Global distribution of grasslands (Source WRI, 2002)



Flooded grasslands

Tropical wet grasslands (flooded grasslands) are flooded either during a particular season or the whole year round and are found in nutrient rich soils. These are found on all the continents.

These grasslands are threatened by water diversion schemes, pollution and eutrophication[8].

Montane grasslands

Montane grasslands are found, as their name implies, at high elevations, in both temperate and tropical regions in all continents. Flora and fauna are adapted to wet, cold conditions and strong sunlight.

These grasslands are threatened by ploughing, extensive burning and over-grazing. (See Annex 7 for details.)

Montane grasslands are found in the Andes Mountains, east and central Africa, in Borneo, in the Western Ghats of South India, Sri Lanka and the central highlands of New Guinea.

In Asia, temperate grasslands (Alpine meadows) are found in Malaysia and the eastern Himalayan slopes.

[8] Eutrophication is a process whereby water bodies - such as lakes, estuaries, or slow-moving streams - receive excess nutrients that stimulate excessive plant growth (algae and weeds). This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water when dead plant material decomposes and can cause other organisms to die.

Deserts

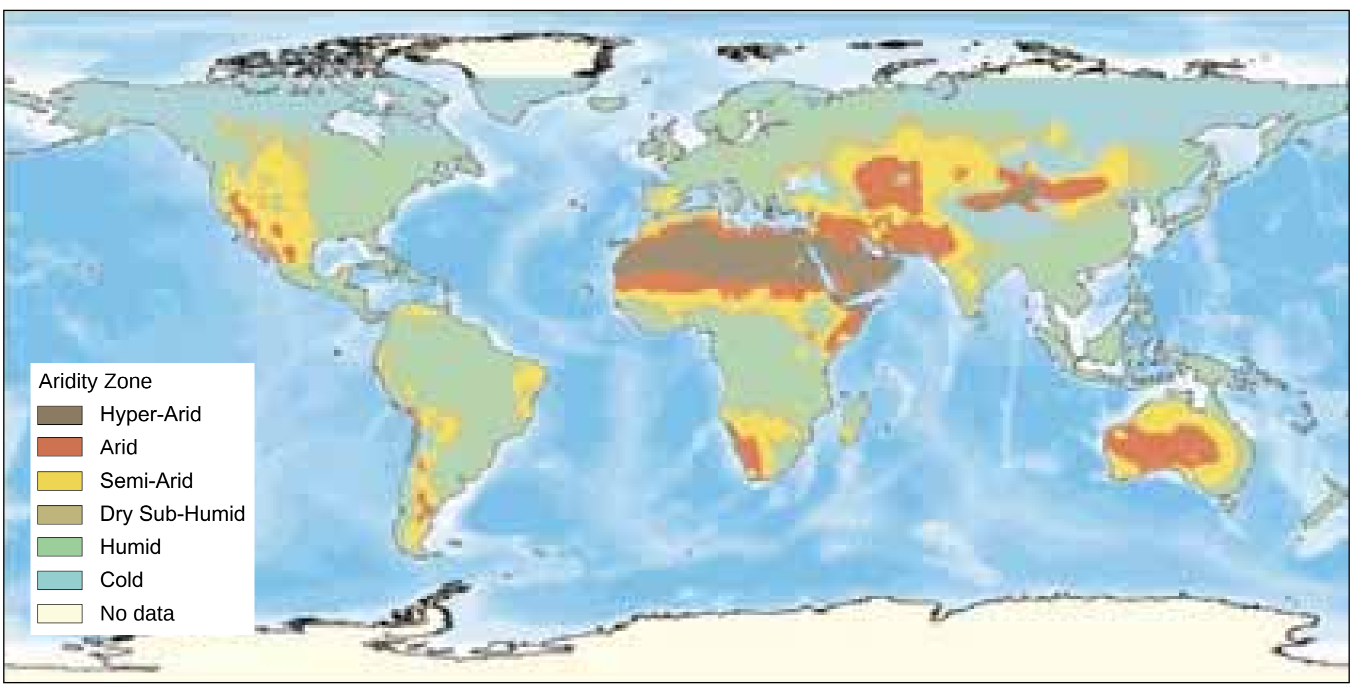
Deserts are characterised by very little rainfall throughout the year – in fact, evaporation in deserts exceeds precipitation. Temperature, however, varies: in some deserts, such as hot deserts, it is hot all year round, while in others – in cold deserts – it becomes cold in the winter. A characteristic of both hot and cold deserts is that temperature varies within a twenty four hour period: it is extremely hot during the day and cold at night. Both flora and fauna are adapted to harsh conditions. Plants have xerophytic characteristics (adaptations to conserve water) and animals also exhibit a wide range of behavioural and physiological adaptations to prevent water loss. The landscape is generally bare, with sparse vegetation.

Deserts are the home to many nomadic cultures, hunter-gathering and pastoral livelihoods. Mineral and oil deposits are found in some deserts. Desert fauna and flora are thought to have provided the base for present day pastoral and agricultural societies.

Over-grazing, mining, pollution of fragile water bodies with heavy metals are threatening deserts. Oil extraction leads not only to water pollution but also to air pollution. Over-extraction of precious water is also a threat in deserts. The increase of desert areas – desertification - is a consequence of over-use of arid scrublands. Desertification is predicted to increase as a result of climate change. (See Annexe 8 for details.)

Deserts are found on all the continents. Major hot deserts include the Sahara (9,000,000km^2) and the Kalahari in Africa, and the Thar in India. Cold deserts include the Gobi in Asia (1,125,000km^2).

Figure 8: Global distribution of deserts (Source: WRI, 2002)



Aquatic inland ecosystems

Inland aquatic ecosystems are freshwater systems that include rivers and streams (created when water runs off in terrestrial habitats), as well as ponds and lakes (where this runoff accumulates in a land locked area).

Streams and rivers

These are bodies of water that move continuously in one direction. At the headwaters of a stream (the beginning) the channel is narrow and the water is pure and carries less sediment than downstream, as well as only a few minerals. Many such streams (tributaries of a river) join together to form a larger river. The river slopes become gentler and slow moving as they flow downstream except where there are steep, rocky and rapidly flowing reaches. Rivers carry sediments down with the water. The coarser particles (sand and gravel) move along the river bed and the finer particles (clay, silt and fine sand) move in suspension. Suspended sediment makes the water turbid. Turbidity is more pronounced soon after it rains.

At the mouths of rivers (where they run into the sea), sometimes deltas form. River deltas are landforms of river-borne sediment, which the river unloads in that area. (Deltas are formed when the amount of sediment accumulating far exceeds sediment that can be carried out by currents into the sea.)

Figure 9: Major river basins of the world (Source: Global Runoff Data Centre 2008)

The terrain in rivers varies with location as does temperature, which varies with altitude and latitude. The amount of water varies seasonally with rainfall or with melting snow.

Flora and faunal communities are adapted to the above conditions but vary significantly between upstream and downstream.

The transport of water downstream to cultivated ecosystems and provision of freshwater are two main ecosystem services provided by streams and rivers. The transport of sand and other sediments and waste products downstream from the catchment is also a less recognised service provided by rivers. Fertile deltas, beaches etc. are products of these services. Navigation is also an important service provided by larger rivers for transport of people and goods. Riverine vegetation stabilises the soil and prevents erosion. Many rivers - such as the Mekong and Amazon rivers – provide fish stock that supports large communities. Floodplains along rivers and coasts provide flood protection. Many rivers and streams provide diverse recreational services such as fishing, boating and camping.

Rivers and streams are threatened seriously all over the world by water diversions schemes – dams. According to the MA large dams have probably done more harm to freshwater ecosystems than any other human intervention. The MA notes that the amount of water impounded behind dams has quadrupled since 1960, and that six times more water is held in reservoirs than flows in natural rivers. However, the hydropower generated by these dams is the largest contributor to renewable and non-carbon emitting generation of electricity (MA, 2005).

Pollution – from industries, farms and households – is poisoning rivers and streams. Invasive alien species – such as Water hyacinth (*Eichhornia crassipes*), *Salvinia* and Water lettuce (*Pistia spp.*) – are clogging up many major rivers in Asia. Eutrophication sometimes results from excessive pollution from fertilisers. (See Annexe 10 for details.)

Climate change is expected to change the quantity, intensity and spatial distribution of rainfall. These changes will have an impact on the hydrological cycle and river flow regime with long term consequences for each river.

In Asia, major rivers include the Mekong (which flows through China, Burma, Thailand, Lao PDR, Cambodia and Vietnam) and the Yangtze in China, while the Indus and Ganges/Brahmaputra in the Indian subcontinent form major deltas.

Ponds and lakes

Ponds and lakes are found where freshwater runoff accumulates in a land-locked area. Such water bodies are called ponds when they are small and lakes when they are large. In ponds and lakes, temperature and light changes along a vertical gradient and animal and plant communities are also stratified.

Ponds and lakes provide protection from floods, resources such as food fish, and recreation – such as angling, boating, camping.

Pollution – from industries, farms and households – is affecting ponds and lakes. Aquatic invasive alien species are clogging up many lakes all over Asia. Eutrophication sometimes results from excessive pollution from fertilisers. Climate change will change rainfall patterns as well as the quantity and intensity of rain. These changes will have an impact on the hydrological cycle and river flow regime with long term consequences on ponds and lakes, which are fed by rivers and streams. (See Annexe 11 for details.)

In Asia, Lake Inle is found in the Shan Plateau, in Myanmar and Tonle Sap lake, in Cambodia.

Coastal ecosystems

Coastal ecosystems include mangroves, coral reefs and sea grasses, but estuaries and marshes, lagoon and salt ponds, inter-tidal zones, kelp forests, rock and shell reefs and inner shelf are also part of a mosaic of interconnected environments and organisms found along the coastline (Kallesøe et al., 2008).

Coral Reefs

Corals are two-layered invertebrates that live in groups (i.e. they are colonial) and are related to jellyfish and sea anemones.

Corals are made up of tiny individuals called polyps. Each polyp is like a fluid-filled bag with a ring of tentacles surrounding its mouth, and looks like a tiny anemone. Polyps within a colony are linked by living tissues and can share their food (Allen & Steene, 1994). In some corals, the polyp extracts calcium carbonate from the sea and secretes it as a cup of calcium carbonate from the bottom half of its body. These cups provide anchorage for the polyps but when threatened, the polyp can retreat into the safety of the hard cup. When the calcium carbonate cups of many billions of these polyps fuse together, they form coral reefs (Veron, 2000).

Some corals obtain their nutrients from one-celled organisms called zooxanthellae. Zooxanthellae are single-celled organisms that use sunlight for photosynthesis and transfer 95% of the food they produce to coral polyps. Both coral and the zooxanthellae benefit from this association: the zooxanthellae receive protection from currents and

herbivores, while corals obtain their nutrients. This kind of association is called a mutualistic association. These corals are called hermatypic corals. Individual polyps of hermatypic corals secrete calcium carbonate (limestone) skeletons which, in time, form coral reefs. Hermatypic corals are also known, therefore, as reef building corals.

Because of this association with zooxanthellae that need sunlight to produce food, hermatypic corals are dependent on sunlight and only grow in shallow waters less than 60m deep, which have a temperature range between 25° and 30°C. To keep the balance of this association, hermatypic corals prefer narrow salinity and low turbidity ranges.

Therefore, coral reefs are found
- where the sea is shallow (less than 100m);
- where the sea is warm (between 25° and 30°C);
- And are, therefore, located within the latitude of 30°N to 30°S i.e., only in tropical seas.

Coral reefs are extremely important as they provide many services to humans. Coral reefs support human life and livelihoods and are important economically. Nearly 500 million people depend - directly and indirectly – on coral reefs for their livelihoods, food and other resources (Wilkinson, 2004). Further, it is estimated that nearly 30 million of the poorest human populations in the world depend entirely on coral reefs for their food (Wilkinson, 2004).

Despite their immense ecological, economical and aesthetic values, it is estimated that 20% of the world's coral reefs are destroyed with no hope of recovery (Wilkinson, 2004). Over-exploitation, habitat destruction, climate change, pollution and invasive alien species affect coral reefs. (See Annexe 12 for details.)

Mangroves

A mangrove is a woody plant or plant community which lives between the sea and the land in areas which are flooded by tides for part of the time. Mangrove forests make up one of the most unique ecosystems on earth in that they thrive where no other trees can survive – in the transition zone between the ocean and land. They are among the world's most productive ecosystems.

Because mangroves are found in this transition zone – where the tide rises and falls daily, where salinity changes with this rise and fall of the tide and where the oxygen content is less – both the flora and fauna of this ecosystem have developed very distinct morphological and physiological adaptations.

Mangroves are found in latitudes of 32ºN and 38ºS of the globe and also in the mouths of estuaries and in other inter tidal areas. Approximately one-fourth of the world's tropical coastline comprises mangrove ecosystems and they are estimated to

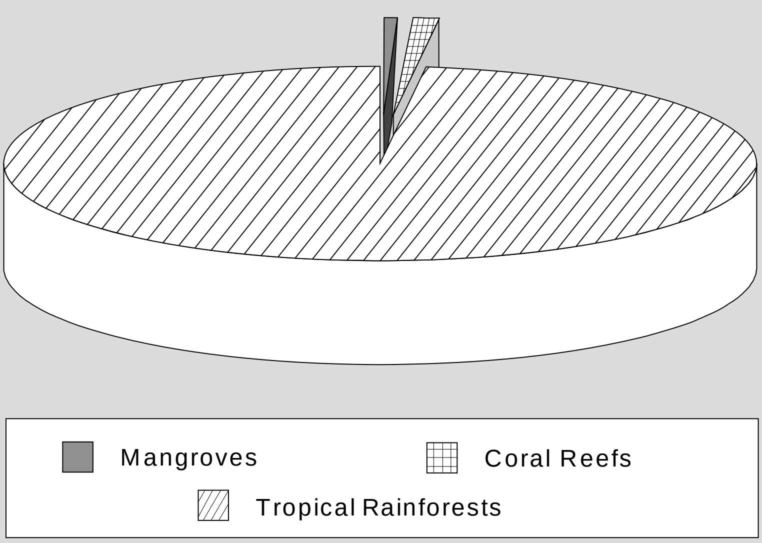
extend along an area of between 167,000 and 181,000km^2, in 112 countries (Spalding, 1997; Kathiresan and Bingham, 2001).

Mangroves are one of the most productive ecosystems in the world and provide humans with many goods such as food, firewood, fuelwood, timber and medicine, and protective, supporting and regulatory services.

However, they are among the world's rarest and most threatened ecosystems. Globally, coral reefs cover nearly twice the area of mangroves, and tropical and subtropical forests more than 125 times as much (EJF, 2005). They are threatened by habitat alteration, over-exploitation, pollution, IAS and climate change. (See Annexe 13 for details.)

Forty percent of mangroves occur in the South and Southeast Asia regions (Spalding, 1997) and the single largest area of mangroves in the world lies in Bangladesh in the Sunderbans, extending over 600,000ha (Bandaranayake 1998).

Figure 10: Extent of mangroves remaining, compared to coral reefs and tropical rainforests (Source: Valiela et al., 2001)



Seagrass meadows

Seagrasses are seed-bearing, flowering, rooted plants which grow submerged exclusively in marine coastal waters and coastal wetlands. Like grasses in terrestrial habitats, they form meadows on the bed of coastal seas. They are dependent on light penetrating for photosynthesis, therefore they generally grow only in shallow waters, in estuaries and coastal seas. They cannot survive outside water, therefore, they often grow where there is shelter from a sand bar or coral reefs.

Sea-grass beds are important because of their provisioning, supporting and regulating services. Seagrasses have been called ‘coastal canaries’ (Orth et al., 2006). Like canaries that were taken into coal mines to test the quality of the air, seagrasses respond to changes in the quality of water, indicating deterioration of the environment by degrading and declining before dying. These changes are visible very quickly, so that it is possible to take management action (Orth et al., 2006). They are threatened by pollution, over-exploitation, invasive alien species and climate change. (See Annexe 14 for details.)

Sea-grasses are found in coastal waters of every continent except Antarctica. In tropical oceans, they are nearly always found near mangroves and coral reefs.

Sand dunes

In intertidal zones of coastal beaches, sand dunes form where there is enough of sand (sediment between 0.2 and 2.0mm) and adequate wind. If the beach is large enough, then the surface dries between high tides. This dry sand is blown landwards and deposited above the high water mark. Some of this sand collects behind rocks or clumps of seaweed. Here, the roots and underground parts of grasses and other specialised vegetation trap the sand from being blown away. The wind then starts eroding sand particles from the windward side and depositing them on the side protected from the wind. Gradually, this action causes the dune to move inland, accumulating more and more sand as it does so. More and more vegetation grows on these dunes, resulting in an often unique assemblage of flora and fauna (Hesp, 2000).

These ecosystems provide humans with regulating, supporting and cultural services but are threatened by over-exploitation and habitat destruction. (See Annexe 15 for details.)

Sand dunes are found worldwide but are less developed in tropical and subtropical zones (where there are lower wind velocities and damper sand) (Packham & Willis, 1997).

Estuaries and Lagoons

Estuaries

An estuary is the last, wide part of a river before it reaches the sea, i.e., it is the tidal mouth of a river. Estuaries are, therefore, important in the movement of sediment from rivers to the sea. Fresh water from the river mixes with the salt water of the sea and creates a transition zone between land and sea. There is always a free connection to the sea in an estuary (NOAA, 2008a).

Lagoons

A lagoon is a body of water cut off from the sea by a sand bank/ spit or coral reef (http://www.wordnet.princeton.edu/perl/webwn). Both estuaries and lagoons can have rivers flowing into them. The main difference between the two is the flow dynamics of the water bodies: in estuaries, the water flows fast and strong, while in lagoons the water is more shallow and sluggish (Ranjit Galappatti, personal communication).

In both estuaries and lagoons, water is brackish[9].

Lagoons and estuaries are productive. The provisioning service of lagoons and estuaries allow for many fisheries-related livelihoods in these ecosystems. They also provide long-term supporting livelihoods in the these ecosystems.

Lagoons and estuaries are under threat from both coastal erosion – which can change the physical structure of mouths and spits – changing lagoon morphology, as well as upstream pollution and hydrology changes. (See Annexe 16 details.)

Coastal lagoons occur all over the world and on every continent except Antarctica. Together with barriers, flats and marshes they occupy about 11% of the world coastline, the longest single stretch being the 2,800km stretch of lagoons landward of barrier islands on the east coast of the USA (http://www.sms.si.edu/ irlspec/Whatsa_lagoon.htm).

[9] Brackish water is water that is saltier than fresh water, but not as salty as seawater.

Water salinity based on dissolved salts in percent (%)			
Fresh water	Brackish water	Saline water	Brine
<0.05%	0.05-3.0%	3.0-5.0%	>5%





The value of ecosystems

Ecosystems are complex and yield a wide range of ecosystem goods, which are used by people for food, construction, fuel, income and other uses. More importantly, they deliver ecosystem services that form the basis for human well-being. (See Figure 1.) In short, ecosystems are valuable because people – living both near them and those far away - depend on them for a variety of reasons to support their well-being (Emerton, 2006). In addition, ecosystem services underpin economic growth at the national level, commerce, trade, global markets and economic processes. These are all critical in terms of value, and also in terms of broader multipliers and linkages as regards pro-poor economic growth. Ecosystem service values, therefore, extend well beyond the small-scale/household level.

Therefore, conserving ecosystems, i.e., investing in them because of their economic value to humans, becomes imperative. But, although ecosystems are tremendously valuable to people and national economies, investment in ecosystems is not a mainstream process and is something about which there is still much argument.

The reality is that many of the products and services generated by ecosystems miss detection because they are not traded in markets and therefore, do not come with a price tag. In addition, many of the costs and benefits remain uncaptured, thus missing opportunities for value-addition, for use in poverty alleviation, and for redistributing costs and benefits more equitably. Thus, they remain under-appreciated and undervalued. Because of this, it is difficult to determine what people lose when ecosystems become degraded or are damaged or in contrast, how people benefit from improvements to ecosystems. In this setting of undervaluation and lack of information, investments in ecosystems are traded-off for seemingly more profitable and important uses such as developments including agriculture, aquaculture, infrastructure, that both damage and degrade these ecosystems (Emerton, 2006).

'If ecosystems are to compete against these alternative uses, there is a need to properly value the various products and services provided so they become an investment opportunity with a good chance of return. Therefore, it is important to value ecosystems so that economic comparisons can be made between maintaining ecosystems or using them for other purposes. In order to assess and value the real environmental and livelihoods impacts of ecosystems on communities, it is necessary to be able to quantify and measure ecosystem loss and environmental damage. It is especially important to do this for proposed land conversions to value the environmental costs of such conversions, and to balance these costs against the benefits of keeping the land untouched by development; and also to assess the socio-economic impacts of 'developments' as they impact on ecosystem services and therefore on human and economic well-being. Ultimately, ecosystems must be viewed as developmental infrastructure and valuation of ecosystems used as a decision-making tool in assessing trade-offs with other economic sectors' (Emerton, 2006).

What is the framework for valuation?

In order to assess and value the real environmental and livelihoods impacts of ecosystems on communities, it is necessary to be able to quantify and measure ecosystem loss and environmental damage. It is especially important to do this for proposed land conversions to value the environmental costs of such conversions, and to balance these costs against the benefits of keeping the land untouched by development. Until now, most development projects such as infrastructure development or agricultural expansion have failed to include the environmental costs of the proposed land conversion. Although Environmental Impact Assessments (EIAs) of large infrastructure and agricultural projects are, in many countries, compulsory by law, the negative environmental impacts are often only described qualitatively and not transformed into economic costs that can be compared directly to, for example, the economic benefits of, for example, increased agricultural production (Emerton, 2006).

To deal with this issue of measuring ecosystem benefits, the theory of Total Economic Value (TEV) was presented almost twenty years ago as a framework to identify these environmental costs and benefits, which, then, could be mainstreamed into project evaluation.

TEV is now one of the most widely used conceptual frameworks and deals with the following:

- *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);
- *Option values* (premium placed on maintaining an environmental good or service for possible future use);
- *Non-use values* (includes existence value - satisfaction from just knowing that a species or ecosystem is present); and
- *Bequest value* - willingness to pay to ensure that future generations inherit a particular environmental asset and intrinsic value (i.e., the value of a species or ecosystem in its own right independent of any value placed on it by humans).

Figure 11: Total Economic Value (Source: Emerton, 2006)

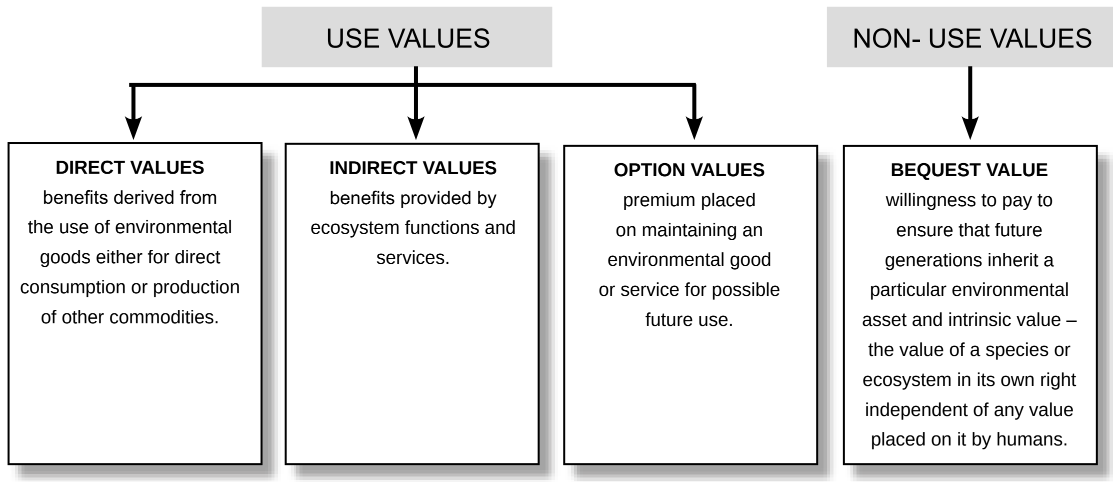
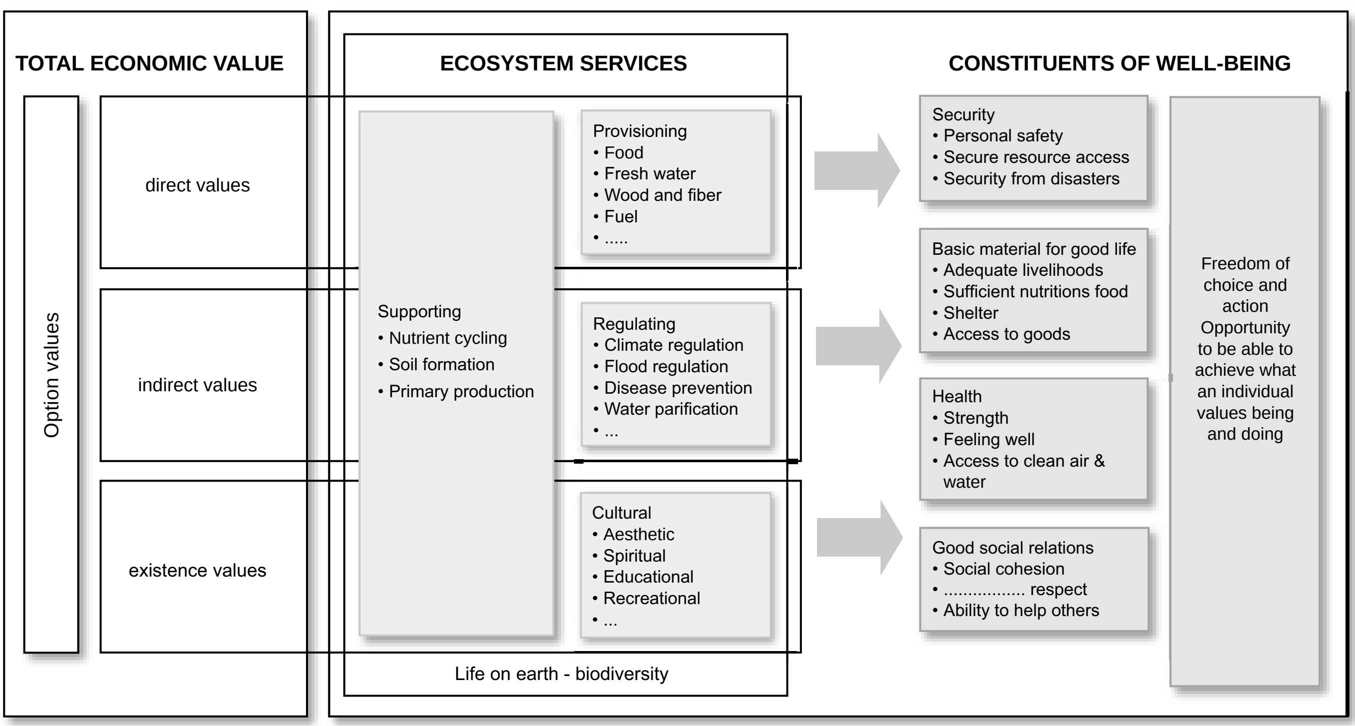


Figure 12: Total Economic Value related to the MA framework (Source: Emerton, 2006)



Now, a wide range of valuation techniques and methods exist and their application is becoming more widespread - although yet to be institutionalised in most conservation and development planning and appraisal processes. These valuation techniques and methods rely on a human-centred approach, so that values are determined by people's preferences. (See Volume 3 for more details.)

Not surprisingly, natural resources make important contributions to the national economies of many Asian countries.

Provisioning Services:

- Annual exports from fishery products from south, southeastern countries and China total 13,411 million USD, with as many as 27 million fishermen engaged in fisheries (WRI, 2002).
- The annual export of marine aquarium fish from Southeast Asia alone is estimated to be between 10-30 million fish with a retail value of up to 750 million USD (Bruckner, 2006).
- The total net value of local fisheries in Ream National Park, Viet Nam is 515,525 USD per annum (Emerton et al., 2002).
- Timber revenues from the forests of Sekong Province earn Lao PDR a total of 605,000 USD per annum (Emerton, 2005).
- The average value of non timber forest extraction is estimated at PPP[10] 2,455 USD per housefold/ year and PPP 40.7 USD/ household/ year in Malaysia (Svarrer & Smith Olsen, 2005).
- The value of medicinal plants extracted from the Sinharaja World Heritage Site, Sri Lanka is estimated to be 22 USD per household (net) and 1.4 USD per hectare for nine months (Batagoda et al., 2000).
- The value of drinking water provided by Bhoj Wetland, India is nearly 2,400,000 USD (Verma, 2001).
- In Maldives marine and coastal tourism contributes almost a fifth of GDP[11] and a third of government revenues (Emerton, 2006).

Regulating Services:

- In India, forests provide water regulation and flood control valued at 72 USD billion per year (http://www.fao.org/docrep/t4450e/T4450E0m.htm).
- Muthurajawala Marsh, Sri Lanka provides flood protection and water treatment services valued at 2,500 USD per hectare to surrounding urban communities (Emerton, 2005).
- The value of fisheries protection by undisturbed forests in Bacuit Bay in the Philippines (calculated through loss and extent of soil erosion) was estimated to be 264 USD per hectare per year (Hodgson & Dixon, 1988).
- The economic value of Asia's wetlands is estimated to be 1.8 billion USD per annum (WWF, 2004).

Supporting Services:

- The value of carbon sequestration in tropical forests ranges from 650 - 3,500 USD per hectare in terms of NPV[12] (IIED, 2003).
- The value of biodiversity and endangered species in terms of value per hectare in Himachal Pradesh, India is 500.6 USD (Verma, 2000).
- The total value of standing stock (an indirect measure of primary production) of the forests in Himachal Pradesh, India is estimated at about 10,200.5 million USD (Verma, 2000).

Cultural Services:

- The total recreational value of Ho Mung Islands, a marine protected area in Viet Nam is estimated to be 7.7 million USD per annum (Khanh Nam & Tran Vo Hung Son, 2001).

Table 2: Economic value of Muthurajawela marsh, Sri Lanka (Source: Emerton and Kekulananda, 2002)

Economic benefit	*Value (USD/year)*	*Value (USD/ha/year)*
Flood attenuation	5,394,556	1,758
Industrial wastewater treatment	1,803,444	588
Agricultural production	336,556	110
Support to downstream fisheries	222,222	72
Firewood	88,444	29
Fishing	69,556	23
Leisure and recreation	48,000	16
Freshwater supplies for local populations	42,000	14
Total	8,072,111	2,631

[10] PPP is Purchasing Power Parity: the estimate of the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power.
[11] GDP is Gross Domestic Product; the total market value of all goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.
[12] NPV is Net Present Value: the sum of discounted net benefits (i.e. benefits minus costs), which shows whether a project generates more benefits than it incurs costs.

The difference between natural hazards and natural disasters

The difference between natural hazards and natural disasters must be made clear in this section. A natural hazard is a naturally occurring phenomenon that is harmful to humans and has the potential to cause damage. Natural hazards are, therefore, events such as drought, wildfires, cyclones, typhoons, earthquakes and tsunamis. Natural hazards cannot be prevented, but they can be expected (http://www.unesco.org/science/disaster/about_disaster.shtml.).

A natural disaster occurs when a natural hazard causes a large number of deaths, displacements and damage to human well-being, as well as to ecosystem well-being. Applying various safeguards can prevent or reduce the effect of natural disasters – i.e., natural disasters can be reduced or prevented. *This is a basic difference between a natural hazard and natural disaster.*

It should also be noted that natural hazards do not automatically give rise to natural disasters. Many human actions - such as bad land use planning, deforestation, human development in hazardous areas - worsen the impacts of natural hazards and cause natural disasters.

Risk and vulnerability

Risk is the potential of a natural hazard to cause damage. But risk is not equal among communities and people. Some people are more at risk from a natural hazard than others. The impacts are different for different people because some people are better able to cope with a natural hazard than others. *The difference in the capability to cope is vulnerability.*

Various elements such as social, environmental, economical and infrastructural factors affect the capability of communities to cope with disasters (Kasperson & Kasperson, 2001). For example, consider a house that has been built on a slope. The risk for the damage is from a landslide. The people whose house is built on this slope are, therefore, physically vulnerable to landslides. The poor and the marginalised are more vulnerable to natural hazards as they lack basic necessities of life – they are socially vulnerable. Communities who are resistant to change and are negative in their approach to life are attitudinally vulnerable. People living near degraded ecosystems and lack basic ecosystem services are environmentally vulnerable.

Figure 13a: The different elements of vulnerability

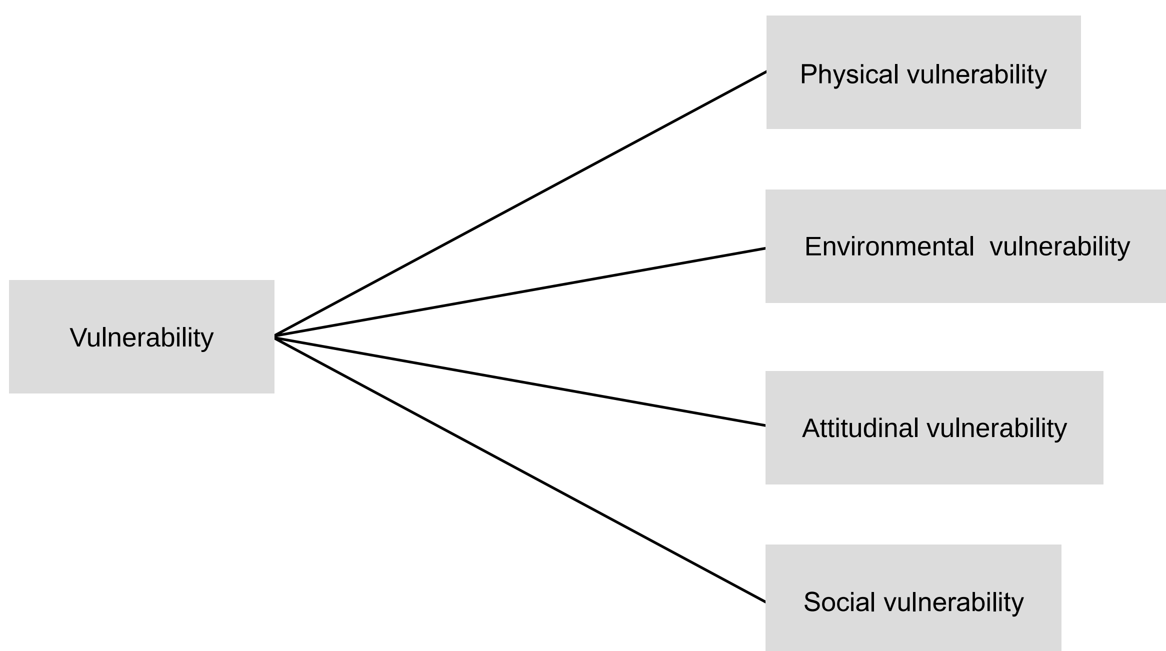
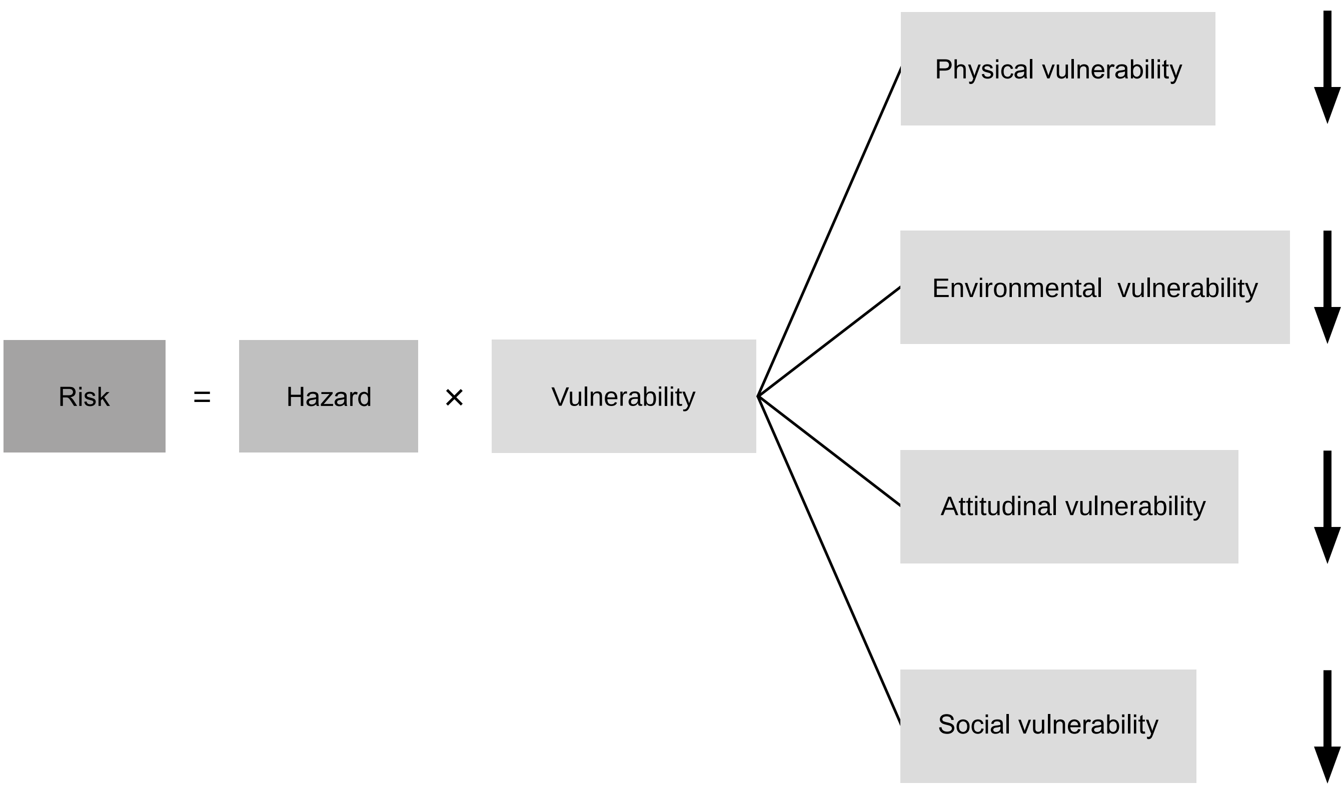


Figure 13b: The relationship between risk, hazard and vulnerability

Risk = Hazard × Vulnerability

The force of a hazard at a given time is constant - i.e., you can not change the hazard. Given that constant, in order to reduce risk, all components of vulnerability must be reduced.

Figure 13c: Risk, hazard and the different elements of vulnerability



Preparing for natural disasters is all about reducing vulnerability.

Natural hazards

Natural hazards can be a) geological, b) hydrological and c) climatic. Because of various factors, some areas of the earth are more prone to certain kinds of hazards than others.

Geological hazards

Earthquakes:

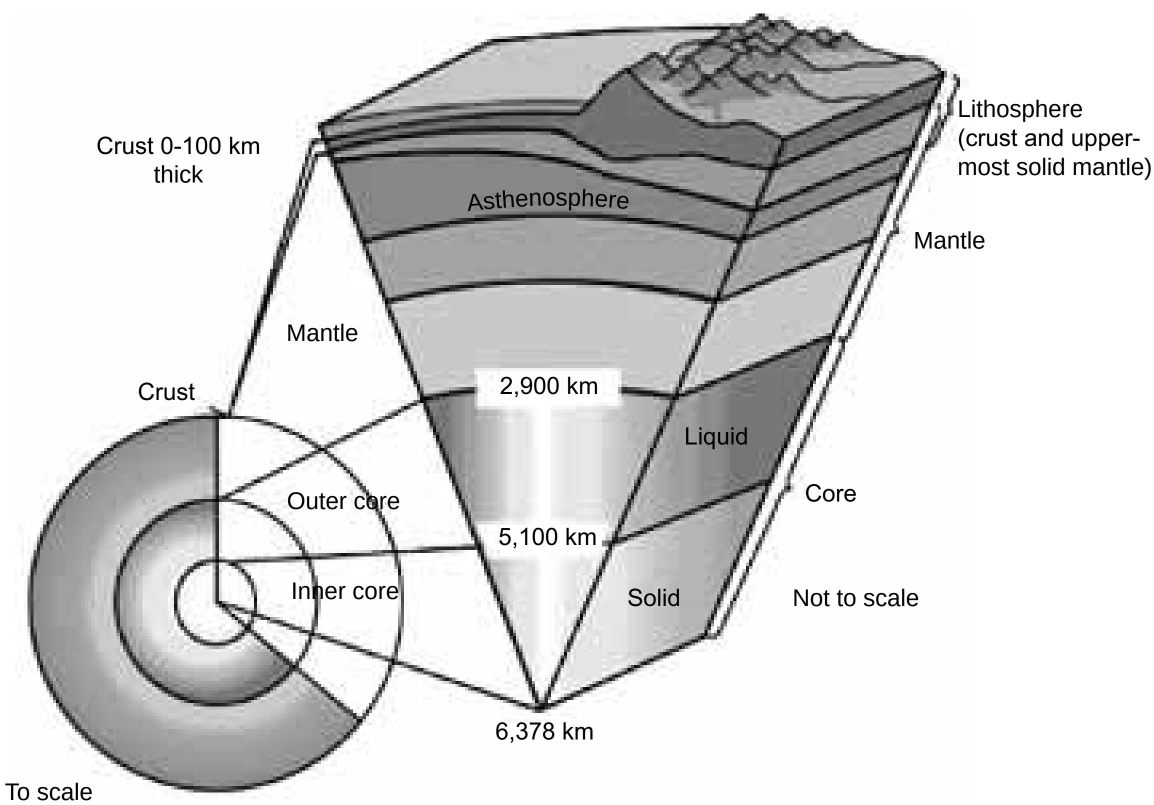
These hazards originate from geological[13] conditions. In order to understand some geological hazards, it is necessary to detail the theory of plate tectonics.

The structure of the earth is rather like that of a par-boiled egg. Outermost is the earth's *crust*, which is hard and brittle. Under that is a hotter and denser, semi-solid rock called the *mantle*. Right at the centre of the earth is the *solid core* (made up of inner and outer parts). Each layer has different chemical and mechanical properties.

The uppermost part of the mantle is harder than the rest, and with the crust, forms the *lithosphere*[14], which functions like a shell. Like a shell, this lithosphere is brittle and can fracture.

Underneath the lithosphere is the part of the mantle that is dense and semi-solid, and the inner *asthenosphere*[15]. Although the asthenosphere is a semi-solid, it can compress, stretch and flow without fracturing, in the same way that cream flows (http://csmres.jmu.edu/geollab/fichter/PlateTect/erthstru.html).

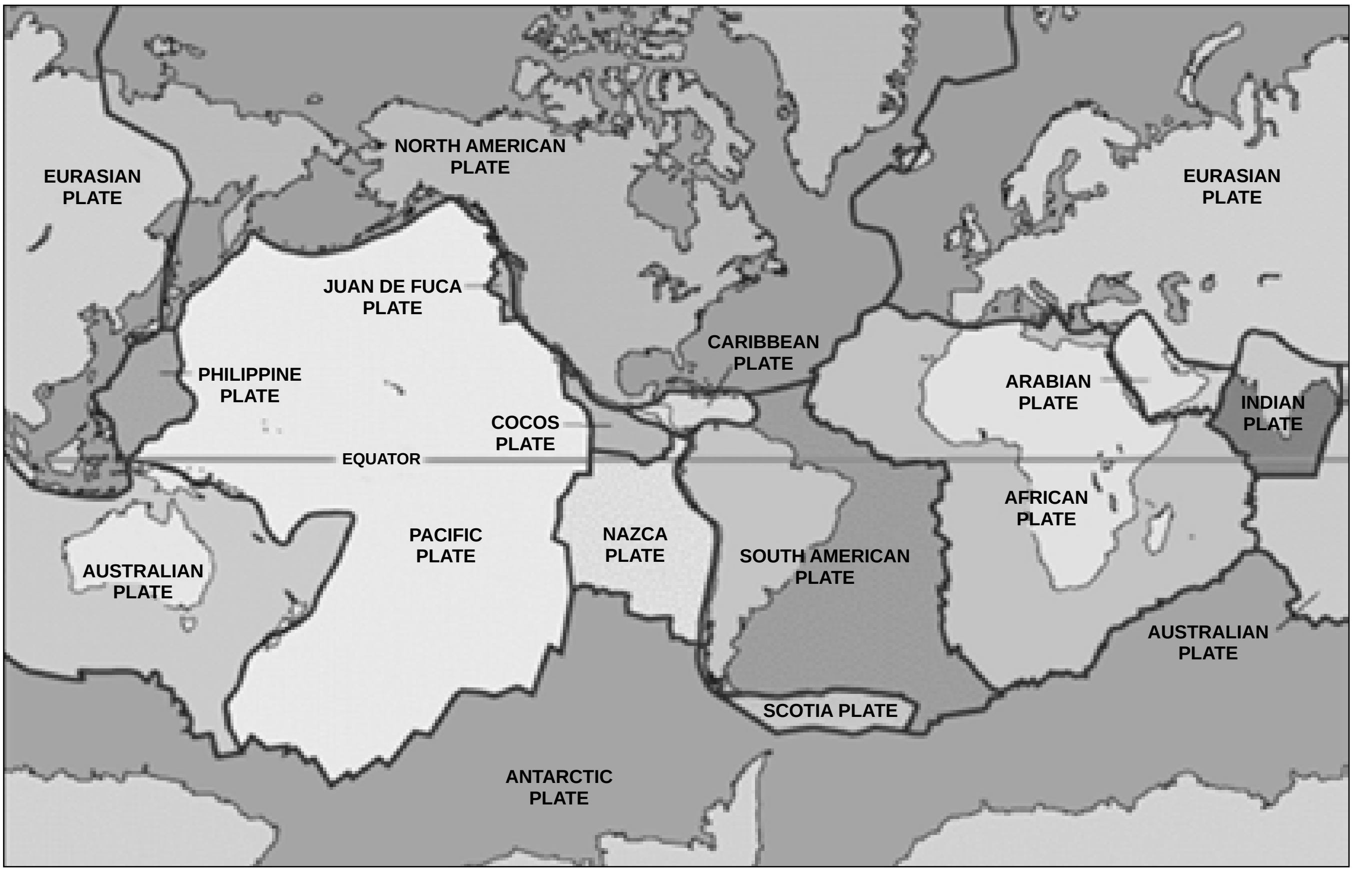
Figure 14: Cutaway views showing the internal structure of the earth
(Source: http://pubs.usgs.gov/gip/dynamic/inside.html)



[13] Geology is the science of the solid matter that makes up the earth.
[14] '*Lithos'* is stone in Greek.
[15] '*Sthenos'* means without strength in Greek.

Tectonic theory explains that the lithosphere is made of separate tectonic plates, which float on the more fluid asthenosphere. The surface of the Earth consists of 14 major plates and 38 minor ones, totalling 52 plates.

Figure 15: Tectonic plates of the world (Source: http://geology.about.com/library/bl/maps/blcrustalplates.htm)



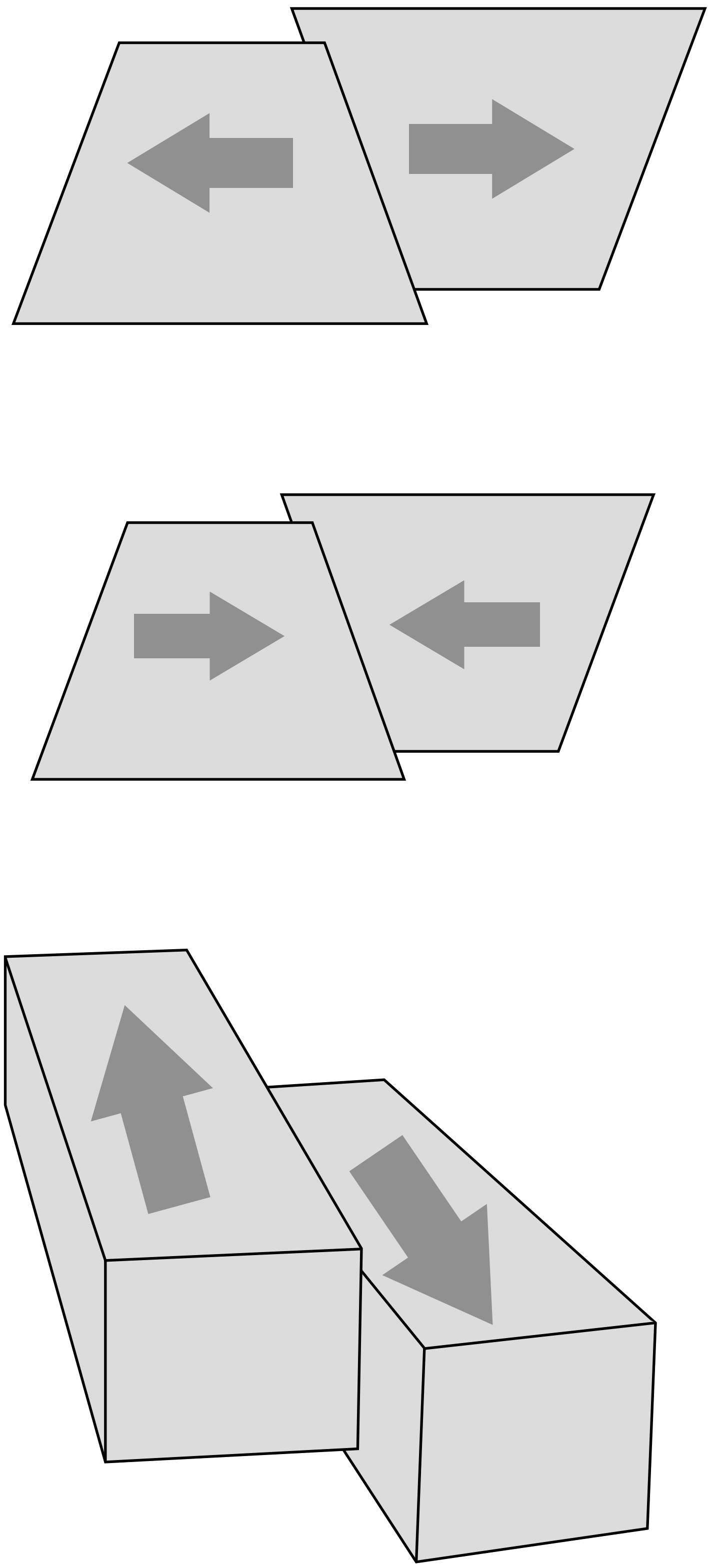
Lithospheric plates are about 100km thick and are made up of both oceanic and continental areas.

The heat from the core of the earth moves outward constantly towards the outer mantle (the asthenosphere), which, already being hot and liquid, moves, because of this heat, towards the surface. The points at which this heat surfaces are at ocean ridges. The hotter liquid rises to the surface and spreads sideways, taking the lithospheric plates (both oceans and continents) with it as if on a slow conveyor belt. These movements – called tectonic movements – happen because the lithosphere is solid and the asthenosphere is not. Plates move, on average, about 10-40mm per year.

The lithospheric plates form three types of boundaries.

1) *Divergent or extensional* boundaries – where plates move away from each other (as seen in the East African Great Rift Valley);
2) *Convergent of compressiona*l boundaries – where plates move towards each other (as seen in the Sumatra-Andaman earthquake); or
3) *Strike slip or transform boundaries* – where plates slide past each other (as seen in the San Andreas fault in California). (See Figure on opposite page.)

Figure 16: Types of boundaries: top: *Extensional*; middle: *Compressional*; and bottom: *Transform* (Source: http://geology.about.com/library/bl/blnutshell_fault-type.htm)



When a lithospheric plate under the sea converges against another plate under the sea or on land, it sinks (is *subducted*) into the asthenosphere. These subduction zones are sea trenches. In contrast, when two lithospheric plates on land converge, they bang together to form huge mountain ranges. For example, when the Deccan (Indian) plate – consisting of the Indian subcontinent – crashed into the Eurasian plate, the great Himalayan range of mountains were formed.

When plates move at boundaries, there is friction and the earth shakes or becomes displaced – causing earthquakes.

The deepest earthquakes and the ones with the greatest magnitude take place at compressional boundaries, where they can go as deep as 700km and their magnitudes can be as high as 9 on the Richter[16] scale. Earthquakes at transform boundaries are usually less than 8.5 on the Richter scale and are shallow – about 25km deep. Earthquakes at extensional boundaries are the least powerful and are usually less than an eight on the Richter scale[17].

The epicentre of an earthquake is the point on the Earth's surface that is directly above the point where an earthquake starts.

The 2004 Indian Ocean earthquake (also known as the Sumatra-Andaman earthquake) occurred in the ocean when the India plate slipped about 15m under the Burma plate, causing an earthquake whose epicentre was north of Simeulue Island, off the western coast of northern Sumatra. The magnitude of the earthquake was measured to be 9.3 on the Richter scale and is the second largest earth quake ever recorded. (Since 1900, the only other earthquake recorded with a greater magnitude was the 1960 Great Chilean Earthquake with a magnitude 9.5.) The length of the entire earthquake site (fault zone) was about 1,200km, and the sea floor displaced by an average slip of 11m with a maximum of 20m.

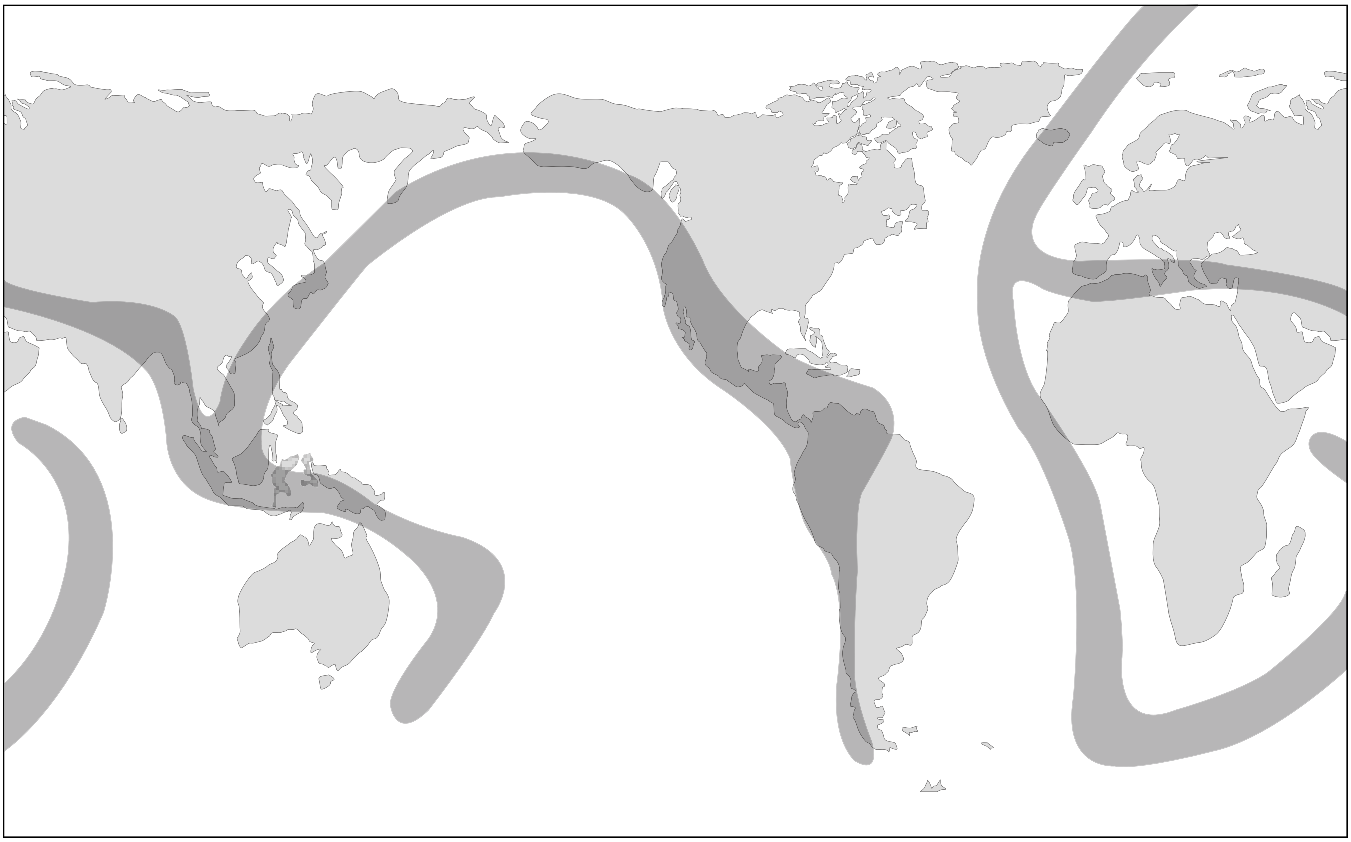
The 2004 Indian Ocean earthquake has also the longest duration of faulting ever observed, lasting between 8.3 to 10 minutes, and it was large enough that it caused the entire planet to vibrate over a centimetre. It also triggered earthquakes in other locations as far away as Alaska (http://www.en.wikipedia.com).

[16] The Richter scale is a scale for measuring the magnitude of earthquakes. The scale is logarithmic so that a recording of 7, for example, indicates a 'shaking' of the ground 10 times as large as a recording of 6.

[17] Tsunamis are created by relatively shallow earthquakes of high magnitude.

It should be noted clearly that earthquakes do not happen randomly in the world, but are usually concentrated near tectonic plate boundaries. Therefore, some areas are more earthquake prone than others. For example, California in the US is an earthquake prone area, while Florida is not.

Figure 17: Earthquake prone areas in the world
(The dark grey swathes depict areas where earthquakes are most likely to occur.)
(Source: www.pvsd.ca/.../planning/thecrust/thecrust.htm)



- An earthquake measuring 3-5 on the Richter scale is considered minor to light; 5-7 is moderate to strong; 7-8 is major and 8 or more is great.
- It is estimated that there are 500,000 detectable earthquakes every year. Of these, 100,000 can be felt and 100 cause damage.
- The U.S. Geological Survey locates 12,000 to 14,000 earthquakes each year; that is, about 35 per day.
- Southern California has an average of about 10,000 earthquakes per year. The majority of these quakes are minor.
- About 20 major earthquakes occur every year (http://science.nationalgeographic.com/science/earth/natural-disasters/earthquake-profile.html).

Volcanoes:

Volcanoes are openings in the earth's surface through which liquid material from the earth's core (*magma*), gases, and other substances burst open (*erupt*).

Volcanoes are found commonly at tectonic plate boundaries, but there are also volcanic hot spots (such as the Hawaiian Islands), which are other places in the earth's crust where magma erupts.

Some volcanoes erupt explosively, while others erupt slowly. Some volcanoes release toxic gases, hot rock and hot ash. Volcanoes can trigger other natural hazards such as earthquakes, landslides, tsunamis (in the case of undersea eruptions) and fires.

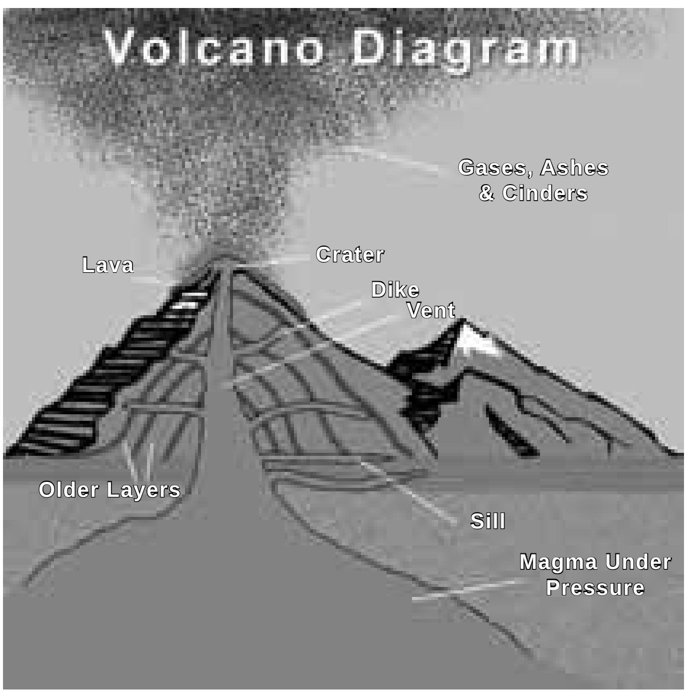
Because volcanoes are found at tectonic plate boundaries, earthquake prone areas and volcanic areas overlap. Elsewhere in the world volcanoes are found in the Pacific Rim (which outlines the Pacific Ocean), also called 'the Ring of Fire' because of its long history of volcanic eruptions. Many countries around this 'Ring of Fire' are at risk from volcanic eruptions. These include Japan, the Philippines, Indonesia, New Guinea, New Zealand, and many of the South Pacific Islands as well as Chile, Peru, Ecuador, Columbia (http://pubs.usgs.gov/gip/volc/text.html.).

There also are volcanoes in the Mediterranean and Middle East including Italy, Greece, Turkey, Iran, Saudi Arabia, Yemen and Pakistan. The Great Rift Valley in eastern Africa also has many volcanoes found in the countries of Ethiopia and Kenya.

It is estimated that there are at least 1,500 and as much as 3,000 active volcanoes in the world.

Volcanoes can occur at any time of year or day. Because volcanoes erupt over and over again, layers of lava erupt and harden resulting in the formation of a mountain – called a volcanic island if it is formed in the sea (http://pubs.usgs.gov/gip/volc/text.html).

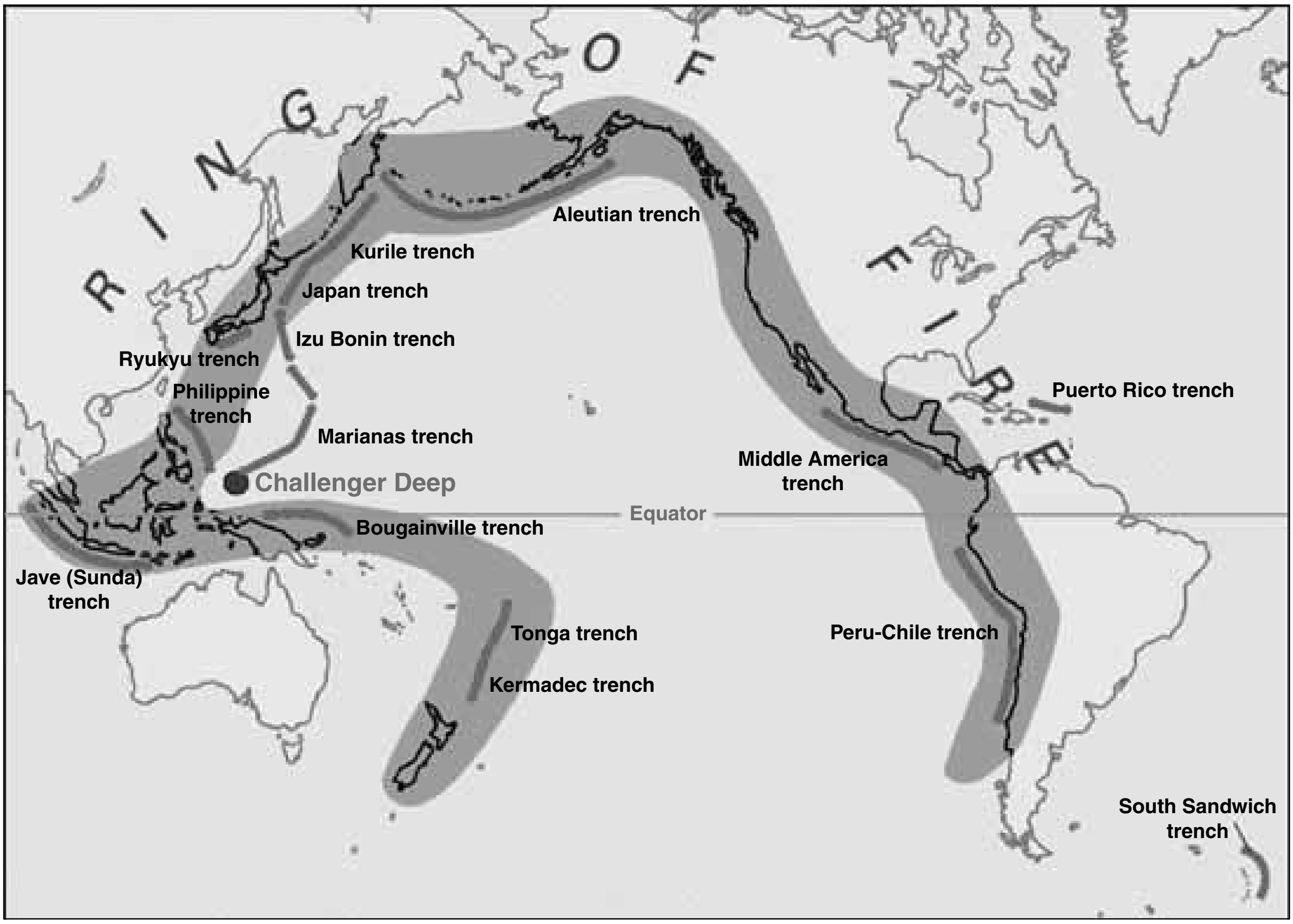
Figure 18: Cross section of a volcano
(Source: http://pubs.usgs.gov/gip/volc/text.html)



Mount Vesuvius is a volcano found near the city of Naples in Italy. Its eruption in AD 79 led to the destruction of the Roman cities of Pompeii and Herculaneum. It has erupted many times since then and is considered as one of the most dangerous volcanoes in the world because 3,000,000 people now live close to it (http://en.wikipedia.org/wiki/Mount_Vesuvius).

Krakatoa is a volcanic island in the Sunda Strait between Java and Sumatra in Indonesia. Throughout history, it has erupted repeatedly with disastrous consequences. The best known eruption was in 1883, which expelled more than 25km^3 rocks and ash and generated the loudest sound recorded in history. The sound was heard as far away as Australia and islands near Africa (http://en.wikipedia.org/wiki/Krakatoa).

Figure 19: Volcano prone areas in the world - The Pacific 'Ring of Fire'
(The darker grey swathes depict areas where volcanoes are common.)
(Source: http://upload.wikimedia.org/wikipedia/commons/thumb/0/09/Pacific_Ring_of_Fire.png/800px-Pacific_Ring_of_Fire.png)



Landslides:

Landslides are mass movements of rock, debris and soil down a slope of land. In nature, landslides can be caused by many events. Any time tectonic plates move, the soil that covers them moves with it. When earthquakes occur in areas with steep slopes, this soil can slip causing landslides. Volcanic eruptions, melting glaciers, excessive snow and rainfall and erosion from rivers can also cause landslides.

The structure of soil, the amount of rain, the water table and the steepness of the slope are all factors that influence landslides. The large amount of soil loosened and released by a land slide can, on occasion, be carried down as debris flows that have buried whole villages.

An unusually strong storm in December 1999 poured down 911mm of rain over just a few days in the Vargas state of Venezuela, triggering soil instability and flow of debris (http://en.wikipedia.org/wiki/1999_Vargas_mudslide).

Hydrological Hazards

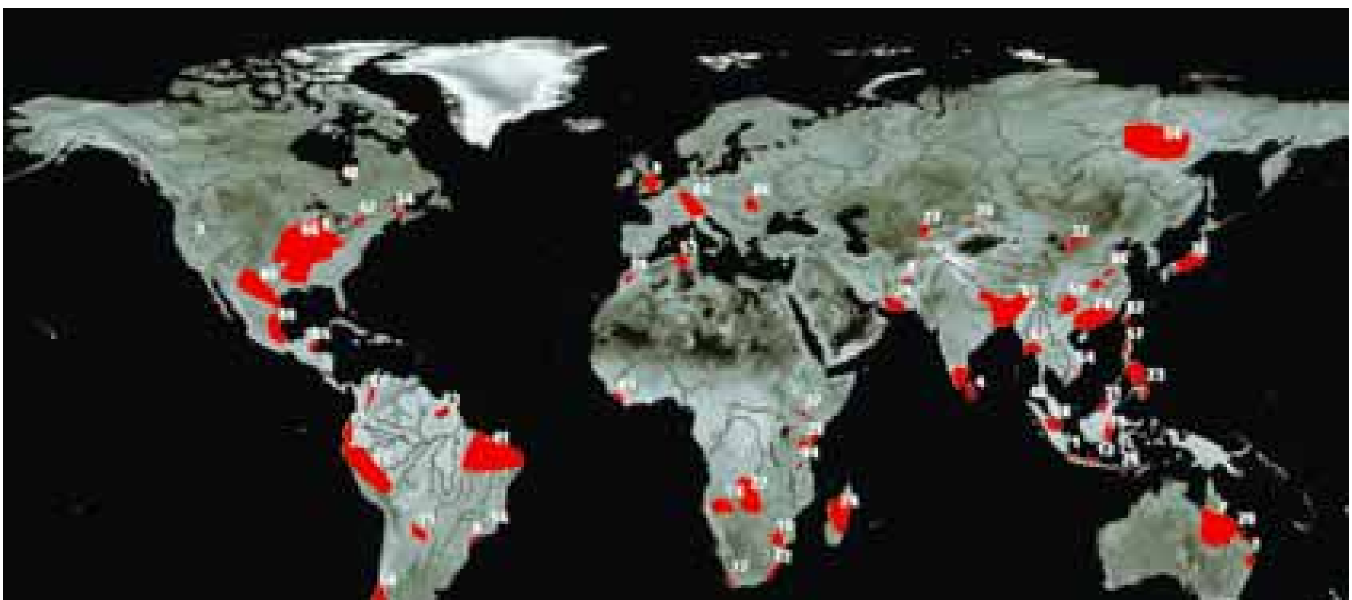
Hydrological hazards originate from and relate to the activities of water. There are many types of hydrological hazards.

Floods:

Floods occur when usually dry areas on banks of rivers, streams, lakes, or coastal areas become submerged with water. Floods can be set off by severe thunderstorms, tornadoes, tropical cyclones, monsoons or melting snow. In coastal areas, storm surges caused by tropical cyclones, tsunamis, or rivers swollen by extremely high tides can cause flooding. Floods occur in both dry and wet environments and in mountains and lowlands. In dry areas, especially those situated at the base of mountain ranges, flash flooding[18] can occur. This is an extremely dangerous type of hazard resulting from intense rainfall in a short period of time that moves, at high speed, downhill.

In temperate regions around the world, spring floods are common and occur because of melting snow. In tropical regions – particularly in Asia - monsoons bring heavy rains that cause recurrent floods.

Figure 20: Major floods reported in 2008 (Source: Dartmouth Flood Observatory)



[18] Flash floods can occur after a period of drought when heavy rain falls onto very dry, hard ground that the water cannot penetrate.

The land area of Bangladesh consists of a vast floodplain formed by a network of rivers connected to three major rivers that supply the Delta. There is an entirely separate area, supplied by the Karnaphuli river, which is not prone to severe flooding, in the south east corner of the country. The combined flood plains of the Ganges, Brahmaputra and Meghna rivers provide much of the very fertile and productive agricultural land. These rivers serve as the main source of water for cultivation, for commercial transportation and for the provision of fish. More than 60% the net arable land is cultivated in the rainy season and nearly 40% of the land is cultivated during the dry winter months. The flat terrain makes it impractical to construct gravity-fed irrigation canal systems. The plentiful groundwater, annually re-charged by the monsoons, is extracted everywhere for irrigating fields.

These rivers of Bangladesh shape both its terrain and the livelihoods of its people. Bangladesh has a land area of only 144,000km^2 (http://www.en.wikipedia.com) but the Brahmaputra (Jamuna) and Ganges which originate far away from the borders of Bangladesh on either side of the Himalayan range reach bring an enormous combined runoff which has to pass through Bangladesh to reach the sea. The Meghna, although it has a relatively much smaller basin, drains areas such as the Megalaya hills that experience some of the highest rainfall in the world.

Before 1776, the Brahmaputra and Ganges flowed separately into the Bay of Bengal. A major earthquake in 1776 shifted the course of the Brahmaputra towards a minor river called Jamuna, which connected it to the Ganges. Jamuna has now taken over as the major channel of the Brahmaputra, meeting the Ganges at Aricha to the west of the capital city Dhaka. The combined flows of the Jamuna and Ganges are conveyed by the Padma river. The Padma then meets the Meghna and together they flow into the Bay of Bengal as the Lower Meghna.

The Jamuna (as the Brahmaputra is known in Bangladesh) has many tributaries (such as the Teesta and Atrai) that flow in from the west and several distributaries (or spill channels) that carry water eastwards and south. The downstream reaches of the Ganges which also has many tributaries feed it from the north on its left bank, has many right bank distributaries carrying water and flood overflows southwards, into the southwest region of Bangladesh - which is a network of river channels and tidal creeks of all dimension intimately connected to the tides (with a range of approximately 3m) of the Bay of Bengal. Many of these distributaries reach the Bay of Bengal though very large estuaries that were, many years ago, the successive outlets of the Ganges.

The flood plain levels are determined by the settling of sediments carried by the overbank flow of flood water. It is usual for at least a part of the flood plains to be flooded every year. In the coastal regions such as the Sundarban mangrove forest, the land levels are such that they are flooded by the highest tides (about 2m above sea level). The deposition of silt makes the delta grow outwards, as well as raising the flooded areas by very small amounts every year. However, consolidation of land under its own weight over the centuries partly counteracts the effect of siltation.

The overall land profile of Bangladesh rises gradually from about 2m above sea level in the south to only about 12m in the north of the country. In the north east however, the land levels are very low – even below 2m in some areas. This results in these lands being flooded for several months after the flood has passed. The water levels in the major rivers of Bangladesh might fluctuate by 9m from the driest season to the highest flood. The fact that the three major rivers meet means that they can affect each others flood levels. The worst possible floods occur when the flood peaks of the Ganges and Brahmaputra coincide.

The combination of the three major, easily flooded rivers, the low lying nature of the terrain, makes Bangladesh one of the most flood prone countries in the world (www.country-studies.com/bangladesh/riversystems.html). In 1998, Bangladesh was hit by the 'worst flood of the century' which covered approximately 100,000km^2 (one third the size of Great Britain and 66% of the land area) for two and a half months from July to September. At the height of the floods, 52 out of 64 administrative districts were flooded. Heavy rainfall in the catchment area of three major rivers (Ganges, Brahmaputra, Meghna) combined with above normal melting of ice in the Himalayas created this enormous flood (Dartmouth Flood Observatory, 2008).

(Source: Ranjit Galappatti, personal communication.
Map: http://upload.wikimedia.org/wikipedia/commons/e/ef/Bangladesh_LOC_1996_map.jpg)

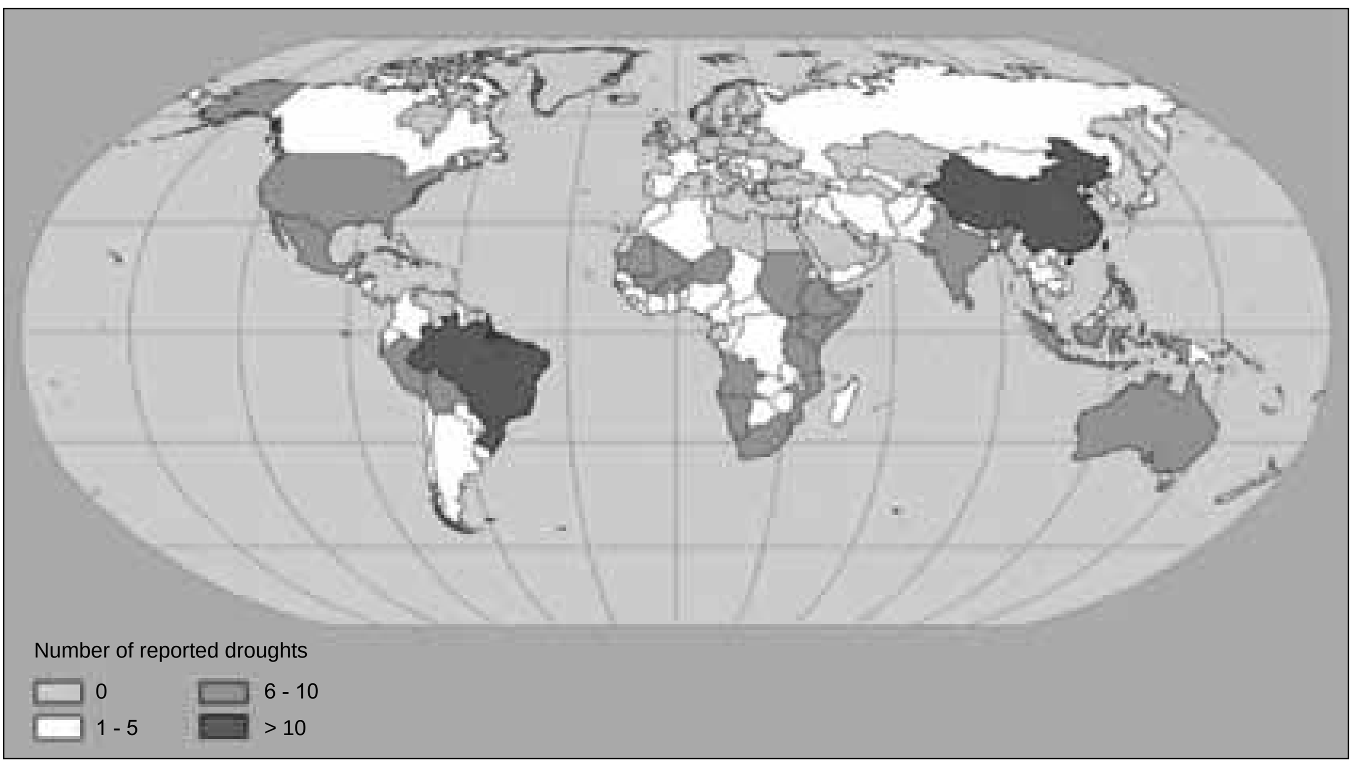
Drought:

If floods are caused by the excess of water, then drought is caused by the opposite: the lack of water. A drought is an extended period during which there is no soil water. When a drought occurs, there is not enough water for human needs, agriculture and ecosystems.

Droughts must not be confused with dry seasons. For example, in Sri Lanka, the northeastern, northwestern and southeastern parts of the island are fed only by a single monsoon – the north east monsoon which extends from November to February each year. For the rest of the year, there is an annual dry season from March to August. When the north east monsoons are delayed, then the dry season can become extended, causing a drought.

In Australia, in late 2006, rain that falls between late winter and mid spring failed. The average rainfall in South Australia that resulted was the lowest since 1900, causing a drought (http://en.wikipedia.org/wiki/Drought_in_Australia).

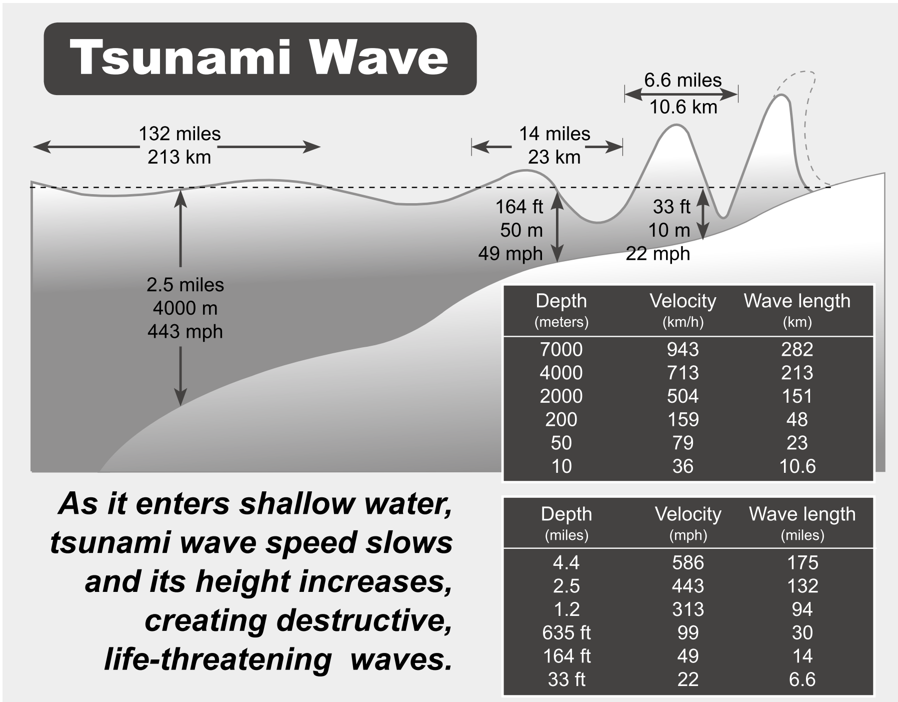
Figure 21: Number of drought disasters reported by country: 1970-2006
(Source: Centre for epidemiology of disasters, 2007)



Tsunamis[19] :

A tsunami is a series of waves that is generated when a large body of water is displaced. The most common natural cause of a tsunami is an earthquake, followed by volcanic eruptions. When the sea floor changes as a result of an earthquake (mostly commonly through subduction at plate boundaries), water is displaced vertically. This water then radiates like ripples in a pond.

Figure 22: Diagram of a tsunami waves
(Source: http://ioc3.unesco.org/itic/files/tsu_wave_characteristics.pdf)



There is difference of an order of magnitude between the properties of tsunami waves and wind waves normally observed in the sea. Waves are characterised by their *height,* their *period* (the average time taken between two wave crests passing a given point) and the *wave length* (the distance between two crests). Normal ocean waves have heights in the range of a few a centimetres in a very sheltered area, to even ten metres at the worst of a severe storm. The wave periods observed are a few seconds in choppy seas to swell waves of periods up to 20 seconds or more. Tsunami waves, on the other hand, have periods of the order of 20 minutes (more than 1,000 seconds) and wave lengths exceeding 200km in deep water.

Deep water waves (where the wave length is much larger that the water depth) propagate at speeds proportional to the square root of the wavelength. In shallow water where the water depths are much smaller than the wavelength, the speed of propagation of waves is proportional to the square root of the water depth. Paradoxically, tsunami wavelengths are so large that they behave like shallow water waves even in the deepest ocean. A tsunami wave - which travels as fast as a jet aircraft over the deep ocean - will slow down as soon as it crosses the continental shelf and really come down to ordinary wave speeds as it approaches the shore. As the wave slows down it shortens and steepens. The wave height that was less than a metre in deepwater could be more than ten metres high as it comes ashore. This not an unfamiliar phenomenon – the waves we witness on the beach (which do not appear to be very high when they are out at sea) – also slow down and grow in height before they come ashore.

- Japan has the most recorded tsunamis of all the countries of the world. The number of tsunamis totals 195 over a 1,313 year period, averaging one tsunami every 6.7 years, the highest rate in the world. (http://en.wikipedia.org/wiki/Historic_tsunami)
- The Indian Ocean tsunami of December 2004 displaced a trillion tons of water (Kerr, 2005).

[19] The word tsunami comes from the Japanese meaning harbour (‘*tsu*’) and wave (‘*nami*’). Fishermen coming into the harbour after tsunami found the harbour wrecked but had not observed any disturbance in the open sea.

Climatic hazards

Climatic hazards are those hazards that are associated with the climate and weather.

Hurricanes//Tropical Cyclones/Typhoons:

The name of this natural hazard depends on where it occurs: it is called a *typhoon* in the western North Pacific and South China Sea; a *hurricane* in the Atlantic, Caribbean, Gulf of Mexico, and in the eastern North and central Pacific Ocean; and a *tropical cyclone* in the Indian Ocean and South Pacific region. In this manual, the term tropical cyclone will be used.

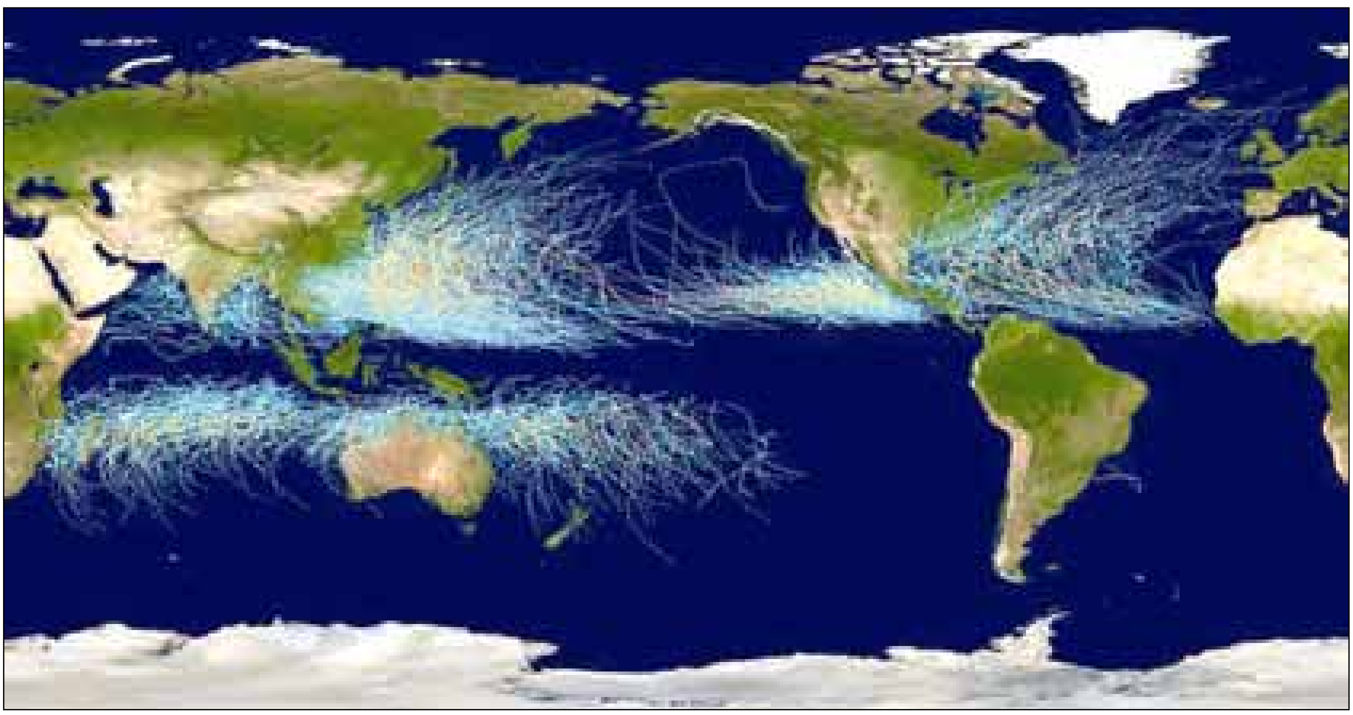
Tropical cyclones are huge, rotating masses of wind and thunderstorms up to hundreds of kilometres across, which form around areas of very low atmospheric pressure over warm tropical waters. Winds can reach speeds of 200km per hour or more. Tropical cyclones, therefore, produce not only heavy, lashing rain but also gale-force winds. The combination of wind-driven waves and the low-pressure of a tropical cyclone can produce a coastal storm surge (a raising of the sea level) which, when approaching the shore, can flood coastal areas and wash away everything in its path.

As the cyclone moves over land, it loses energy, so coastal areas are most affected by tropical cyclones.

About 80 tropical cyclones form every year (http://www.aoml.noaa.gov/hrd/tcfaq/C5c.html.).

Like earthquakes and volcanoes, tropical cyclones are more common in some areas of the world than others. They are found in a belt between 10-30° latitude from the equator.

Figure 23: Distribution of tropical cyclones
(Source: http://upload.wikimedia.org/wikipedia/commons/2/23/Global_tropical_cyclone_tracks-edit2.jpg)



Typhoon Tip is the largest and most intense tropical cyclone on record. It developed near the Pacific island of Pohnpei in 1979. After passing Guam, it reached peak winds of 305km/hr and a worldwide record low pressure of 870mbar and it was the largest tropical cyclone on record with a diameter of 2,220km (http://en.wikipedia.org/wiki/Typhoon_Tip).

Other natural hazards

Wildfires:

Wildfires (also known as bushfires) are uncontrolled fires in forests, grasslands and scrublands. In areas where wildfires are common, the climate is moist enough to let vegetation grow effectively, but there is a long, dry, hot spell during which vegetation becomes dry enough to burn. Volcanic eruptions, lightning and changes in climatic conditions can set off wildfires.

Forest fires are natural parts of ecosystems in many forest types. For example, in coniferous forests they are a frequent and expected event and both flora and fauna are adapted to cope with fire.

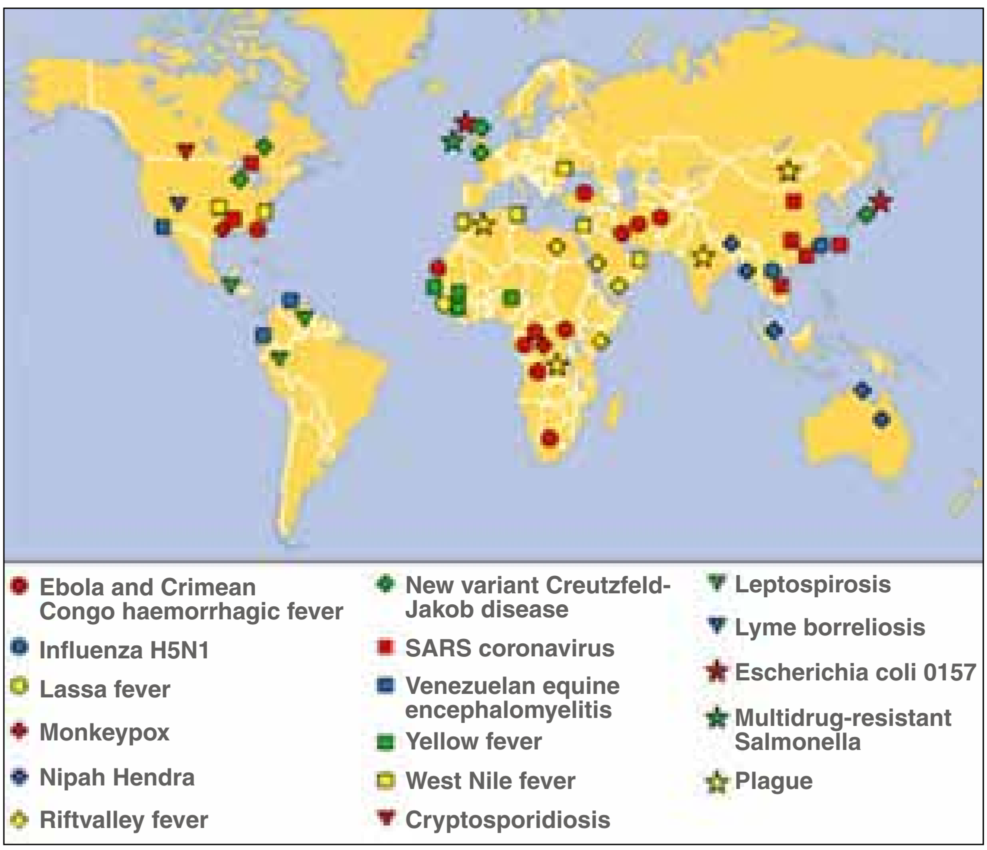
Wildfires occur in much of Australia and forested areas of the USA and Canada, as well as in the grasslands of South Africa.

> In 1998, a severe drought and some strong but dry storm fronts sparked off fires in Yellowstone National Park in the USA burning a total of 3,213km² or 36% of the park (http://en.wikipedia.org/wiki/Yellowstone_fires_of_1988).

Disease:

Infectious disease that can spread rapidly through a population is also a natural hazard. A disease that spreads in a particular locality is called an *outbreak* and one that spreads through a country or a region is called an *epidemic*. A disease that spreads throughout the world is a *pandemic*.

Figure 24: Emerging and re-emerging diseases (Source: WHO, 1996)



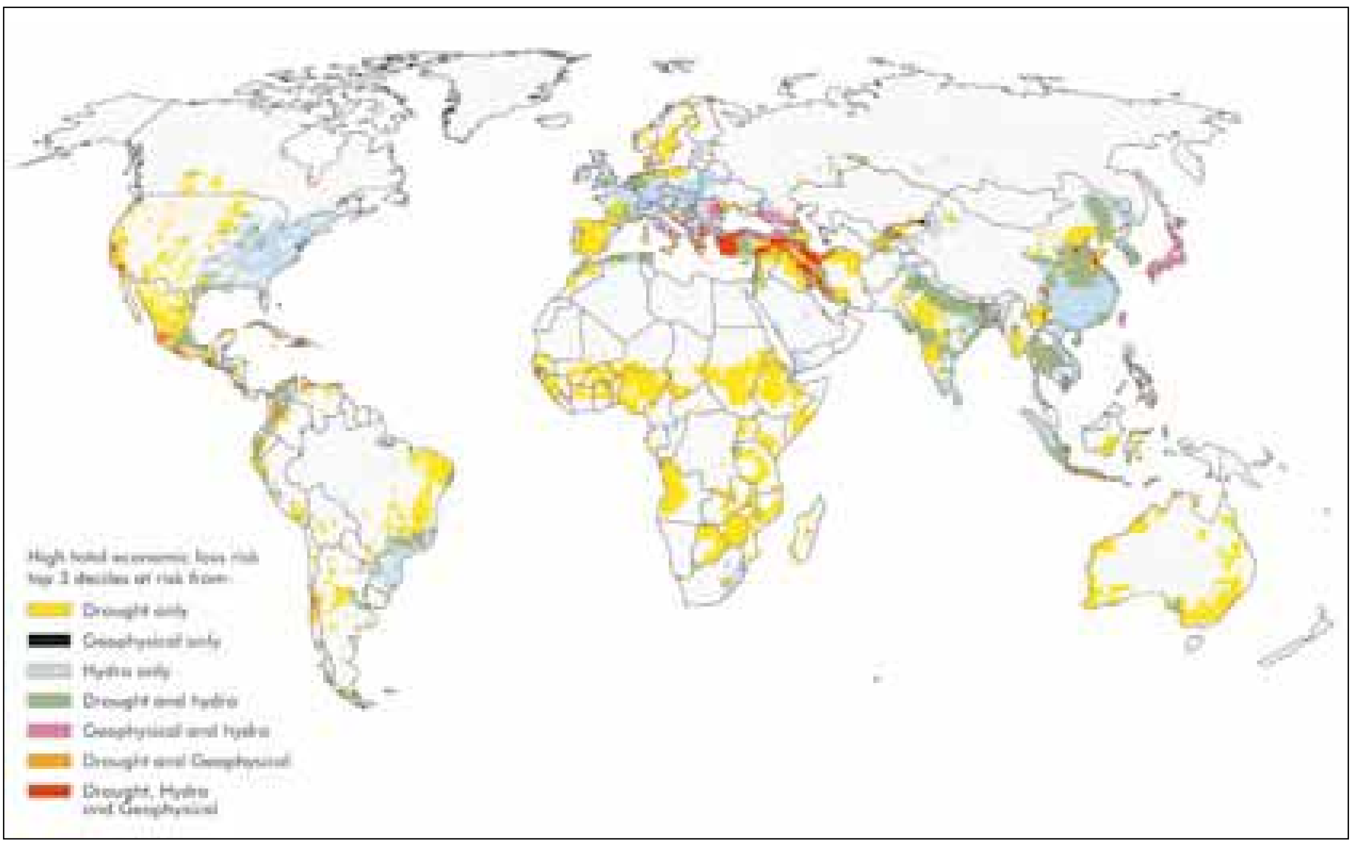
Dengue, chikungunya, Ebola and influenza are such infectious diseases.

Some diseases – such as malaria, yellow fever, cholera and diphtheria - are re-emerging diseases. That is, they are diseases that have been around for decades or centuries, but have come back in a different form or at a different location. In addition, now there are emerging diseases – those that have not been recorded before – such as HIV/AIDS, Severe Acute Respiratory Syndrome (SARS) and Avian Flu.

It is estimated that, globally,

- There are about 1,400 earthquakes every day and a volcano erupting every week (McGuire, 2002).
- There are about 40 fully formed tropical cyclones every year (Lal, 2001).
- Floods and landslides are too many to count.
- A new satellite-based method for early detection, monitoring and analysis of drought shows that nearly 20% of the earth has been affected by drought over the past two years (http://www.publicaffairs.noaa.gov/releases2001/oct01/noaa01102.html).
- An average of 15,000 fires burn 23,000m^2 of forest, grass, crop and townships each year in Australia (http://www.acfonline.org.au/news.asp?news_id=66&c=294135).
- In the last five years alone, the World Health Organization has identified more than 1,100 epidemics in the world, including cholera, polio and bird flu (WHO, 2007).

Figure 25: Natural hazard hotspots, by risk type (Source: UNEP/GRID-Arendal, 2008)



Natural disasters

Natural disasters

Natural disasters occur when natural hazards cause death and destruction. When vulnerability is high, then the risk from a hazard increases. Vulnerability increases through many human activities such as:

- Inappropriate land use: such as building in areas prone to floods, on slopes prone to landslides, coastlines prone to hurricanes and storm surges, or volcanic slopes prone to volcanic eruptions.
- Increasing the severity of a natural hazard: for example, deforesting hill slopes worsens floods, and over-grazing by livestock worsens drought.
- Increase in human population: population growth, urbanisation, improperly built housing and public buildings, poor infrastructure maintenance, increasing poverty. For example, increased poverty and population worsen the effects of drought and cause famine, which is a natural disaster.
- Alteration of the natural environment: for example, deforestation, land reclamation of wetlands, over-grazing of grasslands.
- Globalisation: increased air travel is increasing disease epidemics and pandemics.

Natural disasters can be grouped according to how fast or slow they occur.

Table 3: Rapid and slow onset and cyclic disasters.

Type of disaster	*Rapid onset*	*Slow onset*	*Cyclic/recurring*
Natural disasters	Tsunamis, volcanic eruptions, earthquakes, floods, landslides, cyclones.	Drought, famine.	Floods in some areas, drought, wildfires.
Human made disasters	Violent conflict, accidents with hazardous chemicals, oil spills, biological warfare.	Conflict, pollution from acid rain.	Violent conflict.

Asia is the continent most impacted by disasters triggered by natural hazards.

Figure 26: Natural hazards in the Asian region, current situation.
(Source: http://www.pdc.org/atlas/html/atlas-init.jsp#. The triangles are active volcanoes and circles are active earthquakes; the different colours represent different magnitudes. Accessed August 30, 2008)

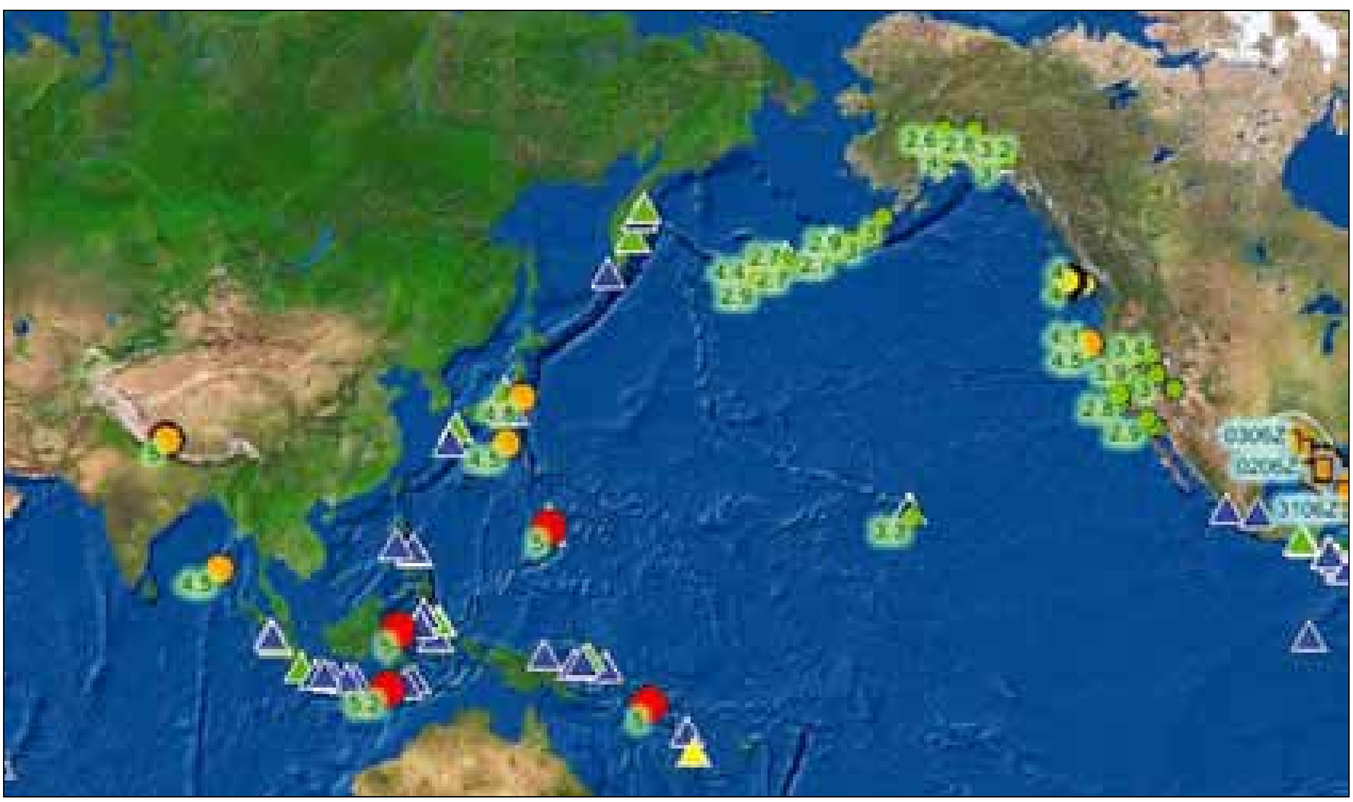


Table 4: Some of the worst natural disasters recorded (evaluated by the number of human deaths)
(Source: http://en.wikipedia.org/wiki/List_of_natural_disasters_by_death_toll)

Type of natural disaster	*Year*	*Location*	*No of human deaths*
Earthquake	1556	Shaanxi, China	830,000
Volcano	1815	Mount Tambora, Indonesia	92,000
Landslide	1999	Vargas, Venezuela	30,000-50,000
Flood	1931	Yellow River, China	1,000,000-4,000,000
Famine	1958-1961	China	20,000,000-43,000,000
Tsunami	2004	Indian Ocean	283,000
Tropical cyclone	1970	Bangladesh	500,000-1,000,000
Wildfire	1871	Wisconsin, USA	1,200-2,500
Disease (Small pox)	20th century	Worldwide	> 300,000,000
Disease (AIDS)	20th century	Worldwide	5 deaths/minute

Table 5: Some of the worst natural disasters recorded (evaluated by cost)
(Source: http://en.wikipedia.org)

Type of natural disaster	*Year*	*Location*	*Damage in USD*
Earthquake	1995	Japan	131,500,000,000
Volcano	1980	USA	1,500,000,000
Landslide	1998	China	890,000,000
Flood	1988	Soviet Union	60,000,000,000
Famine	1982	Australia	6,000,000,000
Tsunami	2004	Indian Ocean	Immediate 8.4 billion
Tropical cyclone	2005	USA, Hurricane Katrina	81.2 billion
Wildfire	1997	Indonesia	17,000,000,000
Disease (AIDS)	2007	Worldwide	10 billion for the year.

Table 6: Natural disasters in Asia in 2008
(Source: http://en.wikipedia.org/)

Type of natural disaster	*Location*	*No of human deaths and displacements*	*Damage in USD*
Tropical storm	Southern Myanmar	22,980 deaths and more than 40,000 other people are reported missing.	10 billion
Earthquake	Sichuan province, China.	69,197 deaths; 374,176 injured; 18,222 missing. 4.8 million people homeless, though the number could be as high as 11 million.	Exceeding 15 billion.
Floods	South Asia – monsoon season	More than 2,000 deaths in South Asia since the monsoon season began in June, mainly in India’s northern state of Uttar Pradesh. Two million displaced.	Not yet estimated.





Although this manual focuses on natural disasters and their effects on ecosystem well-being and therefore, human well-being, it is worthwhile to note that two human-made disasters - oil spills and wars - also impact heavily on ecosystems.

Oil Spills

Oil spreads primarily on the surface, but wave and wind currents move these oil slicks over large areas of pelagic (in the open sea) and coastal habitats. The immediate consequence is mass mortality and contamination. The worse, long term effect is the damage to various levels of foods webs, sometimes permanently.

Oil spills have enormous impacts on fisheries. When oil slicks reach coastlines, they affect tourism and coastal communities. Oil spills, therefore, have long term effects on both society and the economy (http://www.water encyclopedia.com/Oc-Po/Oil-Spills-Impact-on-the-Ocean.html).

- Between 1995 and 2004, there were 232 oil spills from tankers that spilled seven or more tonnes into oceans near 60 countries.
- During this period, USA had the highest frequency of oil spills (24% of the above) and South Korea, the second highest (6.4%).
- Oil spills have decreased in frequency in the last 30 years due to better preventative management (Huijer, 2008).

In July 2003, the oil tanker Tasman Spirit - carrying a cargo of 67,535 tonnes of crude oil – became grounded in the channel of the port of Karachi, Pakistan. It broke in August and 27,000 tonnes of cargo were lost initially, with further losses later.

It occurred in an area of extensive mangrove forests and coastal habitats, important for green and Olive Ridley turtles, cetaceans (dolphins, porpoises and beaked whales), several marine reptiles, over 50 species of birds and 200 species of fish and crustaceans, many of which are important commercially.

Immediately as a result of the spill, 11,000 tonnes of volatile organic compounds caused air pollution. Beaches were contaminated severely. Over five hundred kilograms of dead fish were found. Mangroves vegetation died (IUCN/UNEP/UNDP, 2003).

Wars

Wars have had catastrophic effects on human well-being. In this century and the last, the two World Wars, the Viet Nam War and the Gulf Wars of 1991 and 2003 took prominence, but there have been many small scale, domestic, civil wars (in Africa, Asia, Europe and the Middle East) that have been equally disastrous.

The impact of wars of the environment is manifold. The following description does not include preparing for war – such as the testing of weapons and hazardous waste disposal – and limits itself to post war damage. Using the MA framework, and some of the main drivers of ecosystem change, the following box provides a snapshot of environmental damage from war.

The less obvious but equally important consequence of war is the mass displacement of humans and a concentration and steep increase in the needs of ecosystem services, as well as an increase in the drivers of ecosystem change.

Over-exploitation:

- During the Gulf War of 1991, 8,000 camels were killed (Brauer, 2000).
- From 1998-2003, a civil war was fought in the Democratic Republic of the Congo. Over three million people died in the war, mostly from disease and starvation. More than two million people became refugees. Only 45% of the people had access to safe drinking water. Many refugees hunt wildlife for bush meat and protected areas are raided for minerals and other resources. Ivory poaching is rampant and it is reported that the hippopotamus population in one national park decreased from 29,000 three decades before, to only 900 in 2005.
- During the Viet Nam war, south Viet Nam's lobster fishery industry was reportedly over-fished to supply American soldiers.

Habitat destruction:

- The Viet Nam War of the 1960s and 1970s caused an 'environmental holocaust.' Over 40% of Viet Nam's forests were destroyed by this war. Chemical warfare – involving the application of 72 million litres of Agent Orange – destroyed 14% of Viet Nam's forests and remained in the soil, water and vegetation long after the war. Dioxin, a main ingredient of Agent Orange is carcinogenic[20] and teratogenic[21], and has resulted in spontaneous abortions, skin and lung cancers, lower intelligence and emotional problems among children. Children fathered by men exposed to Agent Orange during the Viet Nam War often have congenital abnormalities. An estimated half a million children have been born with dioxin-related abnormalities.
- The civil war and the Khmer Rouge regime in Cambodia in the 1960s resulted in extensive timber logging to finance war efforts, construction and collection of fuelwood. A total of 35% of Cambodia's forests were destroyed during this period causing severe floods, which in turn, damaged rice crops and caused food shortages. Many landmines were placed during the 1980's, and are still present in the countryside, preventing agricultural use of such land (http://www.lenntech.com/environmental-effects-war.htm).

Pollution:

- On September 11, 2001, terrorists flew airplanes into the buildings of the World Trade Centre in New York. As a consequence of burning jet fuels and their effect on buildings, an atmospheric plume formed, consisting of extremely toxic materials such as asbestos and Polychlorinated Biphenyl (PCB). At the site now called Ground Zero, a large pile of smoking rubble burned intermittently for more than three months.
- The Gulf War of 1991 was one of the most environmentally damaging wars. Iraq dumped approximately one million tons of crude oil into the Persian Gulf, causing the largest oil spill in history. Approximately 25,000 migratory birds were killed, crude oil spilled into the desert, forming oil lakes covering $50km^2$ and, in the long term, contaminating ground water aquifers. Many dams and sewage water treatment plants were targeted and destroyed, causing sewage to flow directly into the Tigris and Euphrates rivers; pollutants seeped from bombed chemical plants into these rivers. Drinking water became polluted, resulting in widespread disease. (For example, cases of typhoid fever have increased tenfold since 1991.)
- In addition, non-recyclable food containers, plastic water bottles, aluminium soft-drink cans, and cellophane food packaging, as well effluents from fuel-leaks and spills, solvents, paints, lubricants, acids, and other toxic materials might have been buried in the desert.
- In the Gulf War that began in 2003, 200 blue plastic containers containing uranium were stolen from a nuclear power plant, the radioactive content of the barrels dumped in rivers and the barrels reused as containers as storage facility for water, oil and milk (http://www.lenntech.com/environmental-effects-war.htm).
- In the Kosovo war of the 1990s, NATO bombed Belgrade, the capital of Serbia, and this caused the leakage of hazardous chemicals (chlorine, hydrochloric acid, vinyl chloride) into air, water and soil. The Danube River was polluted by oil, hydrochloric acid and mercury compounds. A lack of clean drinking water and sanitation problems occurred.

(Source for all of the above: http://www.lenntech.com/environmental-effects-war.htm)

[20] capable of causing cancer
[21] capable of causing birth defects

Global warming and climate change

Between 1970 and 2004, the annual emissions of carbon dioxide (CO_2) grew by about 80%, and during the last century, the concentration of CO_2 in the atmosphere has risen by twelvefold. Increased emissions into the atmosphere of CO_2 and methane (CH_4) – so called greenhouse gases (GHG) – cause a distinct warming of the earth.

Table 7: Greenhouse gases (Source: UNEP/GRID-Arendal Maps and Graphics Library, 2008)

The main greenhouse gases

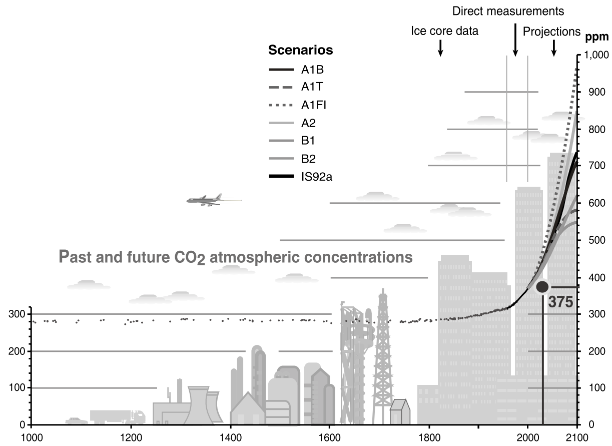
Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Greenhouse gases	Anthropogenic sources
Carbon-dioxide	CO_2	280 ppmv	358 ppmv	50-200	Fossil fuel combustion; land use conversion; cement production.
Methane	CH_4	700 ppbv	1720 ppmv	12-17	Fossil fuels; rice paddies; waste dumps; livestock.
Nitrous oxide	N_2O	275 ppbv	312 ppmv	120-150	Fertilisers; industrial processes; combustion.
CFCs	CFC12	0	503 pptv	102	Liquid coolants; foams.
HCFCs	CFC-22	0	105 pptv	13	Liquid coolants.
Perfluorocarbon	CF_4	0	110 pptv	50 000	Production of aluminium.
Sulphure hexa-fluoride	SF_6	0	72 pptv	1 000	Production of magnesium.

Note : pptv = 1 part per trillion by volume; ppbv = 1 part per billion by volume, ppmv = 1 part per billion by volume

These gases function much like glass panes in a greenhouse, allowing light in, but preventing heat from escaping. This greenhouse effect, as it is called commonly, is important: without it, the earth would be too cold for humans to live. The problem is that now there is just too much GHG, making the earth too hot.

During the last century, the concentration of CO_2 in the atmosphere has risen by twelvefold, through excessive use of coal and oil, countless vehicles that use up gallons of petrol, and industries that are emitting enormous quantities of CO_2 into atmosphere. Meanwhile, forests (that serve to soak up CO_2) are being cut down. Every year, about 23 billion metric tonnes of CO_2 are emitted into the atmosphere. Until recently, the USA was the major culprit (emitting 21.2% of the world's total) but preliminary findings show that since 2006, China's emissions have surpassed the USA's (MNP, 2006). The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios projects an increase of global GHG emissions by 25-90% between 2000 and 2030 (IPCC, 2007).

Figure 27: Past and future concentrations of CO_2 (Source: UNEP/GRID-Arendal Maps and Graphics Library 2008)



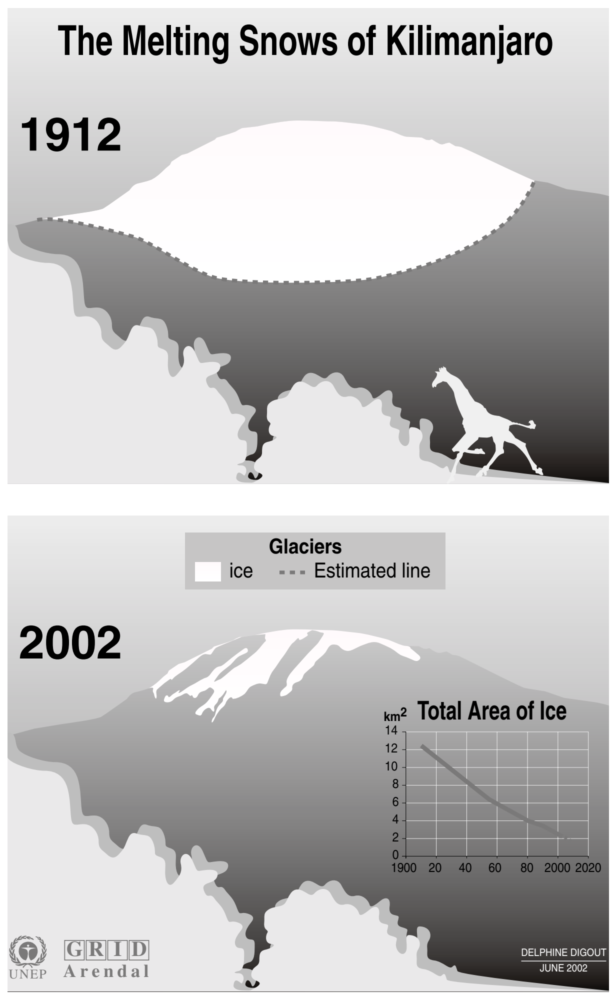
In the meantime, trash and garbage are heaped as solid waste and the livestock industry - rearing millions of herds of cattle and sheep - generates huge quantities of methane.

The result of these emissions and increased greenhouse effect is a distinct warming of the earth. During the last century, global temperature increased by about 0.8°C - measured as the largest increase in thousand years.

The records are startling: the five hottest years on record are in the last decade and this one. The 90s were the warmest decade in a century, with 2005 the hottest year on record worldwide (IPCC, 2007).

The IPCC predicts that for the next two decades the earth will warm about 0.2°C per decade; and even if GHG are kept constant at levels of year 2000, the earth will still warm about 0.1°C per decade (IPCC, 2007).

Figure 28: Melting snow on Kilimanjaro (Source: UNEP/GRID-Arendal Maps and Graphics Library, 2008)



As a result of this warming, changes are occurring in global weather patterns and resulting in *Climate Change*. Snow cover is decreasing and glaciers are retreating. In 2002, NASA confirmed that the extent of Arctic ice had lessened; glaciers in the European Alps have decreased by approximately half their extent since the mid 1800s and one fifth of their remaining volume since 1980. By 2005, the snow cap that covered the top of Mount Kilimanjaro in Africa for the past 11,000 years had almost disappeared.

Melting snow and retreating glaciers result in an increase in sea levels. The current rate of sea-level rise is three times the historical rate and sea levels have already risen by 10-20cm in the last century (IPCC, 2007). The IPCC predicts that global sea levels will rise between 0.09 to 0.88m by 2100. This could mean that many coastal countries and cities such as Bangladesh and the Maldives, Mumbai and Bangkok could become flooded by seawater. It is estimated that in India alone, millions of people are at high risk from sea level rise. In the short term, the runoff from rapidly melting glaciers can cause landslides and floods downstream. In the short term, rapidly melting glaciers mean intense flooding downstream, but in the long term, the reduced quantity of ice produces less freshwater downstream. The snow melts of the Himalayas feed the Ganges,

Figure 29: The decrease of Arctic sea ice (Source: UNEP/GRID-Arendal Maps and Graphics Library 2008)

1982

2007

Indus and Brahmaputra. The Ganges – which alone provides water to 400 million of people – is predicted to lose two-thirds of its water as a result of climate change (Reid & Simms, 2007).

Coastal flooding will result in sea water entry (intrusion) into fresh water bodies. This will damage fresh water supplies for coastal communities and affect livelihoods and human well-being. In China and Bangladesh, the effects of sea level rise and salt water intrusion are already damaging their economies and environments. Salt water intrusion into lagoons, estuaries and mangroves will damage these ecosystems, affecting the services – such as coastal fisheries, flood regulation and storm protection – that they provide humans (Reid & Simms, 2007).

Another effect of increased CO_2 in the atmosphere is that oceans absorb heat as well. With a density far higher than that of the atmosphere, the oceans absorb far more heat than the atmosphere. The three upper metres of the ocean alone contain as much heat as the entire atmosphere above it. However, the heating of the oceans takes time and there is a time lag between the heating of the atmosphere and the heating of the oceans. More CO_2 becomes dissolved in the oceans, forming the weak carbonic acid – i.e., making the oceans more acidic and directly affecting ecosystems such as coral reefs and marine organisms - ultimately affecting food security.

In addition, ocean currents are becoming affected seriously by global warming. Usually, heat moves from the equator to the poles not only through the atmosphere but also by ocean currents, and the cooler water from the poles is circulated to the equator. Such currents are extremely important in maintaining the climate of continents, especially coastal areas. These currents are driven both by heat and salinity, which, together, determine the density of the water. When both heat and salinity of the oceans change as a result of global warming (salinity increases because of increased evaporation or reduces because of increased runoff from large rivers), these currents change, with serious effects on weather patterns.

2010 - 2030

2040 - 2060

2070 - 2090

Climate change

Because of global warming, there are overpowering changes in the world's climate.

Rainfall patterns are changing and the effects of El Niño and La Niña episodes are worsened, resulting in increased cyclones, flooding and landslides.

What is El Niño?

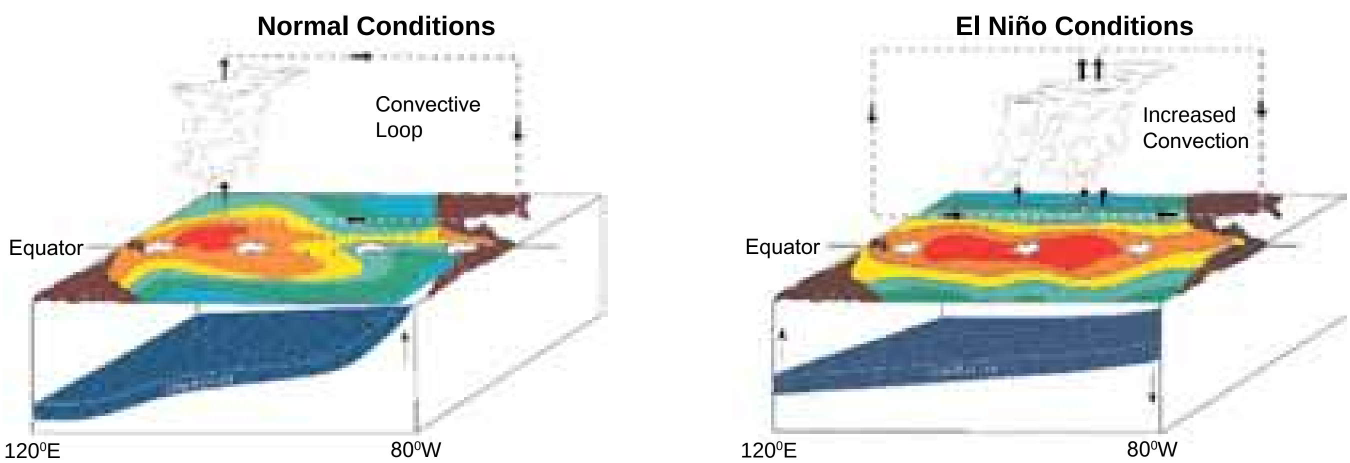
El Niño is Spanish for 'the little boy', referring to the Christ child, because this event is noticed usually around Christmas time. It is a fluctuation of the ocean-atmosphere system in the tropical Pacific Ocean that is important for the world's climate. In normal, non-El Niño conditions, trade winds (prevailing tropical winds) blow towards the west across the tropical Pacific, piling up warm surface water in the west Pacific, so that the sea surface is about 0.5m higher in height and 8°C warmer at Indonesia than at Ecuador. The waters off South America are cool because of an upwelling from the deep and are nutrient-rich, with high marine primary productivity which supports fisheries. During El Niño, the air pressure over the Indian Ocean, Indonesia, and Australia rises, but drops over Tahiti and the rest of the central and eastern Pacific Ocean. The trade winds in the South Pacific weaken. Warm air rises near Peru causing rain in its deserts, while warm water spreads from the West Pacific and Indian Ocean to the East Pacific Ocean. When it spreads, it takes the rain with it, causing rainfall in normally dry areas and drought in normally wet areas. El Niño also results in less upwelling, less nutrients, warmer sea surface temperatures (+0.5°C) and decreased marine primary production near South America.

La Niña, means 'the little girl' in Spanish, meant to reflect that its effects are the opposite to that of El Niño. Here, the result is a lowering of sea surface temperatures by about 0.5°C. It usually follows an El Niño event.

(Source:NOAA, 2008b)

Coral bleaching – mass scale die off of corals – has already occurred worldwide in 1998 as a result of warmer water currents brought by an El Niño event. In 1998, 16% of the world's coral reefs and 50% of the Indian Ocean's coral reefs were bleached. This means that the nearly 500 million people who depend – directly or indirectly – on coral reefs for their livelihoods and to live would have been affected some way or another (Wilkinson, 2004).

Figure 30: Diagram of El Niño conditions (Source: NOAA, 2007)



Lakes and rivers are also warming, and while wet areas are often becoming wetter, dry areas are often becoming dryer. It is predicted that tropical areas will get hotter, that arid areas will become deserts, while temperate regions could become tropical. Dry areas becoming dryer leads to increased droughts and heat waves. These, in turn, lead to famine, increased wildfires, pest attacks, and spread of invasive alien species (IPCC, 2007).

The world's hydrological systems will be rearranged, causing changes in seasonal flows. In water-scarce regions, water availability will be reduced, but increased in some other areas. Generally, the quality of freshwater habitats would be degraded by higher water temperatures. Changes upstream will impact on downstream supplies, affecting water security.

Changing weather patterns are also resulting in changes in the distribution and range of species and are disrupting the natural balance of many ecosystems, with the result that the goods and services that they provide to humans will also be changed or reduced. This will undoubtedly have a serious impact on crops, which, in turn, will lead to food shortages and eventually famine.

Changes in species distribution are also expanding the range of disease vectors such as mosquitoes, so that diseases are spreading, affecting human health.

Figure 31: Climate change and vector-borne diseases
(Source: UNEP/GRID-Arendal Maps and Graphics Library, 2008)

Disease	Vector	Population at risk (million)[1]	Number of people currently infected or new cases per year	Present distribution	Likelihood of altered distribution
Malaria	Mosquito	2,400[2]	300-500 million	Tropics and Subtropics	★★★
Schistosomiasis	Water snail	600	200 million	Tropics and Subtropics	★★
Lymphatic Filariasis	Mosquito	1 094[3]	117 million	Tropics and Subtropics	★
African Trypanosomiasis (Sleeping sickness)	Tsetse fly	55[4]	250 000 to 300 000 cases per year	Tropical Africa	★
Dracunculiasis (Guinea worm)	Crustacean (Copepod)	100[5]	100 000 per year	South Asia, Arabian Peninsula, Central-West Africa	❍
Leishmaniasis	Phlebotomine sand fly	350	12 million infected, 500 000 new cases per year[6]	Asia, Southern Europe Africa, Americas	★
Onchocerciasis (River blindness)	Black fly	123	17.5 million	Africa, Latin America	★★
American Trypanosomiasis (Chagas disease)	Triatomine bug	100[7]	18 million	Central and South America	★
Dengue	Mosquito	1,800	10-30 million per year	All Tropical countries	★★
Yellow Fever	Mosquito	450	more than 5 000 cases per year	Tropical South America Africa	★

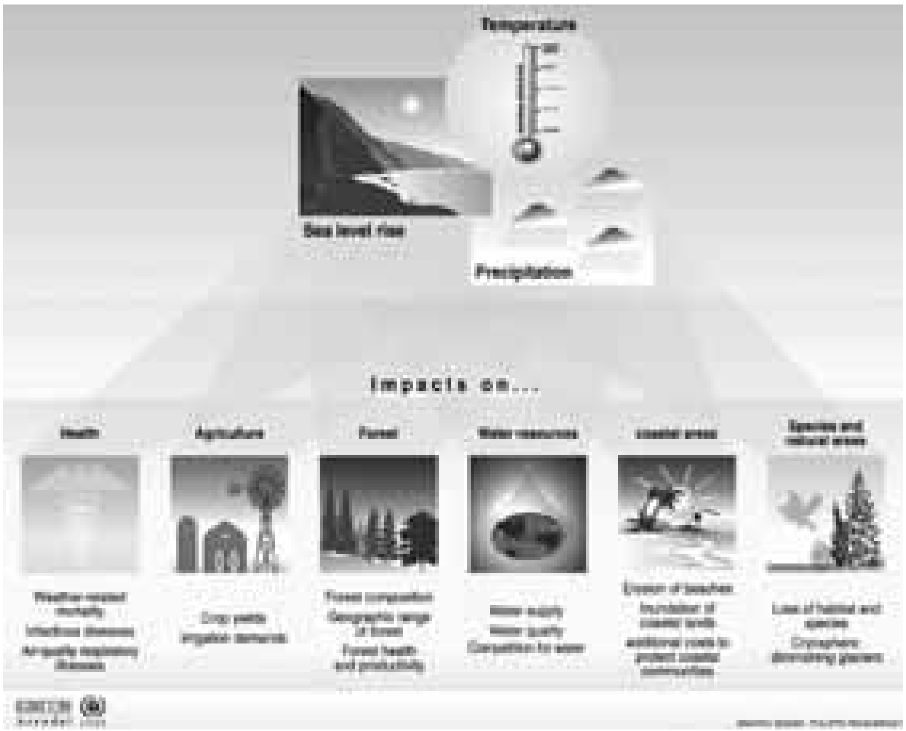
★★★ Highly likely ★★ Very likely ★ Likely ❍ Unknown

1. Top three entries are population-prorated projections, based on 1989 estimates.
2. WHO, 1994.
3. Michael and Bundy, 1995.
4. WHO, 1994.
5. Ranque, personal communication.
6. Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases/yr (PAHO, 1994).
7. WHO, 1995.

GRID Arendal UNEP
GRAPHIC DESIGN : PHILIPPE REKACEWICZ

Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Figure 32: Potential impacts of climate change
(Source: UNEP/GRID-Arendal Maps and Graphics Library, 2008)



In short, climate change is increasing the frequency of natural disasters.

It is estimated that during the last few decades, an average of 250 million people have been affected each year, with nearly 58,000 deaths as a result of natural disasters. In 2004 alone, natural disasters affected the lives of about 140 million people.

Figure 33: Trends in natural disasters
(Source: UNEP/GRID-Arendal Maps and Graphics Library, 2008)

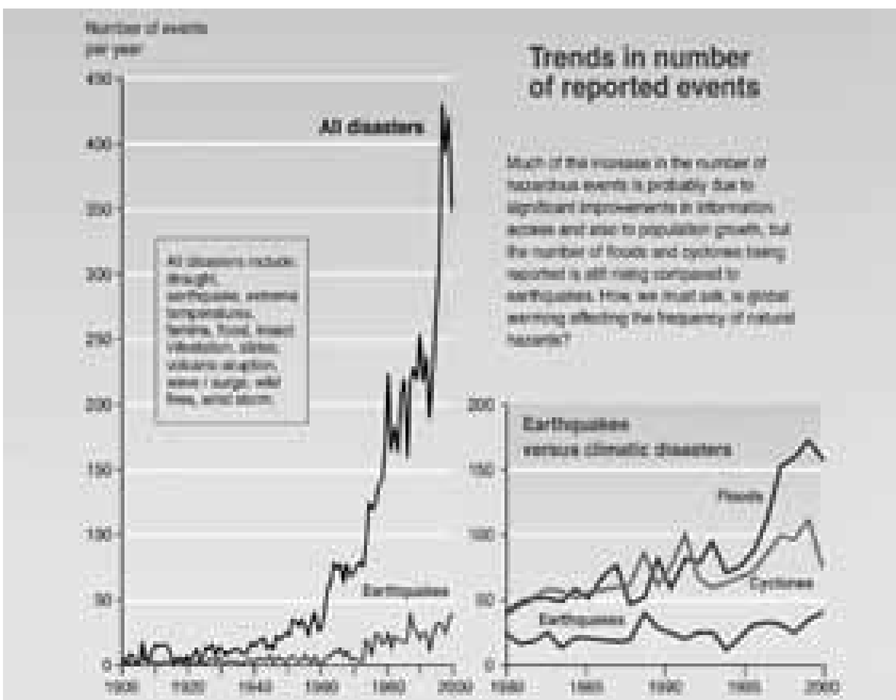


Figure 34: Incidence of floods 1950-2000
(Source: MA, 2005)

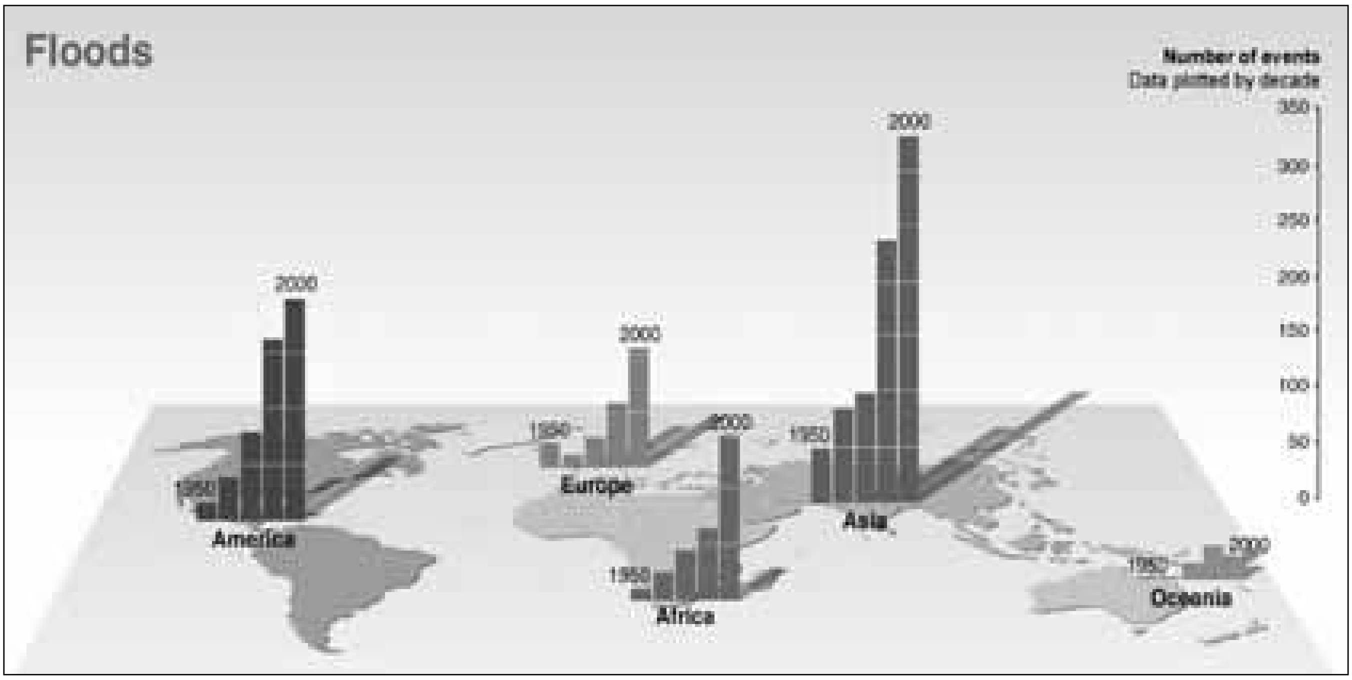


Figure 35: Incidence of wildfires 1950-2000
(Source: MA, 2005)

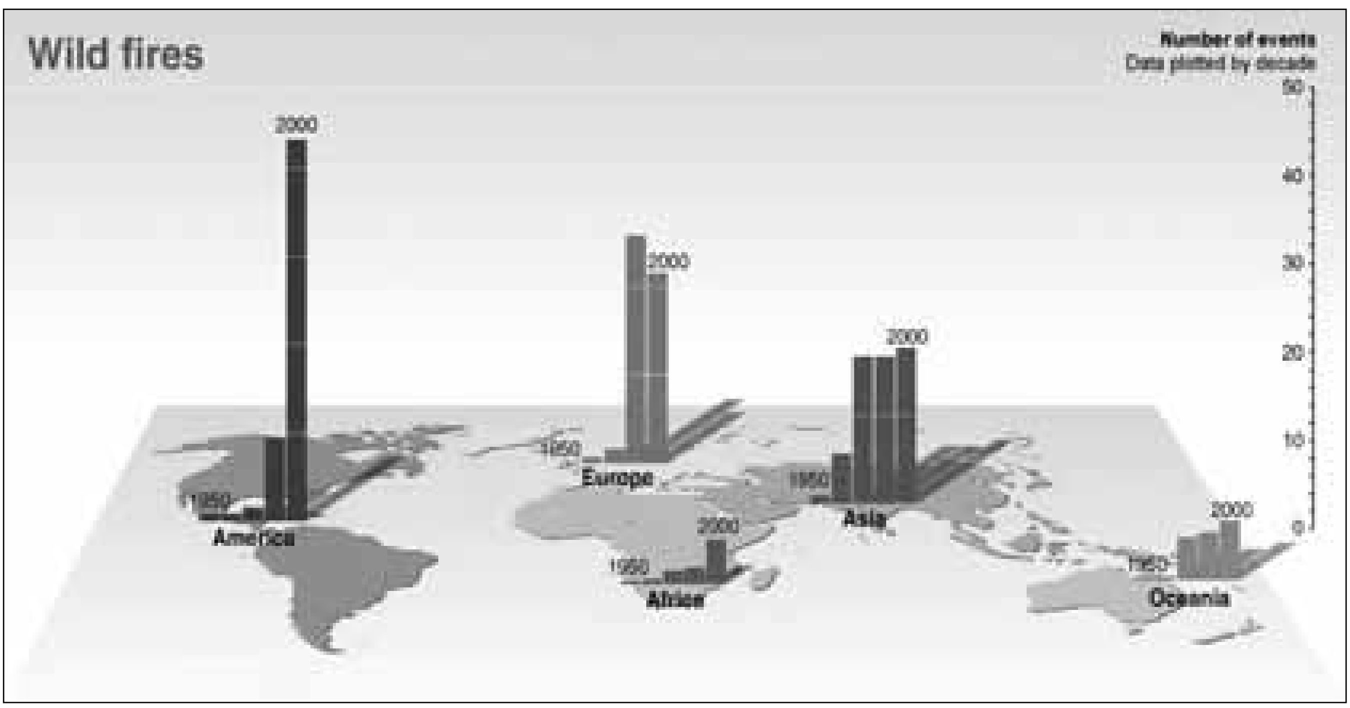
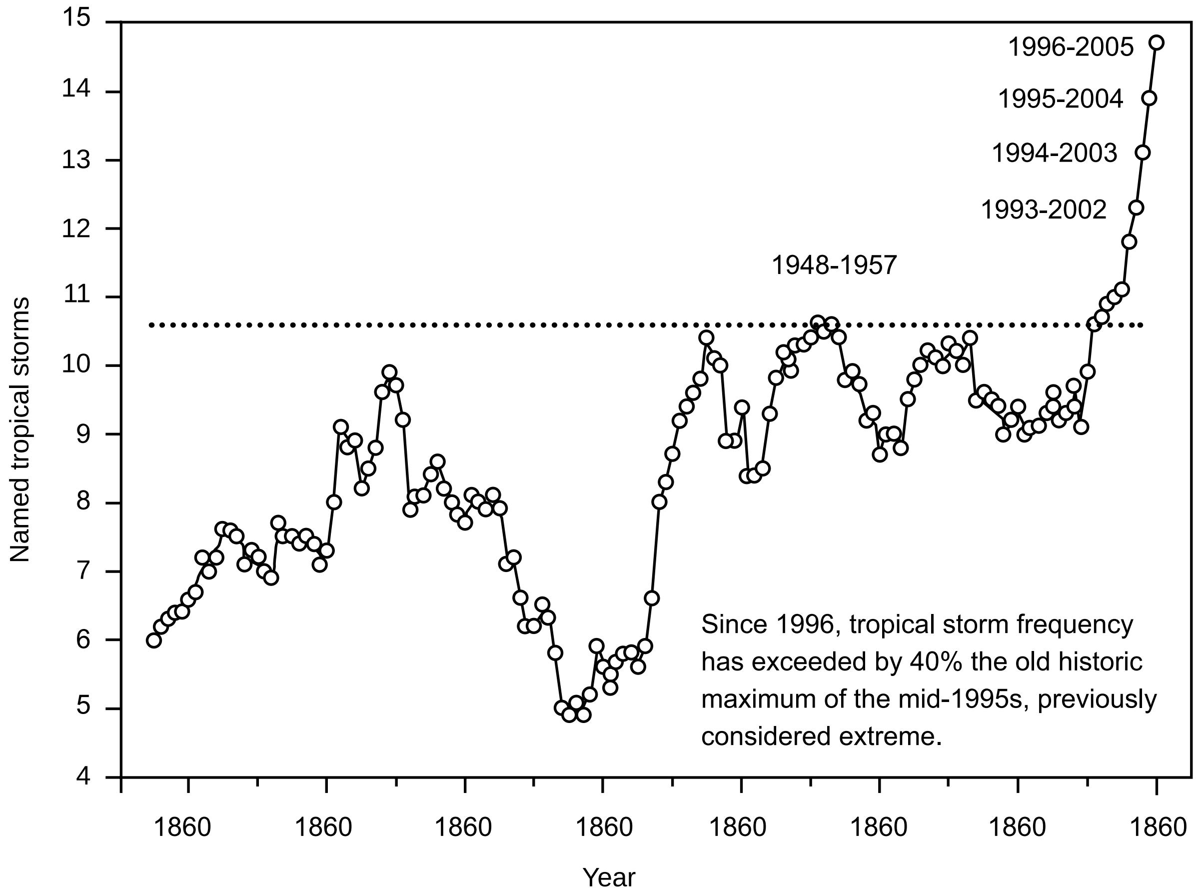


Figure 36: Incidence of tropical storms in the north Atlantic
(Source: National Hurricane Center, 2007)

10-year running everage



These impacts of climate change will have significant economic costs. It is predicted that

- Climate change impacts in the extent of arable lands will have economic losses of 56 billion USD. The highest losses are projected for some parts of Latin America, Africa and Asia (IPCC, 2007).
- The impacts of climate change on agriculture could increase the number of hungry people in the world (IPCC, 2007).
- In 1995, 1,400 million people lived in areas with inadequate water supplies. Projections with different climate change scenarios predict an increase of 364 to 1,661 million people living under conditions of water stress by 2020 (IPCC, 2007).
- Estimates of the property damage caused by Hurricane Katrina in 2005 are as high as 135 billion USD (Ackerman & Stanton, 2006).
- The cost of the 2003 heat wave of Europe, when 35,000 people died and there were agricultural losses, was 15 billion USD (Stern, 2006).
- Extreme storms and flooding in the UK are predicted to become more frequent and more severe. It is estimated that the cost of this flooding will be about 40 billion USD by 2080, fifteen times of the present cost (Ackerman & Stanton, 2006).
- In 2005, natural catastrophes caused 220 billion USD worth of damage (Swiss Re 2006 in litt. Ackerman & Stanton, 2006).
- The German Institute for Economic Research (DIW) estimates that if nothing is done to curb GHG emissions, annual economic damages could reach 20 trillion USD by 2100 (expressed in U.S. dollars at 2002 prices), or 6-8% of global economic output at that time (Ackerman & Stanton, 2006).

The link between climate change and the increase in frequency of natural disasters cannot be over-emphasised. The progression is clear: climate change is worsening El Niño and La Niña events; this is causing more intense and more natural hazards such as floods, cyclones, hurricanes and wildfires. Because the intensity and extents of these natural hazards have worsened, they are causing natural disasters. These natural disasters not only retard sustainable development, but also have far reaching knock-on effects. For example, the December 2004 tsunami severely damaged the southern coast of Sri Lanka. In the rush to rebuild, development was unplanned and sited in elephant migratory pathways. In addition, climate change is now extending annual dry seasons into drought. Elephants seeking water during drought meet human settlements, and conflict results. In this example, the tsunami seems to have worsened human-elephant conflict in southern Sri Lanka.

Climate change impacts on Asia, the poor and women:

Increasing natural disasters will have far reaching global effects, but disproportionate impacts on Asia. In fact, Asia is the world's most disaster prone region, having suffered about half of the world's major disasters over the past fifty years, 67% of the casualties and 28% of the economic losses (Reid & Simms, 2007). Each year, natural disasters impoverish millions of people. However, only 0.2% of economic losses were covered by insurance policies, because many of those affected are the marginalised and the poor.

Asia is also the home to over 70% of the world's poor. Tragically, at the forefront of all these events are the poor. In developing countries, the marginalised and poor are already deprived of adequate food, clean drinking water, sanitation, health care etc. In most cases, it is this section of society who is also forced to live in low lying and other hazard prone areas and so are usually the first to be hit by floods, landslides and cyclones. Mostly neglected by their respective governments, they have the fewest resources to deal with these recurrent shocks and stresses. Therefore, the negative consequences of climate change make them less capable of developing any coping, preventing, and mitigating mechanisms (IUCN, 2007).

Amongst the poor, it is the women and children who are the most vulnerable in any disaster. Out of the 1.4 billion people in the developing world who live below the poverty line, 70% are women. After the tsunami, a shocking statistic revealed that the number of deaths of women and children were disproportionately larger than that for men. Vulnerability to disasters depends on control of financial, physical, natural, human and social assets. Compared to men, women in the poor, developing countries traditionally have limited access and control over these assets (IUCN, 2007).

An increase in natural disasters will have overarching impacts on ecosystem services and the global economy but it will cripple Asia, already stressed with overpopulation, poverty, internal conflict, resource overuse and spread of disease.

References

Ackerman, F. and E. Stanton (2006). *Climate change - the costs of inaction*. USA, Tufts University: Global Development and Environment Institute. http://ase.tufts.edu/gdae/ 48 pp.

Allen, G. R. and R. Steene (1994). *Indo Pacific Coral Reef Field Guide*. Singapore: Tropical Reef Research. 378 pp.

Bandaranayake, W. M (1998) Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* **2**(3):133-148.

Batagoda, B. M. S., Kerry Turner, R., Tinch, R. and K. Brown (2000). *Towards policy relevant ecosystem services and natural capital values: rainforest non-timber products.* CSERGE Working Paper GEC 2000-06. 43 pp.

Bundesministerium für Bildung und Forschung (BMBF) (2002). *Asia Concept 2002: Positive results of the Asia Concept 1995 and challenges for the years ahead.* Germany: BMBF. 38 pp.

Bruckner, A (2006). *New Threat to Coral Reefs: Trade in Coral Organisms.* http://www.issues.org/17.1/bruckner.htm

Centre for epidemiology of disasters (2007). *Number of drought disasters reported by country 1970-2006.* http://divisionoflabour.com/archives/003409.php

Condit, R. D. M Winsor, and S. P. Hubbell (1996). *NPP Tropical Forest: Barro Colarado, Panama, 1969-1990*. Data set.

Conservation International (2008). http://www.biodiversityhotspots.org/Pages/default.aspx

Dartmouth Flood Observatory (2008). http://www.country-studies.com/bangladesh/river-systems.html

Dartmouth Flood Observatory (2008). *Major floods reported in 2008.* http://www.dartmouth.edu/~floods/Archives/2008global.jpg

Earth Policy Institute (2006). http://www.eia.doe.gov/emeu/iea

Emerton, L. A (2006). *Counting coastal ecosystems as an economic part of development infrastructure*. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. 12 pp.

Emerton, L. (ed.) (2005). Values and Rewards: Counting and Capturing Ecosystem Water Services for Sustainable Development. IUCN *Water, Nature and Economics Technical Paper No. 1.* Colombo: Ecosystems and Livelihoods Group Asia, IUCN – The World Conservation Union. 93 pp.

Emerton, L., Seilava, R. and H. Pearith (2002). *Bokor, Kirirom and Ream National Parks, Cambodia: case studies of economic and development linkages.* Field study report, Review of protected areas and their role in the socio-economic development of four countries of the Lower Mekong Basin.

Emerton, L. and B. Kekulandala (2002). A*ssessment of the Economic Value of Muthurajawela Wetland*. Colombo: IUCN – The World Conservation Union, Sri Lanka Country Office and Regional Environmental Economics Programme Asia. 31 pp.

Environmental Justice Foundation (2005). *Mangroves: Nature's defence against Tsunamis - A report on the impact of mangrove loss and shrimp farm development on coastal defences*. London, UK: Environmental Justice Foundation. 32 pp.

Global Runoff Data Centre (2008). *Major river basins of the world*. GRDC in the Bundesanstalt für Gewässerkunde, 56068 Koblenz, Germany. http://nofdp.bafg.de/servlet/is/15693/

Hesp, P. A (2000). Coastal sand dunes form and function. *Coastal Dune Vegetation Network Technical Bulletin*. **4**. Rotorua: New Zealand Forest Research Institute Limited. 28 pp.

Hodgson, G. and J. Dixon (1988). Logging Versus Fisheries and Tourism in Palawan. *Occasional Paper 7.* Honolulu, Hawaii: East-West Environment and Policy Institute. 95 pp.

http://csmres.jmu.edu/geollab/fichter/PlateTect/erthstru.html.

http://en.wikipedia.org/wiki/Drought_in_Australia

http://en.wikipedia.org/wiki/Historic_tsunami

http://en.wikipedia.org/wiki/Krakatoa

http://en.wikipedia.org/wiki/List_of_natural_disasters_by_death_toll http://en.wikipedia.org/wiki/Mount_Vesuvius

http://en.wikipedia.org/wiki/Rainforests

http://en.wikipedia.org/wiki/Typhoon_Tip

http://en.wikipedia.org/wiki/1999_Vargas_mudslide

http://en.wikipedia.org/wiki/Yellowstone_fires_of_1988

http://geology.about.com/library/bl/maps/blcrustalplates.htm

http://geology.about.com/library/bl/blnutshell_fault-type.htm

http://ioc3.unesco.org/itic/files/tsu_wave_characteristics.pdf

http://pubs.usgs.gov/gip/dynamic/inside.html

http://pubs.usgs.gov/gip/volc/text.html

http://science.nationalgeographic.com/science/earth/natural-disasters/earthquake-profile.htm

http://upload.wikimedia.org/wikipedia/commons/b/b1/World_population.PNG

http://www.acfonline.org.au/news.asp?news_id=66&c=294135

http://www.andrew.com.

http://www.aoml.noaa.gov/hrd/tcfaq/C5c.html.

http://www.en.wikipedia.com

http://www.fao.org/docrep/t4450e/T4450E0m.htm.

http://www.pdc.org/atlas/html/atlas-init.jsp#.

http://www.publicaffairs.noaa.gov/releases2001/oct01/noaa01102.html

http://www.pvsd.ca/.../planning/thecrust/thecrust.htm

http://www.country-studies.com/bangladesh/river-systems.html

http://www.runet.edu/~swoodwar/CLASSES/GEOG235/biomes/rainforest/rainfrst.html (Accessed 28 August 2008)

http://www.sms.si.edu/irlspec/Whatsa_lagoon.htm

http://www.unesco.org/science/disaster/about_disaster.shtml.

http://www.upload.wikimedia.org

http://upload.wikimedia.org/wikipedia/commons/2/23/Global_tropical_cyclone_tracks-edit2.jpg

http://upload.wikimedia.org/wikipedia/commons/thumb/0/09/Pacific_Ring_of_Fire.png/800px-Pacific_Ring_of_Fire.png

http://www.wordnet.princeton.edu/perl/webwn

Huijer, K (2008). *Trends in oil spills from tanker ships 1995-2004.* International Tanker Owners' Pollution Federation. http://www.itopf.com/_assets/documents/amop05.pdf. 14 pp.

IIED (2003). *Valuing Forests: A Review of Methods and Applications in Developing Countries.* London: Environmental Economics Programme, International Institute for Environment and Development. 80 pp.

Intergovernmental Panel on Climate Change (IPCC) (2007). *Working group III Summary for policymakers.* http://www.ipcc.ch/SPM040507.pdf

IUCN (2000). *Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species*. Gland: Switzerland: IUCN. 21 pp.

IUCN/UENP/UNDP (2003). *Tasman Spirit oil spill Karachi, Pakistan, Assessment report*. http://www.reliefweb.int/ochaunep/edr/Pakistan.pdf. 22 pp.

Kallesøe, M. F., Bambaradeniya, C. N. B. , Iftikhar, U. A., Ranasinghe, T. and S. Miththapala (2008). *Linking Coastal Ecosystems and Human Well-Being: Learning from conceptual frameworks and empirical results*. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii + 49 pp.

Kasperson, R. E. and J. X. Kasperson (2001). Climate change, vulnerability, and social justice. In *The International workshop on vulnerability and global environmental change workshop summary.* Stockholm, Sweden: *Stockholm Environmental Institute.* http://www.sei.se/dload/2001/sei-risk.pdf.

Kathiresan, K. and B. L. Bingham (2001). Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology* **40:** 81-251.

Kerr, R.A (2005). South Asia tsunami: failure to gauge the quake crippled the warning effort. *Science* **307**:201.

Lal, M (2001). Tropical cyclones in a warmer world. *Current Science* **80** (9).

Lewinsohn, T. M., Novotny, V. and Y. Basset (2005). Insects on plants: Diversity of Herbivore Assemblages Revisited. *Annual Review of Ecology, Evolution and Systematics* **36**:597–620.

McGuire. B (2002). *A Guide to The End of the World: Everything You Never Wanted to Know*. Oxford: Oxford University Press. 191 pp.

Millennium Ecosystem Assessment (2005). *Ecosystems and Well-being Synthesis report.* Washington DC: Island Press. v+86 pp.

Mittermeier, R. A., Gil, P. R. and C. G. Mittermeier (1997). *Megadiversity: Earth's Biologically Wealthiest Nation*s. Mexico: CEMEX, Agrupación Sierra Madre.

MNP (2006). *Netherlands Environmental Assessment Agency: China now no. 1 in CO_2 emissions; USA in second position*. http://www.mnp.nl/en/dossiers/Climatechange/moreinfo/Chinanowno1inCO2emissionsUSAinsecondposition.html

National Hurricane Center (2007). http://usasearch.gov/

NOAA (2008a). http://oceanservice.noaa.gov/education/kits/estuaries/welcome.html

NOAA (2008b). http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

Orth, R. J. and 14 others (2006). A global crisis for seagrass ecosystems. *BioScience* **56**(12): 987-996.

Packham, J. R. and A. J. Willis (1997). *Ecology of dunes, salt marsh and shingle*. New York, NY: Springer. 352 pp.

Phillips, R. C., and E. G. Menéz (1988). Seagrasses. *Smithsonian contributions to the Marine Sciences*. Washington DC: Smithsonian Institution Press. 34 pp.

Poverty Database World Bank (2008). http://wbln0018.worldbank.org/dg/povertys.nsf/Poverty+assessment?openview&count=1999.

Khanh Nam, P. and Tran Vo Hung Son (2001). *Analysis of the Recreational Value of the Coral-surrounded Hon Mun Islands in Vietnam.* EEPSEA Research Report. International Development Research Centre, Ottawa, Canada. 46 pp.

Reid, H. and A. Simms (2007). *Up in smoke? Asia and the Pacific. The threat from climate change to human development and the environment*. UK: International Institute for Environment and Development. 96 pp.

Ross, S. M. Thornes, J. B. and S. Nortcliff (1990). Soil Hydrology, Nutrient and Erosional Response to the Clearance of Terra Firme Forest, Maracá Island, Roraima, Northern Brazil. *The Geographical Journal* **136**:267-282.

Svarrer, K. and C. Smith Olsen, (2005). The Economic Value of Non-Timber Forest Products- A Case Study from Malaysia *Journal of Sustainable Forestry* **20(**1): 17 – 41.

Sodhi, N.S., Koh, L. P.. Brooks, B. W. and P.K.L. Ng (2004). Southeast Asian biodiversity: an impending disaster. *Trends in Ecology and Evolution* **19**(12): 654-659.

Spalding, M. D. (1997). *The Global distribution and Status of Mangrove Ecosystems*. Intercoast Network: Mangrove Edition. Special Edition **1**: 20-21.

Spalding, M., Taylor, M., Ravilious. C., Short, F., and E. Green (2003). The distribution and status of seagrasses. Pp 5- 26 in Green E. P. and F. T. Short (2003) *World Atlas of Seagrasses*. Berkely, CA: UNEP-WCMC, University of California press. xii+298 pp.

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Natural hazard hotspots by risk type.* http://maps.grida.no/go/graphic/natural-hazard-hotspots-by-risk-type (Accessed 28 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Climate change and vector-borne diseases.* http://maps.grida.no/go/graphic/climate_change_and_vector_borne_diseases (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Main greenhouse gases.* http://maps.grida.no/go/graphic/main_greenhouse_gases1 (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Melting snow on Kilimanjaro*, http://maps.grida.no/go/graphic/melting_snow_on_kilimanjaro (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Past and future CO_2 concentrations.* http://maps.grida.no/go/graphic/past_and_future_co2_concentrations (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Potential climate change impacts.* http://maps.grida.no/go/graphic/potential_climate_change_impacts (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). T*he decrease of Arctic sea ice, minimum extent in 1982 and 2007, and climate projections* http://maps.grida.no/go/graphic/the-decrease-of-arctic-sea-ice-minimum-extent-in-1982-and-2007-and-climate-projections (Accessed 30 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Trends in natural disasters* [Internet]. [cited 2008 Aug 28]. Available from: http://maps.grida.no/go/graphic/trends-in-natural-disasters.

UNEP/GRID-Arendal Maps and Graphics Library (2008). *Tropical cyclone frequency*. http://maps.grida.no/go/graphic/tropical-cyclone-frequency (Accessed 28 August 2008)

UNEP/GRID-Arendal Maps and Graphics Library (2008). *World poverty distribution*. UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/world-poverty-distribution (Accessed 28 August 2008)

U.S. Census Bureau (2008). http://www.census.gov/compendia/statab/tables/08s1295.pdf.

Valiela, I. Bowen, J. L. and J. K. York (2001). Mangrove Forests: One of the World's Threatened Major Tropical Environments *BioScience* **51** (10): 807-815.

Verma, M (2000). *Economic Valuation of Forests of Himachal Pradesh.* International Institute for Environmental Development. 7 pp.

Veron, J. E. N (2000). *Corals of the World*. Townsville, Australia: Australian Institute of Marine Science. 3 volumes.

WHO (1996). *The World Health Report 199*6. Geneva: WHO. vi + 137 pp.

WHO (2007). *The World Health Report 2007*. Geneva: WHO. 95 pp.

Wilkinson, C (2004). *Status of Coral Reefs of the World*, 2004 (Vol 1) Townsville, Australia: Australian Institute of Marine Science. xiv + 301 pp.

World Bank Country tables (2005). http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20535285~menuPK: 1192694~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html

World Resources Institute (2002). *Earthtrends database.* http://earthtrends.wri.org/

WWF (2007). http://www.panda.org/about_wwf/where_we_work/ecoregions/about/habitat_types/index.cfm)

WWF (2004). *The Economic Values of the World's Wetlands*. http://assets.panda.org/downloads/wetlandsbrochurefinal.pdf

Annex 1: a) At a glance: services provided by, and threats to lowland tropical rainforests.

Services	Description	Threats
Provisioning services (Goods)		
Food (fruits, vegetables, flavourings, spices and nuts)	Tropical rainforests support diverse plant species, of which an estimated 75,000 species are edible.[1] Fruits (such as bananas, avocados papayas, citrus fruits), vegetables (such as legumes, cassava, peppers, okra) flavourings (such as cocoa, vanilla, sugar), spices (such as nutmeg, ginger, cardamom and cinnamon) and nuts (such as peanuts, Brazil nuts, macadamia and cashew nuts) originated in the rainforest.	Habitat destruction by over-exploitation of land: slash and burn cultivation practices, cattle ranching, construction of dams for hydropower and logging of timber for hardwoods (such as mahogany, teak and rosewood) pose severe threats to tropical rainforests. Recent global estimates suggest that around 150,000km^2 of tropical rainforest - equivalent to the size of England and Wales - is destroyed every year. In addition, a similar area is damaged or degraded.[2] Conversion for cultivation: rainforests are cleared for tea and rubber plantations in Sri Lanka and for oil palm cultivation in Thailand and Malaysia.
Timber and fuelwood	Forestry is important both to the world's economy and local economies of many countries. Of the annual production of timber from tropical rainforests, 85% is used for fuel; 10% for local timber needs and 5% for export.[1] Indonesia is the world's largest exporter of tropical timber, generating more than 5 billion USD annually.[3] Rainforest timbers such as Mahogany, *Sapele*, Teak, *Meranti*, Greenheart and *Ramin* are used for a variety of purposes - ranging from furniture manufacture, paper, window sills, door frames, flooring, furniture, toys and kitchen utensils.[2]	Over-exploitation: industrial logging is one of the primary causes of global deforestation. Habitat destruction: the annual loss of primary forest cover is 60km^2/yr in Sri Lanka, 204km^2/yr in Viet Nam, 668km^2/yr in Cambodia and 14 478km^2/yr in Indonesia.[4] Legal timber harvesting affects 700,000-850,000ha of forest per year in Indonesia, but widespread illegal logging boosts the overall logged area to at least 1.2-1.4 million ha.[3] *Ramin*, found in Indonesia and Malaysia, is threatened by rampant illegal logging and over-exploitation to supply international markets, as well as by forest degradation. Fifteen *Ramin* species are categorised as Vulnerable by IUCN.[5]
Medicines	Chemicals obtained from tropical rainforest plants have revolutionised allopathic medicine. Derivatives from rainforest plants are used to treat cancer, malaria, heart disease, bronchitis, hypertension, dysentery and tuberculosis. These include quinine (used to treat malaria) and curare (a muscle relaxant) as well as vincristine and vinblastine (used to treat some forms of leukaemia).	Same as above.

Annex 1: continued

Services	Description	Threats
Other Non Timber Forest Products (NTFPs)	Indigenous tribes in tropical rainforests depend on NTFPs to sustain their way of life. Several *Kayapó* villages in Brazil harvest and process Brazil nut oil for commercial distribution. Other small enterprises being expanded are based on NTFPs such as *copaiba* oil, *cupuaçu* fruit, honey, cocoa, and mahogany seeds.[7] Rattan and natural fibres such as jute, sisal and ramie are used in the production of furniture, floor coverings, bags, baskets, ropes and clothing. Gums and resins, used to make products including boots, paints, adhesives and varnishes are obtained from tropical rain forests. Plant products such as essential oils are used in products including shampoo, soap, perfume, incense, cough drops, make-up, flavourings and drinks. Dried meat preserve soaked in honey is a delicacy enjoyed by the *Veddhas*, an indigenous tribe of Sri Lanka.[8]	Habitat destruction by over-exploitation of land: slash and burn cultivation practices, cattle ranching, habitat fragmentation, construction of dams for hydropower and logging pose severe threats to tropical rainforests. Over-exploitation of rattan (*Calamus*) in Sri Lanka threatens several species, namely *C. pachystemonus, C. radiatus* and *C. ovoideus.*[9]
Supporting services		
Biodiversity	Tropical rainforests support the greatest diversity of living organisms on earth. They cover less than 10% of the earth's land area but hold 50% of the earth's terrestrial species.[10] The ancient tropical forests of Malaysia are home to 2,650 tree species, 700 species of birds, 350 species of reptiles, 165 species of amphibians, 300 species of freshwater fish, and millions of invertebrate species.[11] In the Sinharaja World Heritage Site of Sri Lanka, over 60% of the trees are endemic and many of these are rare. There are 21 endemic bird species, and a number of rare insects, reptiles and amphibians. Endemism is high, particularly for birds (95%). Endemism among mammals and butterflies is also greater than 50%.[12] Despite covering only 0.013% of the world's land surface, Sri Lanka is home to more than 2% of the world's known frog and toad species, many of which live in lowland rainforests.[3]	Habitat destruction by over-exploitation of land: slash and burn cultivation practices, cattle ranching, construction of dams for hydropower and logging pose serious threats to biodiversity. Habitat loss and degradation affect 89% of all threatened birds, 83% of mammals, and 91% of threatened plants. Sixteen thousand one hundred and nineteen plant and animal species are known to be threatened with extinction. This may be a gross underestimate because less than 3% of the world's 1.9 million described species have been assessed for IUCN's Red List of Threatened Species.[13] Invasive alien species (IAS) cause severe damage to rainforests by bringing new diseases and competing with local species. In Sri Lanka, widespread IAS include Koster's Curse (*Clidemia hirta*), and *Diyapara* (*Dillenia suffruticosa)*, *Mimosa invisa* and Guinea grass (*Panicum maximum*).[14] The illegal trade in timber from *Ramin*, an endangered Indonesian tree species, is fuelling the destruction of Indonesian rainforests and driving species such as Critically Endangered Orang-utans (*Pongo pygmaeus*), Sumatran rhinoceros (*Rhinoceros sumatrensis*) and Malayan sun bears (*Helarctos malayanus*) closer to extinction.[15] Global warming is predicted to put at least 20-30% of plant and animal species at risk of extinction.[16]

Annex 1 contd.

Services	Description	Threats
Primary production	Estimated net primary productivity in the Barro Colarado tropical forest of Panama is at least 1,320g/m^2/yr. In comparison, the net primary productivity of the much larger plantations soybean and corn in central Iowa, Illinois and Ohio, USA is 1,700g/m^2/yr.[17]	Habitat destruction: recent global estimates suggest that around 150,000km^2 of tropical rainforest - equivalent to the size of England and Wales - is destroyed every year. In addition, a similar area is damaged or degraded.
Prevention of soil erosion	Tropical rainforest trees have extensive root systems (buttress roots, prop roots) that extend deep into the soil. The presence of leaf litter, which can be a foot thick, acts to minimise the effect of raindrop impact and increases infiltration capacity by soaking up water and releasing it slowly. Hence, the topsoil is anchored and its removal by rapid sediment run-off is prevented.[18]	Habitat destruction by deforestation: without the buttressing root systems of trees and plants and the sponge effect of leaf litter, rapid run-off of rainwater results in soil erosion, removing topsoil. This leads to a build-up of soil in nearby river beds, causing flooding and affecting fresh water biodiversity.
Nutrient cycling	Tropical rainforests have an efficient nutrient cycle. Dead organic matter is decayed rapidly by many species of decomposers and detritivores, aided by the moist conditions of the forest. Carbon and oxygen are released into the air and nitrogen, calcium and phosphorous and other minerals are absorbed immediately by a thick mat of plant roots and root-like fungi (mycorrhizae). The close association between plants and fungi ensure that there is direct nutrient cycling.[19]	Habitat destruction: the soil in tropical rainforests is poor in nutrients; therefore, long term cultivation of crops cannot be sustained, resulting in the abandonment of these clearings and deforestation of new areas for cultivation.
Water purification	Rain in tropical forests does not directly reach the soil but trickles through the forest canopy. As water percolates slowly, it is purified by biological processes performed by bacteria, fungi and algae, before reaching the soil and flowing into streams.[20]	Habitat destruction: deforestation in tropical rainforests results in rapid water run-off, leading to flooding and soil erosion.
Biological and genetic resources	While domesticated plants and animals are bred and become susceptible to pests and disease, wildlife flora and fauna have diverse traits due to out-breeding. Genes of wild plants are used to strengthen varieties and to introduce disease resistance.	Deforestation and climate change affect the composition of rainforests causing the loss of genetically diverse flora and fauna.
Sequestering carbon	Tropical rainforests are vast reservoirs of carbon (carbon sinks) through CO_2 absorption and conversion to biomass by trees and plants.	Habitat destruction: deforestation in the tropics accounts for nearly 20% of carbon emissions due to human activities. This will release an estimated 87 to 130 billion tonnes of carbon by 2100, which is greater than the amount of carbon that would be released by 13 years of global fossil fuel combustion. [21]

Annex 1 contd.

Services	Description	Threats
Regulating services		
Climate regulation	Excess emission of greenhouse gases into the atmosphere results in the rise of surface temperatures, which alters major planetary weather systems. Often called the 'lungs of the earth', tropical forests help stabilise the climate through absorption of CO_2 by trees and plants. Functioning as water pumps, tropical rainforests add to local humidity through transpiration which releases water vapour to form clouds. Some of this vapour precipitates as rain over the rainforest but often, clouds are carried a great distance to precipitate as rain in the mid latitudes - as far away as Europe and Australia.	Habitat destruction: deforestation in the Amazon region of South America influences rainfall from Mexico to Texas and in the Gulf of Mexico, while forest loss in Central Africa affects precipitation patterns in the upper and lower US Midwest; deforestation in Southeast Asia was found to influence rainfall in China and the Balkan Peninsula.[7]
Flood regulation	The flora of tropical rainforests (such as epiphytes) act collectively as a giant sponge. Rain is absorbed by canopy epiphytes and percolates slowly to the bottom of the forest floor and thick layer of leaf litter. This method of precipitation prevents flooding in outer, clearer areas. In a well-forested watershed, 95% of annual rainfall is trapped and released steadily, replenishing ground water and keeping streams flowing through dry seasons.[1]	Habitat destruction: when the forest canopy is removed, the exposed soil surface bakes hard in the intense heat. Rainfall cannot penetrate easily the soil surface and is lost rapidly from the area in surface run-off, creating a flood hazard.
Cultural services		
Homes for indigenous communities	Lowland tropical rainforests support many indigenous communities. Surviving indigenous people in the Brazilian Amazon demonstrate the remarkable diversity of the rainforest because they comprise 215 ethnic groups with 170 different languages.[6] Other tropical forest groups include the *Mentawai* people of Indonesia,[22] the *Bajau* people of the Philippines[23] and the *Wanniyala-Aetto* of Sri Lanka.[24]	There were an estimated ten million Indians living in the Amazonian rainforest five centuries ago. Today, there are less than 200,000.[6] Deforestation and other factors such as the search for minerals and oil are forcing indigenous people into a steadily decreasing area. Many of the groups have to give up their original way of life, their culture and their religion, because of the destruction of rainforests.
Tourism	Tropical rainforests are of great economic value in the tourism industry. Popular tropical rainforest destinations include the Amazon Rainforest in South America, the Kerinci Sablat National Park (KSNP) in Indonesia, the Sinharaja Forest Reserve Sri Lanka and Sarawak in Malaysia.	Pollution: tourists disturb tropical rainforests by irresponsible trash disposal. Over-visitation results in habitat degradation. Intentional removal or addition of flora and fauna by uninformed tourists creates an imbalance, influencing natural species diversity.[25]

References

1. http://www.coralcay.org/science/forests/why_conserve_forests.php
2. http://www.rainforestfoundationuk.org/s-The%20Destruction%20of%20Rainforests)
3. http://rainforests.mongabay.com/20indonesia.htm
4. http://www.mongabay.com/deforestation_rate_tables.htm
5. http://www.awionline.org/wildlife/cites/press/raminprotected.htm
6. http://www.rain-tree.com/facts.htm
7. http://www.conservation.org/FMG/Articles/Pages/brazil_kayapo_ally_in_amazon.aspx
8. http://en.wikipedia.org/wiki/Veddhas
9. http://www.fao.org/docrep/003/y2783e/y2783e11.htm
10. Millennium Ecosystem Assessment (2005). *Ecosystems and Well-being Synthesis report.* Washington DC: Island Press. v+86 pp.
11. http://www.globio.org.glossopedia/article.aspx?art_id=16
12. http://www.lankalive.info/wildlife/sinharaja/sinharaja.php
13. http://cmsdata.iucn.org/downloads/species_extinction_05_2007.pdf
14. Bambaradeniya, C.N.B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17** (11): 930-935.)
15. http://www.ens-newswire.com/ens/feb2004/2004-02-06-11.asp
16. IPCC (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Eds. M. L. Parry, O.F. Canziani, J.P. Palutikof, P. J. Van Hanson. Cambridge, UK: Cambridge University Press. 976pp.
17. Condit, R. D. M Winsor, and S. P. Hubbell. 1996. *NPP Tropical Forest: Barro Colarado, Panama, 1969-1990. Data set*
18. Ross, S. M., J. B. Thornes and S. Nortcliff (1990). Soil Hydrology, Nutrient and Erosional Response to the Clearance of Terra Firme Forest, Maracá Island, Roraima, Northern Brazil. *The Geographical Journal* **136**: 267-282.
19. http://www.marietta.edu/~biol/102/rainfor.html
20. http://www.sciencelinks.com/lessons.cfm?DocID=275
21. rsdfsdfsdf http://earthobservatory.nasa.gov/Newsroom/MediaAlerts/2007/2007051124943.html
22. http://en.wikipedia.org/wiki/Mentawai_people
23. http://en.wikipedia.org/wiki/Bajau
24. http://en.wikipedia.org/wiki/Wanniyala-Aetto
25. http://en.wikipedia.org/wiki/Tropical_rainforests

Annex 2: At a glance: services provided by, and threats to tropical montane and sub-montane forests

Services	Description	Threats
Provisioning services (Goods)		
Timber	Seven million hectares of bamboo grow in China's mountains. In 1997, the bamboo sector generated 2.2 billion USD, including exports worth over 320 million USD and 25% of China's forest exports. This industry creates employment for 5.6 million people, including 4.5 million farmers. Bamboo is used for furniture, paper, ply-bamboo, food, medicine, and handicrafts.[1] The southwest forests of Ethiopia have served as major sources of timber for saw log, plywood, chipwood and paper industries during the last century. Over 57,987m^3, 6,273m^3 and 7,701m^3 of logs have been removed between 1982 and 1993 from the *Gera* forest, *Belete* forest and *Bonga* forest in *Oromia* and southern regions, respectively.[2]	Deforestation: cloud forests are affected by timber extraction and commercial logging in seven Asian countries, particularly in Indonesia, Malaysia and the Philippines. This reflects the presence of major logging industries in these countries. Timber harvesting was recorded for six African and six Latin American countries, principally for local construction use. Other major threats include habitat degradation and fragmentation through road construction, mining, conversion of forest area to agricultural and grazing land, fire, hunting and deforestation for drug cultivation.[3]
Non Timber Forest Products (NTFPs)	The montane forests of Thailand harbour a multitude of NTFPs, which are used by the local communities. Most of them are collected for subsistence only. These include mushrooms, honey or herbal medicine. Only few products such as the chestnuts of *Castanopsis* are sold seasonally in the market. *Camellia sinensis* grows naturally in the montane forests of Thailand.[4] The leaves of this shrub are used by villagers to produce a Thai delicacy known as *Pak Miang*.[5] A diversity of NTFPs is exploited from cloud forests. These products include medicinal plants (extracted medicines include Quinine and Pygeum), fruits and herbs, natural gums, honey, spices, game meat and ornamental plants. Tree ferns and the abundant epiphytes such as orchids, bromeliads and mosses are extracted for horticultural markets.[3]	Clearance of cloud forests for farming is the most widely recorded threat, reported from 90% of Latin American and Asian countries and 53% of African countries. It is a major deforestation pressure in all countries with cloud forests. The cleared land is used principally for subsistence agriculture by resource poor farmers, although commercial production of temperate-zone fruits and vegetables is expanding in cloud forest areas in Asia.[3] Significant threats from planned mining operations, large dams, and high-altitude timber plantations are increasing.[6]

Annex 2 contd.

Services	Description	Threats
Supporting services		
Biodiversity	Tropical montane rainforests harbour higher levels of biodiversity than the lowland rainforests. Half of Sri Lanka's endemic flowering plants and 51% of the endemic vertebrates are limited to this ecoregion in Sri Lanka. More than 34% of Sri Lanka's endemic trees, shrubs, and herbs are found in montane rainforests. Several endemic animals - such as the Torrent toad (*Adenomus dasi*), Rhinoceros-horned lizard (*Ceratophora stoddartii*) and Sri Lanka Whistling thrush (*Myophonus blighii*) are restricted to these ecosystems.[7] Ninety of India's 484 reptile species are endemic to the montane forests of the southwestern Ghats. Almost 50% of India's 206 amphibian species are also endemic to the ecoregion.[8] More than one half of Borneo's 30 pitcher plant species are found in its montane forests. Rhododendrons are characteristic of upper montane flora, and more than twenty *Vireya* species thrive here. More than 250 bird species are also attributed to this ecoregion. Limestone forests are forests that grow on limestone hill areas. Although in southeast Asia most limestone occurs in the lowlands, Borneo has important limestone forests in the montane zone.[9, 6]	Deforestation: the primary threats to biodiversity in montane forests are from shifting cultivation, especially in the steeper slopes that people (especially in Viet Nam and Thailand) are beginning to clear because of lack of land to support increasing populations. Sub montane forests in the Knuckles Range of Sri Lanka are threatened by cultivation of cardamom and the expansion of tea plantations.[11] Large hydro projects (especially in Laos and Viet Nam) are also serious threats. Over-exploitation through illegal hunting for a huge commercial trade that supplies China; over-exploitation of eaglewood (*gaharu* - the fragrant resinous wood produced by a fungal infection in trees of the genus *Aquilaria*) and wildlife (elephant and gaur) poaching, as well as road construction are also threats to montane forests.[10] Sub montane forests in the Knuckles Range of Sri Lanka are threatened by cultivation of cardamom and the expansion of tea plantations.[11] Invasive alien species are a threat to the biodiversity of montane forests. In Sri Lanka, destructive IAS include Gorse (*Ulex europaeus*), Mistflower (*Eupatorium riparium*), *Cestrum aurantium*, Strawberry guava (*Psidium littorale*), *Naththasooriya (Tithonia diversifolia*) and the Velvet plant (*Miconia calvescens*).[12]
Watershed protection	Tropical montane cloud forests have an abundance of epiphytic plants that capture water from the condensation from clouds and fog. This 'stripping' of wind-blown fog by the vegetation becomes especially important during the non-rainy season and in areas with low rainfall but with frequent clouds. Water originating from cloud forests is also increased because water loss from vegetation wetted by rain or fog is reduced. This results in stream flows from cloud forest areas that are greater and more dependable during dry periods.[3] Montane forests are the most important catchments and watershed areas of the Knuckles range in Sri Lanka. Through the year, they play a key role in providing a water supply to sustain ecosystems and livelihoods through the year in downstream areas. They serve as the catchment for several major rivers.[11]	Of all the types of tropical forest, tropical montane cloud forests are especially vulnerable to climate change. Alterations in climate conditions will lead to the replacement of cloud forests by lower altitude ecosystems and the extinction of cloud forests currently on mountain peaks where they are unable to spread up slope. The reduction of cloudiness over the forests will result in less frequent immersion of the forest in the clouds and reduced capture of water by the vegetation, with a consequent drying out of the ecosystem. Deforestation in lowland areas also affects the hydrological role of cloud forests. Wind passing over these sparse regions lifts clouds in mountainous regions, thereby drying cloud forests.[3]

Annex 2 contd.

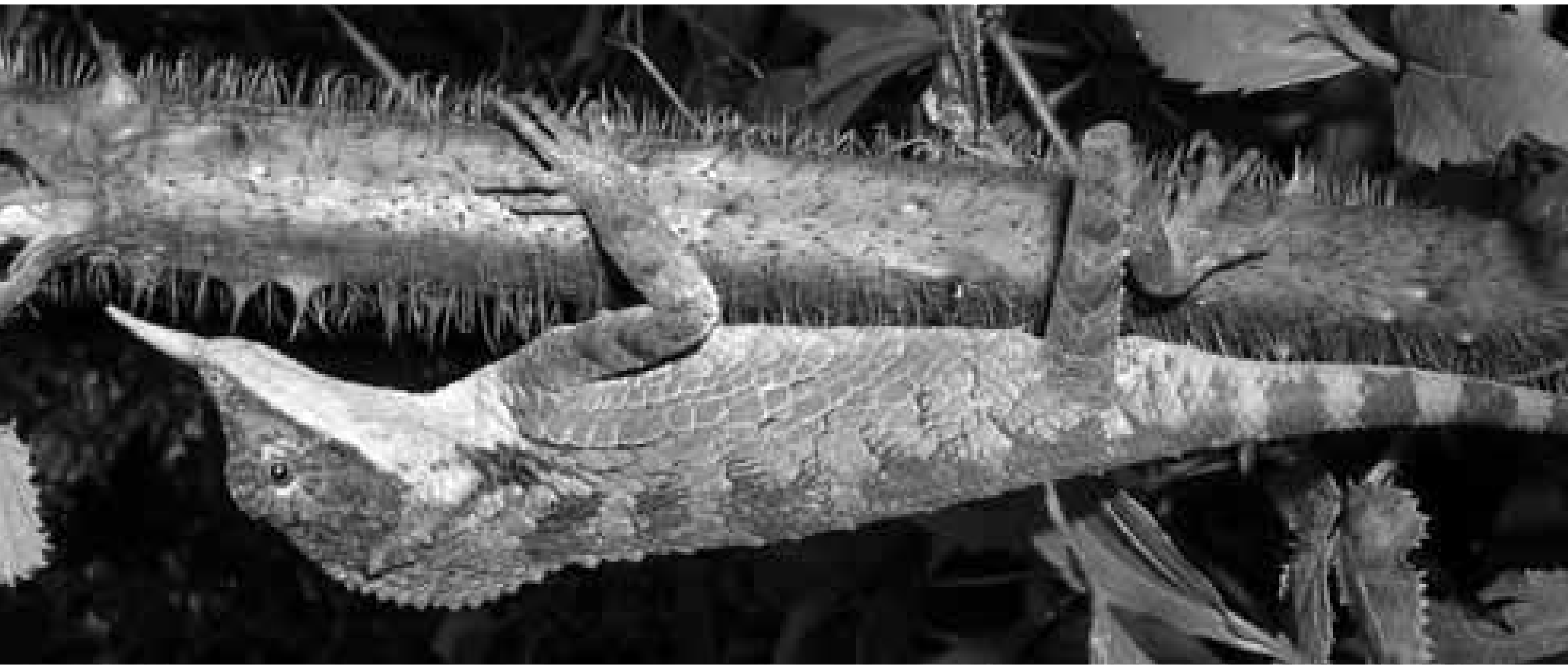
Services	Description	Threats
Supporting services contd.		
Prevention of soil erosion	Cloud forests are located on steep mountain slopes in high rainfall areas. Due to the high infiltration capacity and high organic content of their soils, cloud forests reduce soil erosion and the incidence of devastating landslides.[13]	Habitat destruction by deforestation: logging of montane forests has devastating effects on the landscape and surrounding ecosystems. Extensive erosion on surrounding deforested slopes has clogged the irrigation systems of the once fertile rice fields of Palu Valley in Indonesia.[14] Communities in the Sabaragamuwa province of Sri Lanka are vulnerable to earth slips and floods, during monsoon rains, as a consequence of the instability of hill slopes due to the loss of montane forest.[15]
Genetic resources	An important characteristic of cloud forests is that they are the natural habitat of the wild relatives of many crop species. They are, therefore, important gene pools for the continued improvement of these plants. Wild plants include relatives of papaya (*Carica papaya)*, tomato *(Lycopersicon esculentum)*, tree tomato (*Cyphomandra betacea*), species of passion fruit, avocado *(Persea americana)*, beans of the genus *Phaseolus*, the blackberry (*Rubus spp.*), cucumber (*Solanum muricatum*), potato (*Solanum spp.*) and peppers (*Capsicum spp.)*[3]	Hunting and anthropogenic fires are serious threats to the wildlife assemblages and habitats in Sulawesi, Indonesia. Hunters set fires to facilitate hunting of *Anoa*, a kind of buffalo (*Bubalus quarlesi*), creating montane meadows. Cloud forests and sub-alpine forests are subject to periods of drought, during which the oil-rich leaves of *Rhododendron, Vaccinium*, and *Gaultheria* easily catch fire destroying wild flora and fauna.[14]
Regulating services		
Sequestering carbon	Montane moist forests are also important in helping to sequester CO_2 from the atmosphere and, therefore, are major carbon sinks, helping in reducing the greenhouse effect. Current estimates have shown that the montane forests of Ethiopia sequester nearly 27,579 million kg of CO_2 per annum from the atmosphere.[2]	Climate change is the biggest threat to cloud forests, which depend on the stable position of clouds. Deforestation in lower-lying lands, even regions over 50km away, is changing the local climate, leaving cloud forests cloudless. As winds pass over deforested lowlands, clouds are lifted higher - often above the mountain tops, which dries the cloud forest - so it can no longer support the same vegetation or provide appropriate habitat for many of the rare species originally found there.[16]
Flood regulation	Cloud forests can store the water that is stripped from clouds and release it slowly to the lowland regions. In this manner, catastrophic flash floods are prevented.[13]	Deforestation of cloud forests exposes land on steep slopes which results in the incidence of floods as well as soil erosion.

Annex 2 contd.

Services	Description	Threats
Cultural services		
Tourist attractions	Tourists are attracted by the beauty of the mountain environment as well as rare species characteristic of montane rainforests. Cloud forest sites with significant tourism potential include the Monteverde cloud forest in Costa Rica, Mount Stanley in Uganda, Luquillo National Forest in Puerto Rico, Mount Makiling and Mount Pulog in the Philippines, the Cameron and Genting Highlands in peninsular Malaysia and Mount Kinabalu in Sabah, Malaysia.[3]	Pollution: tourism and recreation activities affect cloud forests through trail making and littering. Tourists also remove souvenirs from the forest. The building of attractions such as golf courses results in the destruction of cloud forests.[13]

References:

1. http://www.peopleandplanet.net/doc.php?id=1032
2. http://www.ibcet.org/?page_id=108
3. Bubb, P., May, I., Miles, L., Sayer, J (2004). *Cloud Forest Agenda*. UNEP-WCMC, Cambridge, UK.
4. P. J. Bee (1972). Economic Systems of Northern Thailand. Pp 663-665 in Structure and Change by Edward Van Roy. *Bulletin of the School of Oriental and African Studies, University of London* **35** (3).
5. http://www.fao.org/docrep/w3735e/w3735e37.htm
6. http://www.eoearth.org.article/Borneo_montane_rain_forests
7. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0155_full.html
8. http://en.wikipedia.org/wiki/Malabar_rainforests#South_Western_Ghats_montane_rain_forests
9. http://www.sabah.gov.my/htan_frc/English/Student%20Zone/Level%202/Forest%20types/limestone.htm
10. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0121_full.html
11. http://www.knucklesrange.org/biodiv.html
12. Bambaradeniya, C.N.B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal*, 17 (11): 930-935.
13. http://www.sciencelives.com/cloudforest1.html
14. http://www.eoearth.org/article/Sulawesi_montane_rain_forests
15. IUCN Best Practice Guidelines, After the Tsunami: Learning to prepare for natural disasters, *Information paper no. 8*. http://data.iucn.org/places/asia/coastalinfo/docs/Best_practice_guidelines_8_preparing_for_natural_distasters.pdf
16. http://cnx.org/content/m12159/latest/)



Annex 3: At a glance: services provided by, and threats to monsoon forests

Services	Description	Threats
Provisioning services (Goods)		
Timber and fuelwood	Timber extraction is an important service of monsoon forests. The principal plant species in the monsoon forests of Bangladesh is *Shorea robusta*, known commonly as *Sal*, hence these areas are also known as *Sal* forests. *Sal* is one of the most important timber yielding plant species and is used for railway sleepers, piles, beams and other load bearing parts of bridge structures, telephone poles, wheels and bodies of carts and other similar load carriers, motor trucks and structures of houses.[1] Teak (*Tectona grandis*) is found commonly as a species in monsoon forests in India and Indo-China. It is used extensively in India and prized for its durability. Teak is used to make furniture, boat decks, indoor flooring and beams in houses.[2] Approximately 16,000m^3 of wood is obtained annually from the tropical dry forests in Jalisco, Mexico.[3] Fuelwood is the only source of cooking fuel in households of the Uttara Kannada district in the Western Ghats of India. On average, each household collects about 1,900–3,300kg of fuelwood per year in the form of fallen twigs or dry branches from the moist deciduous, dry evergreen and dry deciduous forests that are characteristic of the area.[4]	Over-exploitation: of all forest regions in Bangladesh, *Sal* forests are the most threatened due to the high demand of timber, easy access and geographic location. *Sal* forests undergo rapid reduction through illicit felling, excessive leaf litter collection, encroachment and unsustainable collection of economically important plant species. The extent of forest under encroachment is approximately 0.036 million hectares with an estimated 100,000 encroachers threatening the area.[1] Teak is not considered a rare species in countries such as Thailand and India, but extraction of teak at an excessive rate has lead to forest degradation. Illegal felling of teak, particularly in the Myanmar/Thai border is of international concern.[5] Satinwood (*Chloroxylon swietenia*) and Ebony (*Diospyros ebenum*) are now rare species in the monsoon forests of Sri Lanka due to over-exploitation for timber.[6]
Non Timber Forest Products (NTFPs)	Non Timber Forest Products obtained from monsoon forests are used for food, roofing, household ornaments and utensils, fodder and for medicinal purposes. The exudates, leaves and fruits of many monsoon forest flora are prescribed by medical practitioners for ailments. Fruits from *Shorea robusta* are used to treat diarrhoeal diseases and the stem sap can be used to treat skin diseases. Serpentwood (*Rauvolfia serpentina)* is used for the treatment of snake bites and for the treatment of hypertension. Plants with medicinal properties are used to treat both humans and livestock. Garden owners and cattle farmers collect grass for use as fodder. The quantity of fodder collected in the semi evergreen zone of the Uttara Kannada district in the Western Ghats of India is 2,870 kg/household/yr.	Habitat destruction through forest-to-pasture conversion, which results in forest fragmentation; livestock grazing; slash-and-burn cultivation; and dams constructed for hydropower. Over-exploitation (excessive collection of fuelwood by indigenous people, over-exploitation of trees for timber and poaching of animals for the wildlife trade). Invasive alien species are spreading in disturbed forest areas.[7]

Annex 3: contd.

Services	Description	Threats
Provisioning services (Goods)		
NTFPs contd.	In the Uttara Kannada district, mushrooms, honey and fruits of Indian gooseberry (*Emblica officinalis)* and Bengal currant/*Karanda* (*Carissa carandas)* are collected in small quantities for use at the household level. Honey is extracted annually from the dry deciduous zone and sold commercially. Other valuable food sources include wild mangoes, lime, chilli peppers, Garcinia (*Garcinia indica)* and Ebony (*Diospyros melanoxylon)*. Gum is extracted from Axlewood (*Anogeissus latifolia*) and Soap nut (*Acacia sinuata*) is used to make shampoos. Cane, bamboo and Silver date palm *(Phoenix sylvestris)* are used to produce baskets, rooms, material for roofing, furniture and ropes.[4]	Habitat destruction through forest-to-pasture conversion, which results in forest fragmentation; livestock grazing; slash-and-burn cultivation; and dams constructed for hydropower. Over-exploitation (excessive collection of fuelwood by indigenous people, over-exploitation of trees for timber and poaching of animals for the wildlife trade). Invasive alien species are spreading in disturbed forest areas.[7]
Supporting services		
Biodiversity	The monsoon forests of Hainan Island - located in the South China Sea - support a high floral biodiversity with 4,200 plant species, 630 of which are endemic to the island. Two mammal species - the Hainan moonrat (*Neohylomys hainanensis*) and the Hainan flying squirrel (*Hylopetes electilis*) - are endemic to Hainan. Other notable mammals include the Black gibbon (*Hylobates concolor)*, the Asiatic black bear (*Selenarctos thibetanus*), and the Hainan mole (*Talpa insularis*).[8] The dry-zone dry evergreen forests of Sri Lanka are home to one of Asia's largest mammals - the Elephant (*Elephas maximus*), whose populations are estimated at 2,500 - 4,000 - as well as other large mammals such as Leopards (*Panthera pardus*) and Sloth bears (*Melursus ursinus*).[9] The Kathiarbar-Gir dry deciduous forests of India support the only surviving population of the Asiatic lion (*Panthera leo persica*).[10] The Madagascar monsoon forests are a major centre of endemism in Madagascar and have high biological importance. Endemic mammal species to the ecoregion include the Golden-crowned sifaka (*Propithecus tattersalli*), Mongoose lemur (*Eulemur mongoz*), Western forest rat (*Nesomys lambertoni)*, Golden-brown mouse lemur (*Microcebus ravelobensis*), Northern rufous mouse lemur (*M. tavaratra*), Western rufous mouse lemur (*M. myoxinus*), Perrier's sifaka (*Propithecus diadema perrieri*), Milne-Edwards's sportive lemur (*Lepilemur edwardsi*) and a species of forest mouse, *Macrotarsomys ingens*. The dry deciduous forests are one of the primary habitats for the island's largest predator, the Fossa (*Cryptoprocta ferox*).[11]	The dry deciduous forests in the Central Deccan Plateau of India are under severe threat from conversion to plantations for cash crops, over-grazing by cattle, excessive fuelwood collection and large hydroelectric projects. Habitat loss results in decreasing prey for tigers that turn to livestock as a source of food. Retaliation by the local people against these predations has affected the tiger population.[12] The primary threats to the dry-zone monsoon forests of Sri Lanka are from deforestation caused by agriculture, shifting cultivation, small-scale logging and encroachment into protected areas. Several mammals in these forests are threatened, including Asian elephants, Leopards, Sloth bears, the endemic Purple-faced leaf monkey (*Semnopithecus vetulus*) and the Sri Lanka red slender loris (*Loris tardigradus*).[13] Hunting to supply the wildlife trade has depleted wildlife biodiversity in the southeastern Indochinese dry evergreen forests, home to the Critically Endangered Javan rhinoceros (*Rhinoceros sondaicus*), one of two populations of this species on earth.[14] Invasive alien species are rampant in disturbed monsoon forests of Sri Lanka. Feral buffalo (*Bubalus bubalis*) is a common invasive animal in forest areas. Common IAS plants include Prickly lantana (*Lantana camara*), Siam weed (*Chromolaena odorata*), *Leucaena leucocephala* and the Mile-a-minute-weed (*Mikania micrantha*).[15]

Annex 3: contd.

Services	Description	Threats
Supporting services contd.		
Genetic resources	Wild species of flora and fauna found in tropical dry forests are genetically more diverse than domestic livestock and cultivated crops. Native tropical dry forest species are adapted to low and seasonal water availability. Predictions for climate change in the tropics include increasing temperatures and decreasing water availability, making tropical dry forest plant species important sources of genetic diversity which can be propagated vegetatively. Wild relatives of crops such as squash are found in dry forests in the Chamella region of Mexico.[3]	Climate change can affect genetic diversity through effects on breeding systems, plant-pollinator and plant-seed disperser interactions and species reproduction. As a consequence, genetic diversity will be lost to inbreeding and extinction of species. Over-exploitation of wild species and destruction of their natural habitat decreases surviving populations and reduces gene pools.[3]
Soil erosion	In spite of the deciduous character of monsoon forests, there is always a constant leaf litter layer on the forest floor. This protects the soil from the direct impact of raindrops which keeps high infiltration rates in the soil, preventing runoff and soil erosion.[3]	When monsoon forests are transformed into agriculture and pasture fields soil cover and infiltration rates decrease. This results in soil erosion and sediment transport which increases the incidence of flashfloods.[14]
Carbon sequestration	Carbon sequestration in the dry evergreen forests of the Kanchanaburi Province in Thailand is 70.29 tonnes C/ha.[16]	Fires during forest-to-pasture conversion in the dry forests of Mexico are a major source of CO_2 emissions to the atmosphere contributing to global warming, which further dries tropical dry forest ecosystems. Potential annual carbon emissions from the burning of biomass through slash and burn cultivation may amount to 708 million tonnes of carbon in comparison to 569 million tonnes of carbon from evergreen forests.[3]
Primary production	The net primary productivity of tropical dry forests in the Chamela region of Mexico is estimated to be 12-14 Mg/ha/yr.[3]	Teak has been shown to be sensitive to variations in climate. In India, depletion of soil moisture as a result of global warming is likely to cause teak productivity to decline from 5.40 m^3/ha/yr to 5.07 m^3/ha/yr.[17]
Maintenance of soil fertility	The strong seasonal pattern of rainfall causes nutrient leaching from forest soil. However, tropical dry forests have extremely fertile soils due to various recycling mechanisms to minimise nutrient loss from the ecosystem. The dense leaf litter layer prevents nutrient leaching by surface runoff. Further, a strong microbial population immobilises nutrients and therefore, nutrients are reabsorbed into plants prior to shedding leaves during the dry season.[18]	When forests are transformed through slash and burn cultivation, 80% of the litter layer and above ground biomass is destroyed. Forest-to-pasture conversion results in 77% of carbon and 82% of nitrogen being lost from the above ground biomass and soil erosion results in the loss of 179 and 24 kg/ha/yr of nitrogen and phosphorus respectively.[3]
Regulating services		
Climate regulation	Monsoon forests regulate the local climate by providing shade and moisture to farmers and livestock. Climate conditions on a regional and global scale are also regulated by the carbon sequestration service of these forests.[3]	Clearance of land increases the surface albedo (the direct reflection of solar radiation back to outer space) of monsoon forests. This effect, combined with increasing temperatures due to global warming, may produce some disturbances of monsoon circulation and seasonal variation in forests of the southeast Asian region. Fire - which is also influenced by fluctuations in temperature - rainfall, seasonal variation and human land use, significantly affects the structure, composition and age diversity of forests. [29]

Annex 3: contd.

Services	Description	Threats
Regulating services contd.		
Flood regulation	The Chamela region in Mexico is prone to cyclonic events with highly erosive storms. Because of the constant leaf litter layer on the forest floor, the soil has a high infiltration capacity and the occurrence of floods is reduced greatly.[30]	When monsoon forests are transformed into agriculture and pasture fields, soil cover and infiltration rates decrease resulting in soil erosion and sediment transport which increases the incidence of flash floods.[31]
Cultural services		
Home to indigenous people	Monsoon forests are home to the *Hmong* and *Yao* tribes of Thailand,[32] the *Adivasi* of Central India[33] and the *Veddas* of Sri Lanka.[34]	The biggest threat to the dry deciduous forest of the Narmada Valley in India is the construction of a series of dams along the Narmada river. Nearly 60% of the natural dry forest of this region has been cleared. These dams flood critical habitat and force large numbers of people from local communities to relocate.[35]
Tourism	Important tourism destinations in monsoon forests include the Komodo National Park in the Lesser Sunda islands of Indonesia,[36] Yala, Wasgomuwa and Minneriya National Parks in the dry-zone monsoon forests of Sri Lanka,[37] the Gir Forest National Park [38] and the Betla National Park of India.[39] The Lao system of 20 National Protected Areas covers nearly 14% of the country and is recognised as one of the best designed protected areas systems in the world. With large tracts of tropical monsoon forest, diverse wildlife populations and many ethnic minority groups, Laos' protected areas have an abundance of ecotourism attractions.[40]	Tourists disturb monsoon forests by over-visitation. This results in habitat degradation by trampling and pollution by vehicles. Removal or addition of flora and fauna by uninformed tourists creates an imbalance, influencing natural species diversity. Habituation of wildlife - such as deer and juvenile Komodo dragons - has been observed in the Komodo National Park in Indonesia. Experts project that habituation and dependency on visiting tourist adversely affects wildlife. [41] Harassment of elephants and other wild animals, off-road driving that destroys vegetation and littering by tourists threaten the Yala National Park in Sri Lanka.[42]

References

1. http://banglapedia.search.com.bd/HT/S_0035.htm
2. http://en.wikipedia.org/wiki/Teak
3. http://www.ecologyandsociety.org/vol10/iss1/art17/
4. Murthy, I. K., Bhat. P. R., Ravindranath, N. H. and R. Sukumar (2005). Financial valuation of non-timber forest product flows in Uttara Kannada district, Western Ghats, Karnataka. *Current Science Association* **88** (10): 1573-1579.
6. http://www.unep-wcmc.org/species/tree_study/asia/3-147.html
7. http://www.fao.org/DOCREP/003/W7708E/W7708E02.htm28. http://www.ecologyandsociety.org/vol10/iss1/art17/
8. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0205_full.html
9. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0169_full.html
10. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0212_full.html
11. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0206_full.html
12. http://www.worldwildlife.org/wildworld/profiles/terrestrial/at/at0202_full.html
13. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0201_full.html
14. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0212_full.html
15. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0210_full.html
16. Bambaradeniya, C.N.B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal*, **17** (11): 930-935.
17. www.ecology.uni-corvinus.hu/pdf/0502_093102
18. http://www.grida.no/climate/ipcc/regional/298.htm
19. www.springerlink.com/index/8237363P4J202961.pdf

Annex 4: At a glance: services provided by, and threats to scrub forests

Services	**Description**	**Threats**
Provisioning services (Goods)		
Timber and fuelwood	Trees that are important timber species such as *Palu (Manilkara hexandra),* the 'Mustard Tree' (*Salvador persica*) and Margosa/*Neem* (*Azadirachta indica*) are interspersed among the scrub vegetation in the scrub forests of Sri Lanka.[1] The *Soliga* people in the *Biligiri Rangaswarmy* Temple Wildlife Sanctuary in India depend on species such as Axlewood (*Anogeissus latifolia*), Satinwood (*Chloroxylon swietenia)*, Red Catechue *(Acacia sundra*) and *Grewia oppositifolia* for fuelwood.[2]	Over-exploitation: logging and cutting of vegetation for timber and fuelwood, excessive mining for mineral resources and over-exploitation of plant species for the ornamental plant trade. Habitat destruction: slash and burn cultivation, fires to create grazing lands and over-grazing by livestock).[3] Invasive alien species such as Mesquite (*Prosopis juliflora)*, Prickly pear (*Opuntia dillennii*) and *Lantana camara* are also spreading.[4]
Non Timber Forest Products (NTFPs)	An important NTFP of scrub forests in India is the fruit of *Nelli/Amla (Phyllanthus indofischeri)* which is used as a common ingredient of many medicines and tonics in traditional Indian health practices. Experimental preparations of *Nelli/Amla* leaf, fruit and bark extracts have properties that can be used to treat diseases such as diabetes, inflammation and age-related renal disease.[2] The *Nelli/Amla* fruit is used commercially to prepare pickles, jams and juices. It is also used to make hair dyes, shampoos, hair oil and tannins, which fix dyes in fabric.[5] Creole lemon (*Ampbypteryngium adstingens*), found in the open scrub forests of the volcanic complex of Colima in Mexico, is used as a cure for stomach ulcers and gastritis and *Cuachalalate (Arbutus tessellate)* is used to treat headaches.[6] Honey is a source of income and sustenance for the *Solig*a community of India.[2]	Same as above.
Mineral resources	The Jhangar Valley scrub forest of Pakistan is a site of extraction of minerals and ores such as coal, gypsum, clay and limestone. More than 100 coal mines are situated in this forest and are a source of considerable revenue for the government of Pakistan as well as the local community.[7]	Several cement factories obtain raw materials from the Jhangar Valley and destroy its scrub forest by blasting large areas to extract these raw materials. Dust particles and other pollution released by cement factories settle on scrub vegetation and block plant biological processes. Extensive coal mining has led to serious habitat degradation and erosion of fertile scrublands.[7]

Annex 4: contd.

Services	Description	Threats
Supporting services		
Biodiversity	The Deccan Thorn scrub forests of India harbour the remaining populations of Jerdon's courser (*Rhinoptilus bitorquatus*), a Critically Endangered bird species.[8] Several large mammals of conservation importance including Leopards (*Panthera pardus*), Caracals (*Felis caracal*), Indian gazelles (*Gazella bennettii*), Four-horned antelopes (*Tetracerus quadricornis*), Wild dogs (*Cuon alpinus*) and Blackbucks (*Antilope cervicapra*) find refuge in the northwestern scrub forests of India and Pakistan. These forests also harbour the Globally Threatened Indian bustard (*Ardeotis nigriceps*) and the Lesser florican (*Eupodotis indica*).[3] The Caatinga scrubland of northeastern Brazil provides habitat to over 1,200 species of vascular plants, of which 30% are endemic.[9] The Guatemalan beaded lizard (*Heloderma horridum charlesbogerti*), found in the Montagua Valley scrub forest of Guatemala, is helpful to humans as its venom is used as an effective treatment for diabetes.[10]	The Brazilian Caatinga is home to the Lear's macaw (*Anodorhynchus leari*) and the Spix macaw (*Cyanopsitta spixii*), two of the most threatened bird species in the world. More than 50% of the Caatinga has been degraded as a result of agricultural development, cattle grazing, extraction of fuelwood, extensive and uncontrolled human-induced fires and cotton cultivation.[9] The scrub forests of the Deccan Plateau are threatened by Mesquite (*Prosopis juliflora*) - an invasive alien species, which invades village pastures - resulting in the loss of grazing areas for cattle. This results in encroachment into the protected scrub forests for grazing. Other IAS include Prickly pear (*Opuntia dillennii*) and *Lantana camara*.[8] *Tillandsia xerographica*, a bromeliad endemic to the Montagua Valley scrub forest of Guatemala, is in danger of extinction because of its extraction for the ornamental plant trade. Other flora that are extracted illegally for this trade include cactus species of the genera *Mammillaria* and *Melocactus*.[11]
Carbon sequestration	Annual above ground carbon sequestration in a New Zealand scrub forest as large as 2.6 million hectares is 3.4 million tonnes of carbon.[12]	The largest potential losses of carbon from vegetation and soil are due to soil erosion, intensive grazing and over-exploitation of plant species for food and fuelwood.[12]
Regulating services		
Climate regulation	Scrub forests play a role in regulating global climate patterns through carbon sequestration. The extent of ground cover by scrub vegetation affects albedo (the amount of solar radiation that is reflected back into space) and the fraction of soil water that is transpired to the atmosphere. These effects drive atmospheric energy and water-balance processes.[13]	Over-exploitation of scrub vegetation leads to increased land albedo, reduced shade, increased surface temperatures, a rapid decrease in soil moisture which leads to reduced evaporation and reduced rainfall in the wet season.[13]
Cultural services		
Home to indigenous tribes	The scrub forests of the *Biligiri* National Wildlife Sanctuary in India are home to the *Soliga* community.[2] Other indigenous populations living in scrub forests include the *Tagbanua* of Palawan, Philippines[14] and the *Ramkokamekrá* of the Canela, Brazil.[15]	Ninety per cent of the scrub forests of the Deccan Plateau have been degraded as a result of human activities. Pastoralism is a serious cause of land degradation through heavy cattle grazing and over-exploitation of forest produce by pastoralists.[8]
Tourism	Scrub forest tourism attractions include the Biligiri National Wildlife Sanctuary of India,[2] the Montagua Valley of Guatemala[10] and the Caatingas of Brazil.[9]	Pollution through tourist activities such as irresponsible trash disposal. Over-exploitation through removal of cactus species for ornamental purposes. Habitat degradation by tourists who trample vegetation. Invasive alien species also threaten scrub forests.[16]

References

1. http://www.ias.ac.in/currsci/mar102007/586.pdf
2. Shankar. U., Murali. K. S., Shaanker. R. U., Ganeshaiah. K. N. and K. S. Bawa (1998). Extraction of Non-Timber Forest Products in the Forests of Biligiri Rangan Hills, India. Impact on Floristic Diversity and Population Structure in a Thorn Scrub Forest. *Economic Botany* **52** (3) pp: 302-315.
3. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im1303_full.html
4. Bambaradeniya, C. N. B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17** (11): 930-935.
5. Ganesan, R. and R. Siddappa Setty (2004). Regeneration of *Amla* an Important Non-Timber Forest Product from Southern India. *Conservation & Society*, **2** (2): 365-375.
6. http://www.chem.uu.nl/nws/www/publica/Studentrapporten/Studrap2006/12006-17.pdf
7. http://www.un.org.pk/undp/sgp/green-pioneers/chap-05.htm
8. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im1301_full.html
9. http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt1304_full.html
10. http://www.nature.org/wherewework/centralamerica/guatemala/news/news2429.html
11. http://www.nature.org/wherewework/centralamerica/guatemala/work/art8613.html
12. http://www.rsnz.org/advisory/nz_climate/climchgwk01/tate.php
13. www.fao.org/ag/agl/agll/drylands/status.htm
14. http://www.ethnobiomed.com/content/2/1/36
15. http://www.socioambiental.org/pib/epienglish/canela/localiza.shtm
16. http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0802_full.html

Annex 5: At a glance: services provided by, and threats to coniferous forests

Services	Description	Threats
Provisioning services (Goods)		
Timber	Conifers are valued for their timber as they are easy to fell, handle and saw into planks. The wood is used as building and packaging timber and in the making of chipboard and hard board.[1]	Habitat destruction: over-grazing by cattle, logging of forests to clear land for agricultural purposes and to build highways and roads. Over-exploitation: excessive resin extraction and collection of plants for their ornamental value).[2] Invasive alien species such as Crofton weed (*Eupatorium adenophorum*) and Japanese cedar (*Cryptomeria japonica*) are spreading.[3]
Non timber forest products (NTFPs)	Conifers are important sources of a wide range of non-wood products, which are derived from their foliage, bark, roots, seeds, resins and cones. Conifer wood is the main raw material for the world's paper industry and is the raw material for cellophane, viscose and wood flour used in plastics.[1] The wood, foliage and resin of conifers yield essential oils, which are important ingredients in perfumes, shampoos, disinfectants and cleaning products. Cedar wood oil obtained from *Cedrus deodara* in India has reduced the necessity to import cedar wood oil from China or the United States. Coniferous forests are home to lichens which are used as a source of dye. Some edible products from coniferous forests are eaten as delicacies. Pine nuts are an ingredient in gourmet dishes in Asian cuisine, southern Europe and the south-western United States. Juniper berries *(Juniperus communis var. depressa*) are a key ingredient of gin. Edible mushrooms harvested from coniferous forests are an important source of income. The Japanese Matsutake mushroom (*Tricholoma matsutake*), which grows in coniferous forests of *Pinus densiflora* in Japan, is an expensive delicacy.[4]	Excessive extraction of resin results in the weakening of coniferous trees which become prone to disease and die.[5] Habitat destruction: over-grazing by cattle, logging of forests to clear land for agricultural purposes and to build highways and roads. Over-exploitation: excessive resin extraction and collection of plants for their ornamental value. Invasive alien species are also spreading.[2]
Mineral resources	The Central Cordillera mountain range - in which the Luzon tropical pine forest of the Philippines is located - is famous for its mineral wealth. Its mineral resources include gold, copper, silver and zinc. Non-metallic minerals such as sand, gravel and sulphur are abundant in this region.[6]	Extensive mining of mineral resources is a major threat in the Central Cordillera and results in severe habitat destruction.[7]

Annex 5: contd.

Services	Description	Threats
Supporting services		
Biodiversity	Although they are not as rich in biodiversity as lowland tropical rainforests, tropical coniferous forests are home to many wild flora and fauna. The Sambar (*Cervus unicolor*), Barking deer (*Muntiacus muntjac*), Wild boar (*Sus scrofa*), Asiatic black bear (*Selenarctos thibetanus*) and Serow (*Capricornis sumatrensis*) are some of the species that find refuge in the northeast India-Myanmar pine forests.[5] The Sierra Madre de Oaxaca pine-oak forests of Mexico house a high diversity of reptiles and amphibians. The Canyon tree frog (*Hyla arenicolor*) and the Mexican salamander (*Ambystoma mexicanum)* find refuge in these forests. The Sierra Madre de Oaxaca is one of five centres of endemism for the Leguminosae family.[2]	Plant species of the Trans-Mexican Volcanic Belt pine-oak forests that are threatened due to selective exploitation include Mexican cedar *(Cedrela odorata)*, Mexican mahogany (*Swietenia humilis*), Shamel ash (*Fraxinus uhdei*), Arizona walnut (*Juglans major*), Basswood *(Tilia mexicana)*, Sacred fir (*Abies religiosa*), *Guayacan (Guaiacum coulteri*), *Talauma spp*. and *Magnolia iltisiana*.[8] In deforested coniferous forests, grass species - which alter the distribution and numbers of remaining flora and fauna - invade. Livestock grazing results in direct competition between native forest wildlife and livestock.[9] Invasive alien species such as Crofton weed (*Eupatorium adenophorum*) and Japanese cedar (*Cryptomeria japonica*) are critical threats in the coniferous forests of the eastern Himalayas in Nepal.[3]
Prevention of soil erosion	Coniferous forest floors have a layer of waxy pine needles, which form a dense network over the soil. This thick mat and the roots of coniferous trees provide mechanical stability of the soil. This prevents soil erosion on mountain slopes.[10]	The mountainous terrain on which coniferous forests are located favours high rates of erosion and the occurrence of landslides. The removal of vegetation by deforestation for farming, agriculture and timber increases the threat of devastating landslides and flashfloods.[8]
Source of freshwater	Tropical coniferous forests play an important role as a 'rain trap'. Rainfall percolates slowly into the soil due to the dense layer of pine needles and streams into ground-water tables and underground aquifers that supply fresh water to nearby towns.[11]	Deforestation in coniferous forests worsens the threat of soil erosion. Intense erosion of the mountain slopes contributes to poor water retention, and therefore, the lack of water availability for wildlife and humans.[8]
Carbon sequestration	Forty three percent of plantations in the tropics are of coniferous species, which are immense sinks of atmospheric carbon.[12]	Broad-leaved trees could, potentially, encroach on coniferous forests due to increasing global temperatures as a result of climate change. This will lead to a decline in coniferous species.[13]
Regulating services		
Flood regulation	The extensive root systems of conifers anchor the soil on mountain slopes and provide a mechanical barrier to surface runoff during the wet season and this minimises the incidence of flashfloods.[11]	Degeneration of the barrier provided by conifers is due to mechanical soil compaction caused by the cutting of skid trails, construction of roads, movement of logs, the pressure of heavy logging machinery and trampling by animals while working or grazing.[11]
Climate regulation	Coniferous forests sequester carbon and play a critical role in climate regulation. In Pakistan, the coniferous forests of *Murree* and *Patriata* intercept moisture laden air during the monsoon season which directly influences rainfall in surrounding regions. Coniferous forests harvest 20-25% of additional precipitation during the monsoon season.[14]	Climate change: as temperatures increase, tropical coniferous forests can be colonised by deciduous vegetation. Coniferous forests do not have an extensive microbial population due to their cold climate. An increase in temperature has the potential to alter microbial activity with unexpected results.[15]

Annex 5: contd.

Services	Description	Threats
Cultural services		
Home to indigenous cultures	Tropical coniferous forests are home to many indigenous populations. The Luzon tropical pine forest of the Philippines is a refuge for indigenous tribes such as the *Bontoc*, the *Ibaloi*, the *Ifugao*, the *Isneg*, the *Kalinga* and the *Kankana-ey*.[16]	The traditional practice of burning down most of the lower stratum of the forest to provide food for cattle is one of the most significant threats to coniferous forests. Eighty per cent of the volcanic belt pine-oak forest of Mexico has been destroyed by burning.[8]

References

1. http://www.arkiveeducation.org/resource/coniferous_forest_notes.pdf
2. http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0308_full.html
3. HMGN/MFSC. August 2005. *Proceedings of the National Stakeholders' Consultation on Sacred Himalayan Landscape in Nepal.*
4. http://www.fao.org/docrep/x0453e/X0453e14.htm
5. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0303_full.html
6. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0302_full.html
7. http://www.eoearth.org/article/Luzon_tropical_pine_forests
8. http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0310_full.html
9. http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0309_full.html
10. Pannkuk, C. D., and P. R. Robichaud, (2003). Effectiveness of needle cast at reducing erosion after forest fires, *Water Resources Research* **39**:1333-1342
11. http://www.fao.org/docrep/x5385e/x5385e03.htm
12. http://www.actahort.org/members/showpdf?booknrarnr=615_38
13. www.grida.no/climate/ipcc_tar/biodiv/pdf/bio_eng.pdf
14. http://www.chowk.com/articles/10782
15. http://www.metla.fi/tiedotteet/2005/2005-05-23-ilmastonmuutos-en.htm
16. http://en.wikipedia.org/wiki/Igorot

Annex 6: At a glance: services provided by and threats to temperate broad-leaved and mixed forests

Services	Description	Threats
Provisioning services (Goods)		
Food	The fruits and nuts of broad-leaved trees are edible. These trees are important agricultural crops for products such as apples, pears, cherries, peaches, apricots, plums, almonds, walnuts, pecans, pistachios and olives. The nuts and fruits of temperate broad-leaved trees - such as hazelnuts, walnuts, olives and China wood oil extracted from the Asian Tung tree (*Aleurites fordii*) - are also important sources of oil.[1]	Major threats to temperate broad-leaved and mixed forests include habitat destruction (due to extensive logging, conversion of land for agriculture, clearance of land for cattle grazing and human induced fires), as well as over-exploitation (over-harvesting of tree species for non timber forest products such as cork and uncontrolled cutting of timber species).[2] Climate change and invasive alien species such as the White birch (*Betula platyphylla*) and the Dahurian birch (*Betula davurica*) are also threats.[3]
Timber	More than 70 tree species including the Korean pine (*Pinus koraiensis*), the northern Korean spruce (*Picea koraiensis*) and Mancana ash (*Fraxinus mandshurica*) are valuable timber sources in the broad-leaved and mixed forests of the Changbai mountains in China.[4]	Same as above.
Non timber forest products (NTFPs)	Temperate broad-leaved trees are a source of important NTFPs, which are derived from every part of the tree and include flowers, foliage, bark, sap, fruits and nuts. Cork - the soft, spongy inner bark of Cork oak (*Quercus suber*) - is the only product acceptable for use as a bottle stopper for fine wines and champagne. Commercially important products such as wild honey, essential oils from foliage and tannins are derived from temperate broad-leaved forests. Syrup from Maple (*Acer saccharum*) and Birch (*Betula lenta*) trees provide important sources of income. Commercially important products from organisms associated closely with temperate broad-leaved trees include edible mushrooms such as Truffles (*Tuber spp*.), Shiitake (*Lentinula edodes*) and Morels (*Morchella spp.*) produced by fungi, as well as silk produced by caterpillars feeding on the foliage of mulberry (*Morus spp.*) and Oak (*Quercus spp.*). Approximately 50,000 tonnes of Tussah silk was produced each year between 1987 and 1989 in China. Tung oil, obtained from the Asian tung tree (*Aleurites fordii*), which is native to China, is used in the manufacture of lacquer, varnishes, paints, linoleum, resins, synthetic leather, felt-based floor coverings, greases, brake linings and in cleaning and polishing compounds.[1]	Same as above.

Annex 6: contd.

Services	Description	Threats
Provisioning services contd.		
Medicine	Some organisms found in temperate broad-leaved forests have important medicinal properties. The Turkey tail mushroom (*Trametes versicolor*) is used in cancer treatments and accounts for 16% of Japan's national expenditure on anti-cancer agents. It is also used to treat pulmonary disorders and has been shown to have cholesterol lowering properties. It is also used as an immune stimulant, an antibiotic, an antiviral against hepatitis and in infections of the respiratory, urinary and digestive tract. The Chicken-of-the-woods mushroom (*Laetiporus sulphureus*) has anti-microbial and anti-oxidant properties and the Red-banded polypore (*Fomitopsis pinicola*) is used to regulate fevers and for liver and spleen support.[1]	Major threats to temperate broad-leaved and mixed forests include habitat destruction (due to extensive logging, conversion of land to agriculture, clearance of land for cattle grazing and human induced fires) and over-exploitation (over-harvesting of tree species for non timber forest products such as cork and uncontrolled cutting of timber species).[2] Climate change and invasive alien species - such as the White birch (*Betula platyphylla*) and the Dahurian birch (*Betula davurica*) are also threats.[3]
Supporting services		
Biodiversity	Temperate broad-leaved and mixed forests are hosts to diverse species of flora and fauna. From autumn to spring, the Umbrella bamboos (*Fargesia robusta* and *Yushania chungii)* attract Giant pandas to the temperate broad-leaved and mixed forests of the Sichuan giant panda sanctuary, in China.[5] The eastern Himalayan mixed forests are home to mammals such as the Endangered Golden langur (*Presbytis bieti*), Lesser panda (*Ailurus fulgens*), Clouded leopard (*Neofelis nebulosa*), Himalayan black bear (*Selenarctos thibetanus*) and Takin (*Budorcas taxicolor*). Endangered endemic plants of the broad-leaved and mixed forests of the eastern Himalayas include many orchid species such as White's Cymbidium (*Cymbidium whiteae*), Fairrie's Paphiopedilum (*Paphiopedilum fairrieanum)* and *P. wardii,* and maple species such as the Evergreen maple (*Acer oblongum*) and *Acer hookeri.*[6] The broad-leaved and mixed forests of Mount Sanqingshan in eastern China are home to rare species of flora including *Rhododendron simiarum*, the Taiwan red pine (*Pinus taiwanensis*) and the Chinese torreya (*Torreya grandis*).[7]	Same as above. Forest fires alter the composition of flora in broad-leaved and mixed forests. Tree species such as the Gmelin larch (*Larix gmelinii*) and the Scots pine (*Pinus sylvestris*) that are more tolerant of fire and need fire for seed germination will invade cleared areas and dominate the forest.[3]

Annex 6: contd.

Services	Description	Threats
Supporting services contd.		
Fertile soil	The soil of these forests is rich in organic matter derived from the annual accumulation of dead leaves from broad-leaved trees and conifer needles. A host of bacteria and fungi play a crucial role in slowly decomposing and recycling the organic matter on and within the soil, thus making it extremely fertile.[8]	Deforestation of mixed forest land for agriculture results in the loss of the leaf litter and pine needle layer and this reduces the fertility of the soil. Increased soil erosion rates - due to clearance of forest land - remove layers of soil, resulting in the loss of nutrients.[9]
Prevention of soil erosion	The forest canopy in temperate broad-leaved and mixed forests intercepts precipitation resulting in the slow percolation of rainfall to the forest floor, which is covered by a thick layer of leaf litter and pine needles. This effect minimises surface runoff. Forest tree species buttress the soil and provide a mechanical barrier to surface runoff, thus preventing soil erosion and the incidence of floods.[10]	The clearance of forest land for shifting cultivation and poppy cultivation in the Northern Triangle temperate mixed forest of Myanmar has caused severe soil erosion, loss of habitat and biological diversity.[11]
Carbon sequestration	The carbon uptake of the broad-leaved Korean pine mixed forest in the Changbai Mountains of China was 184gC/m^2 in 2003.[12] Russian temperate broad-leaved and mixed forests are huge carbon sinks because of their vast land coverage and slow rate of litter decomposition in the soil. These forests have 86.5 billion tonnes of carbon stocked in forest vegetation and 74 billion tonnes of carbon stored in the forest soil.[3]	Forest fires are a major disturbance in Russian temperate broad-leaved forests. The carbon stock in forest biomass is released by burning vegetation in forests fires, thus contributing to global warming.[3]
Source of freshwater	The forest canopy ensures that rainfall percolates slowly to the forest floor and streams into the soil and underground aquifers providing freshwater to surrounding regions. The water table depth beneath a mixed forest in southern China is 30cm deeper than beneath bare land.[10]	Deforestation of land for agriculture and cattle grazing, extensive logging and human-induced fires destroy the forest canopy and leaf litter resulting in very slow soil infiltration rates. Rainfall can no longer stream onto the forest floor and is washed off rapidly, resulting in a loss of freshwater.[13]
Regulating services		
Climate regulation	Temperate broad-leaved and mixed vegetation increase humidity and reduce maximum temperatures near the forest floor and regions surrounding the forest. Heat is absorbed by the transpiration of trees. Trees also serve as windbreaks, thereby reducing wind speeds. These forests play a role in regulating global climate conditions by sequestering carbon.[1]	Research shows that the broad-leaved and mixed forests in temperate monsoon Asia will face changes in species composition due to climate change. As air temperatures increase and rainfall decreases, the Korean pine (*P. koraiensis*) will likely disappear from the forest and the mixed forest will likely revert to predominantly hardwood forest.[14]
Flood regulation	The forest vegetation and leaf litter that intercept rainfall and the mechanical barrier provided by the roots of trees and shrubs protect the forests and surrounding regions from devastating floods.[10]	The infiltration of rain water into the soil in a medium aged mixed forest in North Carolina, USA occurs at a rate of 31.56 cm/hr, while the infiltration rate of land stripped of forest canopy and leaf litter is 11.20 cm/hr. This decrease in soil infiltration due to clearance of land can result in disastrous floods.[13]

Annex 6: contd.

Services	Description	Threats
Cultural services		
Landscape and ornamental value	Many species of temperate broad-leaved trees are important landscape and ornamental plants and are used in landscape design. Conifers and temperate broad-leaved trees are popular for bonsai culture, the technique for retaining the essential growth form of a tree but reducing it to pocket size. Popular species include the Japanese hornbeam (*Carpinus japonica*), Toringo crab apple (*Malus sieboldii*) and Yeddo spruce (*Picea Jezoensis*).[1]	Major threats to temperate broad-leaved and mixed forests include habitat destruction (due to extensive logging, conversion of land for agriculture, clearance of land for cattle grazing and human induced fires) as well as over-exploitation (over-harvesting of tree species for non timber forest products such as cork and uncontrolled cutting of timber species)[2].Climate change and invasive alien species - such as the White birch (*Betula platyphylla*) and the Dahurian birch (*Betula davurica*) are also threats.[3]

References

1. http://www.fao.org/DOCREP/005/y4351e/y4351e0e.htm.
2. www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0403_full.html.
3. Makoto. K., Nemilostiv, Y. P., Zyryanova. O. A., Kajimoto. T., Matsuura. Y., Yoshida. T., Satoh. F., Sasa, K. and T. Koike (2007). Regeneration after Forest Fires in mixed Conifer Broad-Leaved Forests of the Amur Region in Far Eastern Russia: the Relationship between species specific traits against fire and recent fire regimes. *Eurasian Journal of Forestry Research* **10**(1): 51-58.
4. http://vsia.brim.ac.cn/English/BackgroundChangbai.asp#Char3.
5. http://www.eoearth.org/article/The_Sichuan_Giant_Panda_Sanctuaries_China.
6. http://www.panda.org/about_wwf/where_we_work/ecoregions/westhimalayan_temperate_forests.cfm.
7. http://www.sqs.gov.cn/english/sw.htm.
8. http://www.zoosauvage.com/page.php/en/1/24.html.
9. Devkota. B. D., Omura. H., Kubota, T. and K. Morita (2006). State of Vegetation, Erosion Climatic Conditions and Re-vegetation Technology in Mid Hill Area of Nepal. *Journal of the Faculty of Agriculture, Kyushu University,* **51** (2): 361–365.
10. Zhou. G. Y., Morris. J. D., Yan. J. H., Yu. Z. Y. and S. L. Peng (2002). Hydrological Impacts of Reafforestation with Eucalypts and Indigenous Species: A Case Study in Southern China. *Forest Ecology and Management* **167**(1-3): 209-222.
11. www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0402_full.html.
12. http://scholar.ilib.cn/A-zgkx-ed2005z1011.html.
13. Kays. B. L. (1980). Relationship of Forest Destruction and Soil Disturbance to Increased Flooding in the Suburban North Carolina Piedmont. *Metropolitan Tree Improvement Alliance (METRIA) Proceedings* **3**:118-125.
14. Shao. G., Yan. X. and Bugmann (2003). Sensitivities of Species Compositions of Mixed Forest in Eastern Eurasian Continent to Climate Change. *Global and Planetary Change*, **37**(3):307-313.

Annex 7: At a glance: services provided by and threats to grasslands

Services	Description	Threats
Provisioning services (Goods)		
Food (Grain)	The world's major grains such as rice, wheat, rye, oats, barley corn, millet, and sorghum originated in grasslands. These grains are important commercially as they are part of the staple diet in many countries and are important for their nutritional value. Approximately 218g of 40% protein dehydrated grass supplies 18,600 units of vitamin A, 113mg of Vitamin C and 5.7g of protein.[1]	Conversion to agricultural areas has caused the greatest loss of the world's grasslands. Native vegetation is removed and replaced with farm crops, soil is exposed and is made vulnerable to wind and water erosion. Pesticides and fertilisers that affect soil composition are added and the water holding capacity of the soil is lessened, reducing the moisture available to plants and animals supported by the grasslands.[2]
Forage for domestic livestock	Grasslands provide livestock with fodder for consumption, thereby supporting human livelihoods associated with meat, milk, wool and leather products. Grasslands contribute 78 billion USD annually to the economy of the United States by supporting an estimated 60 million cattle and eight million sheep.[3] Dominant forage species in grasslands of Sri Lanka include *Arundinella spp*. and *Pollinia spp*. in montane grasslands, *Panicum spp*. and *Themeda triandra* in the lowland savannahs and *Cynodon dactylon, Stenotaphrum secundatum* and *Bothriochloa glabrain* in wet grasslands (*villu* grasslands).[4]	Humans start fires in grasslands to maintain good grazing conditions for livestock, to clear away debris and control pests. However, intense and frequent fires induced by humans destroy vegetation and increase soil erosion. Over-grazing is a significant threat to grasslands. It is most acute when livestock numbers are high, animals are confined to small grazing plots without rotation. Then soils are eroded easily and vegetation becomes sparse.[2]
Supporting services		
Biodiversity	Grasslands contribute 19% of the world's centres of plant diversity, 15% of the endemic bird areas and 30% of the World Wildlife Fund's unique ecoregions.[5] The alpine grasslands of the Qinghai province in China are home to fauna such as the Plateau pika (*Ochotona curzoniae*), Vlangal's toad-headed lizard (*Phrynocephalus vlangalii*), Hume's ground tit (*Pseudopodoces humilis*), several species of Snow finches (*Montifringilla spp.*), Asian polecats (*Mustela eversmanni*), Tibetan sand foxes (*Vulpes ferrilata*), Black kites (*Milvus migrans*), Upland buzzards *(Buteo hemilasius*), Grey wolves (*Canis lupis*) and Brown bears (*Ursus arctos*).[6] The wet grasslands of the Terai belt of the India/Nepal border host the Vulnerable Swamp francolin (*Francolinus gularis*). The Endangered Great Indian bustard (*Ardeotis nigriceps*) and the Lesser florican *(Sypheotides indica*) are key bird species characteristic of Indian grasslands.[7] Plant species characteristic of grasslands in the Republic of Palau include *Pennisetum polystachium*, Wild sugarcane (*Saccharum spontaneum*), Signal grass (*Brachiaria decumbens*), Para grass (*Brachiaria mutica*) and Congo grass (*Brachiaria ruziziensis*).[8]	Over-grazing by livestock affects the composition and structure of grasslands, as palatable and productive species decrease in abundance, while poisonous species will increase and dominate the area.[9] The Plateau pika (*Ochotona curzoniae*) - an important keystone species in the grasslands of the Qinghai province - is being poisoned over large areas to increase forage for livestock. This adversely affects a number of other species - such as Asian polecats (*Mustela eversmanni*) and Upland buzzards (*Buteo hemilasius*) - dependant on the Pika as prey. Pikas provide nesting sites in their burrows for other species, and their burrowing recycles nutrients which enhances plant species richness. Their elimination affects diverse ecological processes of the grassland ecosystem.[6] Invasive alien species that threaten grasslands in Sri Lanka include Gorse (*Ulex europaeus*), Cocklebur (*Xanthium indicum*) and the Erect Prickly pear cactus (*Opuntia stricta*) which invade coastal grasslands in south eastern Sri Lanka.[10]

Annex 7: contd.

Services	**Description**	**Threats**
Supporting services contd.		
Carbon sequestration	Grasslands store approximately 34% of the global stock of carbon in terrestrial ecosystems, while forests store 39% and agrosystems store approximately 17%. Unlike forests, where carbon is stored primarily in vegetation, most of the carbon stock in grasslands is in the soil.[11] Rehabilitation of over-grazed grasslands can result in 45 million tonnes of carbon being sequestered each year.[12]	The future capacity of grasslands to store carbon will decline if their soils are over-grazed, cleared through frequent cultivation and eroded.[12] Burning biomass in grasslands is the source of nearly 40% of gross CO_2 and tropospheric ozone. Much of these emissions originate in Africa, referred to as the 'burn centre' of the planet because of extensive burning in its savannas.[2]
Prevention of soil erosion	Grasslands such as savannahs go through periodic drought conditions, hence a majority of plants live more 'in' the soil than above it. Under the surface of the soil is a tangled web of roots and rhizomes. Some grass roots grow down to the depths of a metre in the soil, while the tap roots of soft stemmed plants reach as far as 5m to acquire water. This system of horizontal and vertical roots anchors the soil protecting it from erosion by wind and water.[9]	Over-grazing will reduce grasslands to sparse shrub lands and soil erosion will be a serious threat. Soil formation is a slow process and it takes 100-1000 years to form a 2.5cm layer of soil, which can be eroded easily when the web of roots in over-grazed grasslands wither and can no longer anchor it.[9]
Genetic resources	Agriculturally important grains originated in grasslands and these ecosystems are the primary source of genetic resources for improving crops. Research in wild grass species in grasslands will, therefore, improve genetic variation in crop species such as sorghum, whose genetic diversity is eroding significantly.[13] Plant species that are valuable forage genetic resources include False brome (*Brachypodium sylvaticum*), *Bromus himalaicus* and *Medicago spp.* Ten wild relatives of Alfalfa (*Medicago sativa*) have been found in grasslands. Many forage species from the Steppes are of interest for resistance to cold, arid and saline or alkaline conditions.[14]	Desertification results when land is degraded severely in arid, semiarid, and dry sub-humid areas. Increased pressure on dry grasslands - such as over-grazing, intensive fires and climate change - leads to desertification, which will decrease grassland productivity and water availability and threaten flora and fauna.[2] Over-grazing by livestock is rampant in grasslands. Satellite data revealed that the grasslands in *Talala Taluka* in India can support sustainably only 589 cattle. The actual cattle population size is 49,737 which is 84 times larger than the carrying capacity of *Talala Taluka*.[9]
Fertile soil	Grasslands grow in soils that are nutrient rich, due to the abundance of soil microorganisms that recycle nutrients and decompose plant tissue. Small grassland mammals - such as Pikas (*Ochotona spp.*) and Zokors (*Myospalax spp.*) - found in the Tibetan regions of China - transport organic matter between the subsoil and the surface and their burrows and provide channels to transport water and essential nutrients to underground plant stems and fibrous root systems. Wet grasslands are particularly rich in nutrients that are churned up and brought in to the ecosystem during the flooding season.[15]	The fertile soils (characteristic of grasslands) result in their conversion to agricultural land. The productive alluvial grasslands of the *Terai-Duar* savannah in Nepal, which provide habitat to the world's tallest grass species, have been converted to agricultural terrain. No more than 2% of the alluvial grassland of the Gangetic floodplain remains intact.[16]

Annex 7: contd.

Services	**Description**	**Threats**
Supporting services contd.		
Primary production	The net primary productivity of dry grassland forages in Sri Lanka is estimated to be between 68,000 and 111,000 kg/ha/yr.[17]	Desertification results when land is degraded severely in arid, semi-arid, and dry sub-humid areas. Increased pressure on dry grasslands such as over-grazing, intensive fires and climate change leads to desertification, which will likely decrease grassland productivity and water availability and threaten flora and fauna.[2]
Regulating services		
Climate regulation	Grasslands contribute to the regulation of global temperatures by sequestering carbon into their soils.[11]	Increased global temperatures degrade grassland ecosystems, decreasing their productivity and expediting desertification. Climate models predict hotter summers and warmer, wetter winters in montane grasslands, affecting species composition. Livestock grazing is a significant source of carbon emissions, contributing to global warming.[18]
Water regulation	Wet grasslands are important in flood alleviation because they retain water during the flood seasons. Due to this retention of water, surrounding regions are protected from devastating floods. The retention of water by wet grasslands within watersheds allows groundwater tables to be replenished. Riparian wet grasslands (grasslands near rivers) retain nutrients, toxic substances and sediment, thereby improving the quality of water entering watercourses.[19]	Wet grasslands are exposed to significant threats including agricultural practices such as the increased use of fertiliser, which leads to eutrophication. Land drainage practices modify natural hydrological regimes resulting in low water levels in drainage channels and ground water tables. Increased use of herbicides affects and destroys flora and fauna. Fragmentation of wet grasslands for agriculture results in isolation of species restricted to wetlands and makes them vulnerable to extinction.[19]
Cultural services		
Tourism	Grasslands are popular tourist attractions for viewing game animals, hiking, fishing, trophy hunting, observing large mammalian herbivores, diverse plant life and open-air landscapes.[14] Grassland tourism attractions include the Royal Chitwan National Park in Nepal,[16] the wet grasslands of the Knuckles range in Sri Lanka,[21] the Masai Mara[22] and the Serengeti of Kenya[23] and the Emas National Park of Brazil.[24]	Irresponsible tourism causes pollution (through irresponsible trash disposal); habitat destruction (through clearance of grassland areas to build hotels and lodges); habitat degradation (through off-road driving); and over-exploitation (through poaching of wild animals).

References

1. http://www.tuberose.com/Grasses.html.
2. http://earthtrends.wri.org/features/view_feature.php?fid=8&theme=9.
3. www.ducks.org/Conservation/Habitat/1572/EconomicBenefits.html.
4. http://www.fao.org/ag/AGP/agpc/doc/Counprof/srilanka/srilanka.htm#natural.
5. http://www.philipallan.co.uk/images/743-T2.
6. Foggin, J. M. and A. T. Smith (1996). *Rangeland Utilization and Biodiversity on the Alpine Grasslands of Qinghai Province, People's Republic of China: Conserving China's Biodiversity (II*) J. S. Peter, S. Wang and Y. Xie eds. Beijing: China Environmental Science Press. 247-258 pp.
7. http://www.rrcap.unep.org/reports/soe/sa_part2_5.pdf.
8. http://www.fao.org/ag/AGP/AGPC/doc/Counprof/southpacific/palau.htm.
9. http://www.gisdevelopment.net/application/nrm/forestry/mi04068abs.htm.
10. Bambaradeniya, C.N.B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17**(11): 930-935.
11. http://www.wri.org/publication/content/8273.
12. Conant, R. T. and K. Paustian (2002), Potential soil carbon sequestration in overgrazed grassland ecosystems, *Global Biogeochemical Cycles* **16**(4):1143, doi:10.1029/2001GB001661.
13. http://www.cirad.fr/en/presse/communique.php?id=273.
14. http://www.fao.org/docrep/008/y8344e/y8344e0f.htm#bm15.4.
15. http://www.usembassy-china.org.cn/sandt/final3.htm.
16. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0701_full.html.
17. Amarasinghe. A. and M. A. Pemadasa (1983). The ecology of a montane grassland in Sri Lanka, VII, Biomass production, *Ceylon Journal of Science* **16**: 15-21.
18. http://www.grasslands-trust.org/page.php?pageid=5.
19. http://www.ramsar.org/key_guide_under-represented_e.htm.
20. http://archive.wri.org/item_detail.cfm?id=1073&section=pubs&page=pubs_content_text&z=?.
21. www.knucklesrange.org/biodiv.html.
22. www.kilimanjaro.com/kenya/mara.htm.
23. en.wikipedia.org/wiki/Serengeti.
24. www.geocities.com/TheTropics/Cabana/6292/emas.html.
25. http://www.wri.org/publication/content/8273.

Annex 8: At a glance: services provided by and threats to deserts

Services	Description	Threats
Provisioning services (Goods)		
Petroleum	Deserts are renowned for the provision of biologically derived, but non-renewable energy resources which dramatically boost the political standing and per capita GDP of several desert countries. The petroleum sector of Saudi Arabia accounts for 75% of budget revenues, 35% of GDP and 90% of its export earnings.[1] Deserts contribute more than 50% of world oil production and contain 75% of its reserves, while 28% of the world's natural gas reserves are found in the deserts of West Asia, North Africa and Central Asia.[2]	Over-exploitation of oil and natural gas reserves threatens the deserts of the Middle East. Oil extraction causes air pollution, spills and chronic leakages that affect desert surface and subsurface organisms, as well as human populations supported by deserts.[2]
Mineral resources	Deserts are rich in non-renewable mineral resources in quantities much larger than are required to support local populations. Water soluble salts such as gypsum, borates, saltpetre (potassium nitrate), table salt and sodium are exported to non-desert regions. The saltpetre and salt beds of the Atacama desert of South America contain 40% of the world's reserves of lithium, used extensively in medicine and technology. In 2004, 33% of the world's diamonds were extracted in the dry lands of Botswana and Namibia and 35% of the world's production of gold was accounted for by northwestern China, South Africa, Australia, Uzbekistan and Mali. The most important contribution of deserts to mineral wealth is their deposits of soda, boron and nitrates, which are not found in other ecosystems.[2]	Over-exploitation of mineral resources: the unsustainable mining of diamonds and copper threatens a significant area of the Namib desert, an extremely diverse habitat. When a mine reaches the end of its life, the site is abandoned and remains a mixture of deteriorated materials, mining by-products and unproductive rubble, which is coarse and chemically toxic. These sites cause pollution of land and groundwater.[2] Human induced degradation through over-grazing, clearance of woody vegetation, farming, irrigation-induced salinity, soil and water pollution by agrochemicals and groundwater exploitation also threaten deserts. As global temperatures increase due to climate change, desert regions become drier, water resources are depleted and productivity decreases further.[2]
Renewable biological resources	Desert countries such as Turkmenistan and Uzbekistan practise irrigation agriculture and export their produce such as cotton. Because of mild winter temperatures of many deserts, proper water resource management results in intensive production of vegetables, fruits and cut flowers, which are sold at high prices in non-desert regions, where temperatures are significantly lower and therefore unsuitable for the production of such crops. Dates, vegetables and cut flowers of the Negev desert of Israel are exported to Israel's non desert markets serving 90% of its population.[2]	Military activities and off-road vehicles cause extensive, lasting damage to the fragile desert cover. The Mesopotamian shrub desert - located in the Tigris and Euphrates River valleys - is an ecologically and culturally important desert. It has been degraded greatly by the recent Iraq wars.[2]

Annex 8: contd

Services	Description	Threats
Provisioning services contd.		
Medicine	Countries with large deserts such as China and India export herbal and medicinal plants. Germany imports 1,500 plant species from the deserts of China and India for medicinal purposes. Ninety five per cent of disease treatments of the Thar desert in India are provided through the use of 85 desert plant species.[2] Derived chemicals from *Hoodia gordonii* of the Kalahari desert are components of commercially marketed dietary supplements. *Hoodia* is used by desert tribesmen who use it to control their appetite when they go into the deserts for several weeks to hunt. Desert plants are adapted to the stressful environmental conditions of their habitat. Recent findings - including compounds with anti - oxidative and anti-herbivory action found in desert plants - have shown that these adaptations are chemically based. Bio-prospecting of desert flora could catalyse the pharmaceutical industry. Screening of plants in the Negev desert of Israel identified desert plant species with cytotoxic and anti-malarial properties. Further development of the medicinal potential of desert plants could, therefore, revolutionise modern medicine.[2]	The Thar desert is known to be one of the most densely populated deserts in the world. Grazing of livestock - such as sheep and goats - is intensive and affects soil fertility and destroys native vegetation. Many edible plant species are being replaced with inedible plants, thus changing the vegetation composition and ecosystem dynamics of the desert.[3]
Supporting services		
Cooling the global atmosphere	Deserts habitually cool the adjacent global atmosphere due to the desert albedo effect. (Desert albedo is the direct reflection of solar radiation by the desert's surface back to outer space.) The typical hot desert albedo is 20-35% of solar radiation reflected back to space (much higher than the 15% of the savannah and 5% of the rainforest). The albedo of snow in cold deserts - such as Antarctica - can be as high as 80%. Desert albedo cools the air in the troposphere and this cool air is dispersed by winds over great distances away from deserts to non desert dry lands, which become cooler and drier.[2]	Global warming is projected to increase desert albedo, through reducing desert vegetation cover. This will further amplify the effect of cooling the non-desert atmosphere and drying adjacent non desert drylands. Thus, whereas global climate change makes deserts drier, deserts make the global atmosphere cooler, and the drier the desert becomes, the more its cooling effect will increase. This phenomenon not only worsens desertification in deserts, but will alter the climate of non-desert regions with unpredictable consequences.[2]

Services	Description	Threats
Supporting services contd.		
Biodiversity	Although plant and species richness is low, deserts contain large numbers of ancient and relic species. Many plants occurring in Chinese deserts are relics of the Cretaceous period. The ancientness of its flora and fauna, combined with the harsh ecological conditions, determines the uniqueness of the biotic elements of deserts. China's Junggar Basin plain and Ga Shun Gobi desert are home to many endemic plant genera such as *Tetraena, Potaninia, Tugarinovia, Stilpnolepis* and *Systemon*.[4] The Mesopotamian shrub desert is transitional between the deserts to the south and the Steppes to the north and harbours a unique biodiversity. The flora includes Umbrella-thorn acacia (*Acacia tortillis*), Shrubby rock-rose species (*Cistus spp.*) and many dwarf shrubs. Reeds and rushes grow in the wetland areas, while Poplar (*Populus euphratica*) and Tamarisk (*Tamarix*) grow along river channels. Among the plants that are unique to the deserts of Africa are *Welwitschia mirabilis* of the Namib, which is considered to be a living fossil. There is also a great variety of woody legumes and succulent (plants with thick, fleshy tissues that can store water) stemmed species such as Baobabs (*Adansonia spp.*), Commiphoras (*Commiphora spp.*), Bottle-trees (*Pachypodium spp.*), Phantom-trees (*Moringa spp.*) and Quiver trees *(Aloe dichotoma*). The Madagascar thorny thickets represent a unique, very diverse assemblage of plants and animals - such as the local baobabs and the Octopus tree (*Didierea madagascariensis*) - most of which are found nowhere else.[2] The Succulent Karoo - which is known as the world's most extraordinary desert - is the world's only plant hotspot that is found completely within the desert biome and is entirely arid. The number of plant species in the region is unparalleled anywhere else in the world for an area of its size. At least 40% of these species are endemic. Most are succulents. One-third of the world's 10,000 species of succulent plants grows in this desert.[5]	Over-grazing of livestock is a persistent threat and catalyst for desertification. Illegal hunting is a serious threat in the South Iran Nubo-Sindian desert. Egg collection and nest disturbance affect nesting migratory waterfowl. Significant portions of the Azerbaijan shrub desert and the Central Asian northern deserts are farmed under irrigation, causing water and soil pollution by the use of fertilisers and pesticides. Currently, the desert biome holds on average an abundance of original species of 68%, but the rate of biodiversity loss in deserts may double in the coming decades. A decline in original species to a mean of 62.8% by 2030 and 58.3% by 2050 is expected, as a result of the new pressures and impacts brought forward by agriculture and human land use (41% of the loss), fragmentation associated with infrastructure (40%), and climate change (6% in 2000 and 14% by 2050).[2] Climate change and increased levels of soil nitrogen caused by atmospheric nitrogen deposition may increase the dominance of invasive alien plants and decrease the diversity of plant communities in desert regions because they are tougher competitors. Dominant IAS of the Mojave desert include the grasses *Bromus madritensis ssp. rubens* and *Schismus arabicus and S. barbatus,* as well as the forb *Erodium cicutarium.*[6]
Prevention of soil erosion	Desert soil is covered by a biological crust composed of a highly specialised community of cyanobacteria, fungi, mosses and lichens. In deserts, these soil crusts perform many functions, such as the stabilisation of sand and dirt, promotion of moisture retention and the fixation of atmospheric nitrogen. The most prominent of these functions is the prevention of soil erosion as crust-forming cyanobacteria have an extensive network of filaments that secrete a sticky polysaccharide sheath that cements soil particles together. Fungi, lichens and mosses assist in soil stability through their hyphae and rhizoids, improving the resistance of soil to erosion by wind and water action.[5]	Soil crusts are adapted poorly to physical disturbances. Domestic livestock grazing, tourist activities - such as biking - and military activities affect the strength of the soil crust by breaking the sheaths and filaments of the microorganisms in the soil. This reduces the capability of the soil organisms to provide soil stability which increases the rate of soil loss sixfold.[7]

Annex 8: contd

Services	Description	Threats
Regulating services		
Climate regulation	Recent findings linking desert dust to climate regulation suggest that dust carried over oceans blocks and reflects incident sunlight, thereby causing a decrease in oceanic temperatures. The chilling effect of dust was responsible for one-third of the drop in North Atlantic sea surface temperatures between June 2005 and 2006, possibly contributing to the difference in hurricane activity between the two seasons (five hurricanes in 2006 compared to 15 hurricanes in 2005).[8]	Climate change: in deserts where rainfall is predicted to increase, desert dust flux will be reduced, sustaining, in turn, wet conditions away from deserts. Yet, due to uncertainties, projections of dust emissions for the next 100 years range between a 60% decrease to a 50% increase in dust emissions.[2]
Cultural services		
Supporting modern societies and indigenous populations	Currently, approximately 500 million people live in deserts and desert margins, totalling 8% of the world's population. Deserts support indigenous tribes such as the Bedouin tribes of the Sahara, Negev and Arabian Desert, the *San* people of southern Africa, the *Herero* people of the Kalahari Desert the *Ugyur* people of the Gobi Desert and the *Bishnois* of the Thar Desert.[2]	More than 90% of the original habitat of the Madagascar thorny thickets has disappeared through extraction of wood for firewood and charcoal, grazing and clearance for farming. Livestock browsing and human firewood collection also threaten the deserts around the Horn of Africa and in the southern Arabian Peninsula, from the Red Sea to the Gulf of Oman.[2]
Tourism	Many desert areas south of the Mediterranean basin are popular destinations for tourists from northern countries who are attracted by the balmy climate of the desert. Eleven per cent of Egypt's gross national income is from tourism. Services for the desert tourism industry also create new jobs and attract immigration into the growing desert cities.[2]	Land degradation in deserts is increased through tourist activities. Trampling causes a disturbance of the fragile desert surface; irresponsible trash disposal affects desert wildlife; increased use of water resources threatens the availability of an already scarce resource and the introduction of exotic flora and fauna by uninformed tourists disrupts and threatens desert biodiversity.[2]
Knowledge of the early history of animals, people and earth	The sparse vegetation cover, lack of thick soils and aridity of deserts provide large areas of exposed rock. The lack of precipitation that reduces chemical leaching by groundwater promotes the preservation and detection of fossils that allow deciphering the evolutionary history of plants, animals and of early man. Deserts have been treasures of paleontological findings. In the badland terrains of the cold Gobi Desert, a great diversity of late Cretaceous (65 million year old) dinosaurs and mammals have been unearthed. Egypt's Fayum Desert has preserved important Eocene-age (40 million year old) fossil treasure of early cetaceans (whales and dolphins) and sirenians (dugongs and manatees).[2]	Human induced degradation through over-grazing, clearance of woody vegetation, farming, irrigation-induced salinity, soil and water pollution by agrochemicals and groundwater exploitation threatens deserts.[2]

References

1 http://en.wikipedia.org/wiki/Economy_of_Saudi_Arabia
2. http://www.unep.org/Geo/gdoutlook/
3. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im1304_full.html
4. http://english.biodiv.gov.cn/images_biodiv/ecosystems/deserts-en.htm
5. http://www.nationalgeographic.com/wildworld/profiles/terrestrial/at/at1322.html
6. http://www.blackwell-synergy.com/doi/abs/10.1046/j.1365-2664.2003.00789.x
7. http://en.wikipedia.org/wiki/Soil_crust
8. http://www.nasa.gov/topics/earth/features/cooling_dust.html

Annex 9: At a glance: services provided by and threats to rivers and streams

Services	**Description**	**Threats**
Provisioning services (Goods)		
Food (Fish)	Fish are a rich source of protein, vitamins and minerals. Rivers and streams provide humans with fish species such as Salmon, Trout, Carp, Eel (primarily *Anguilla anguilla* and *A. japonica)*, *Ayu* (*Plecoglossus altivelis*), Milkfish (*Chanos chanos*), Tilapia (*Oreochromis niloticus*), Pickerel (*Esox niger*) and Whitefish (*Coregonus huntsmani*).[1] The Mekong River system produces 1.3 million tonnes of fish per year.[2] Freshwater fisheries in the Mekong River basin have a commercial value exceeding 1.7 billion USD and provide 80% of the animal protein consumed by 55 million people.[3] Freshwater shrimp (*Macrobrachium spp*.) found predominantly in the Indus river delta are important food species.[4]	Threats to freshwater species in rivers, streams and deltas include over-fishing, climate change, pollution by agricultural run-off and waste, water extraction for irrigation[5] and invasive alien species such as Rainbow trout (*Oncorhynchus mykiss*), Clown knife fish (*Chitala chitala*), Water hyacinth (*Eichhornia crassipes*) and Salvinia (*Salvinia molesta*).[6] Over-exploitation and the use of destructive fishing practices and methods such as derris roots, poisons, explosives, small mesh nets and fish traps lead to a reduction in populations of most fish species.[5]
Freshwater	Less than 3% of the earth's water is fresh and most of that water is frozen in the North and South poles. Rivers and streams are an important source of freshwater required for human consumption, sanitation, agriculture, the survival of terrestrial organisms and in industries.[7] The Amazon river forms the largest basin in the world and contains approximately 20% of the world's freshwater.[8] The Brahmaputra river accounts for nearly 30% of the total water resources in India.[9]	Pollution is the largest threat to rivers. Sources of pollution include effluents from livestock farms, domestic and industrial sewage, chemicals from manufacturing and agro-based industries, suspended solids from mining, domestic waste, road construction waste and heavy metals from factories. Sewage pollution causes outbreaks of water borne diseases such as cholera, typhoid and Hepatitis A that affect humans.[5]
Hydro-electric power	Many countries dependent on hydropower as an energy source rely on rivers. Hydro-electricity is generated by turbines that extract energy from fast flowing water from rivers. Major hydropower plants in Asia include the Ertan hydropower plant in China which generates 3,300 million watts annually[10], the Kukule Ganga hydropower plant in Sri Lanka[11] and the Darjeeling and Shimsa plants in India.[12]	Channelisation of rivers running through urban areas, river diversion, deepening, straightening and widening of rivers and the clearance of riverine vegetation are required to build dams, control floods and store water in reservoirs and affect rivers. These activities affect rivers, streams and the aquatic life by causing shifts in flow regimes, sediment deposition, changes in river water chemistry and processes, thereby altering the natural river ecology and hydrology.[5]

Annex 9: contd.

Services	Description	Threats
Supporting services		
Biodiversity	Rivers and streams support diverse plant and animal life, adapted differently to various water environments. Key species that are dependent on the Amazon river basin include Pink river dolphins (*Inia geoffrensis*), Manatees (*Trichechus manatus*), Jaguars (*Panthera onca*), Pumas (*Puma concolor*), River otters (*Lutra canadensis*), Tapirs (*Tapirus terrestris)*, Capybaras (*Hydrochaeris hydrochaeris*), Peccaries (*Tayassu tajacu*), Harpy eagles (*Harpia harpyja)* and one of the largest scaled freshwater fishes in the world, *Arapaima gigas*, which can reach nearly 2.5m in length.[8] The Euphrates river is home to species such as Basra reed warblers (*Acrocephalus griseldis*), Iraq babblers (*Turdoides altirostris*), Eurasian otters (*Lutra lutra*), Smooth-coated otters (*Lutra perspicillatamaxwelli*), Pygmy cormorants (*Phalacrocorax pygmaeus*), Lesser white-fronted geese (*Anser erythropus*), and Red-breasted geese (*Branta ruficollis*).[13] The Mekong river in southeast Asia is the tenth largest river in the world with a biological diversity comparable to that of the Amazon. It is home to species such as Mekong Giant catfish (*Pangasianodon gigas*), Mekong Giant carps (*Arapaima gigas*), Mekong stingrays (*Dasyatis laosensis)*, Irrawaddy dolphins (*Orcaella brevirostris)*, Giant ibis (*Thaumatibis gigantean*) and Siamese crocodiles (*Crocodylus siamensis*).[14] The Indus river delta is home to one of few species of freshwater dolphin, the Endangered Indus River dolphin (*Platanista minor*). A number of fish including the Indus baril (*Barilius modestus*), Indus garua (*Clupisoma naziri*) and Rita catfish (*Rita rita*) are endemic to this ecoregion.[4]	Rivers and streams contaminated by waste contain high levels of organic pollutants that result in eutrophication and the spread of harmful bacteria and viruses that can cause mass deaths and loss of reproductive ability of freshwater species.[5] Invasive alien fauna that threaten rivers and streams in Sri Lanka include the Rainbow trout (*Oncorhynchus mykiss*), Clown knife fish (*Chitala chitala*), Plectosomus catfish (*Hypostomus plecostomus*), Walking catfish (*Clarias batrachus*), Western mosquito fish (*Gambusia affinis)*, Tilapia (*Oreochromis mossambicus*) and Guppies (*Poecilia reticulate*).[6] Invasive alien flora that threaten rivers and streams in Sri Lanka include the Water hyacinth (*Eichhornia crassipes*), Salvinia (*Salvinia molesta*), Hydrilla (*Hydrilla verticillata*) and Canadian pondweed (*Egiria densa*).[6] Warmer temperatures as a result of global warming will lead to higher metabolic rates of species which will contribute to the proliferation of IAS in rivers and streams. Cold water species will likely become extinct in regions where water temperatures are too high to tolerate. Commonly cultured freshwater species such as carp and Tilapia may grow faster at higher temperatures, but more food is required for their growth and there is an increased risk of disease.[15]
Movement of sediment and nutrients	Fast moving water in rivers can pick up, suspend and move soil, sand and debris. This transport of sediment carries important minerals and nutrients such as nitrogen and phosphorus. These particles and nutrients are carried and deposited in river deltas, banks and floodplains making the land extremely fertile.[16] Replacing the soil nutrients carried out to sea by rivers each year with fertiliser would cost 1,000 million Indian Rupees.[17]	Dams reduce the flow of water in lower regions of rivers and limit the transport of fertile sediment downstream into deltas.[4] Climate change affects rainfall and therefore, affects river flow and underground water supplies. Some river basins will experience increased flooding while others will become progressively drier. This will have severe effects on freshwater species.[18]

Annex 9: contd.

Services	Description	Threats
Supporting services contd.		
Prevention of soil erosion	During rainstorms, unanchored soil washes into rivers affecting turbidity, composition as well as flora and fauna. Riverine vegetation stabilises the riverbank by anchoring the soil in place and preventing the erosion of soil.[22]	Deforestation of riverine and forest vegetation results in river bank erosion. The soil particles deposit on the riverbed in slow moving regions, thereby increasing water levels and the incidence of floods.[18]
Water table replenishment	Most of the earth's freshwater is underground and collects in aquifers, which store 97% of the world's unfrozen freshwater. Water from rivers and streams travels through layers of sand and gravel to recharge aquifers, renewing the underground water supply. People dig wells into these aquifers to pump out water for drinking, irrigation and industrial use.[23]	The lack of sustainable agricultural practices harms the environment by severely depleting water in rivers, lakes and underground water sources, increasing soil salinity and destroying its quality. Pollutants and pesticides washing into rivers, in turn, destroy downstream ecosystems such as coral reefs.[24]
Regulating services		
Flood regulation	Floodplains are flat areas of land that lie adjacent to rivers or streams that are periodically or occasionally flooded. During wet seasons and intense storms, these floodplains are inundated with the water that overflows from rivers. This water is retained in the plains and this prevents the occurrence of floods in regions of lower altitude. This periodic flooding brings in nutrients and minerals making flood plains very fertile and suitable for agriculture.[25]	The construction of dams, dikes, levees and physical alterations of river flow by straightening, deepening and widening river courses disrupts the natural flooding cycles, reduces flows, drains wetlands, cuts off rivers from their floodplains and flood riparian habitats, resulting in the destruction of species and the intensification of floods.[18]
Cultural services		
Supporting civilizations	Rivers have been very important to the development of civilizations and many historically important civilizations have flourished around them because of the supply of water for agriculture. The Sumerians built the first cities of the world between 4000 and 3000BC on the Tigris and Euphrates rivers. The Indus river valley was the location of the first civilization of India in 2500 - 1500BC and China's earliest civilizations were around the three large rivers, the Yellow River, the Yangtse and the West River.[26] The population of Egypt has depended on the Nile river for more than 5,000 years. Currently, the Nile delta is home to virtually all of Egypt's 78 million people.[27]	The lack of sustainable agricultural practices harms the environment by severely depleting water in rivers, lakes and underground water sources, increasing soil salinity and destroying its quality. Pollutants and pesticides washing into rivers, in turn, destroy downstream ecosystems such as corals reefs.[24] Agriculture wastes 60% or 1,500 trillion litres, of the 2,500 trillion litres of water it uses each year, which is 70% of the world's accessible water.[28]

Annex 9: contd.

Services	Description	Threats
Cultural services contd.		
Transport	Rivers were used to transport commuters and goods long before roads and railways were built.[19] Rivers are used as a cheap and efficient method of transporting logs from forests to nearby paper mills and other logging industries. Other goods transported using rivers include dry bulk cargo such as grain, cement, coal and liquid bulk cargo such as petroleum, gasoline, chemicals and liquefied natural gas.[20] Rivers form a critical link between land and sea and provide transportation routes for humans and make it possible for fish to migrate between marine and freshwater systems.[18]	Inland shipping infrastructure projects alter natural river function and habitats, as they involve water pumping, channelling, dredging and gravel and sand extraction to make deep, straight and uniformly banked waterways that cut the river off from its floodplain. Vessel operations create waves that disturb habitats and ecological processes. Also, spills and ship collisions pollute and severely damage freshwater species and habitats by the release of oil and hazardous substances such as cadmium, lead, mercury and DDT.[21]
Tourism	Rivers and streams are important tourist attractions for recreational activities such as fishing, boating, water sports, camping and their historical and cultural importance. Popular tourist destinations include the Amazon river[8], the Mekong river[3], the Ganges[29], the Nile[27] and the Congo river.[30]	Tourist actions such as irresponsible trash disposal in the river, camping and construction of toilet pits close to rivers and oil pollution and disturbance of wildlife by boating and fishing and inadvertent introduction of exotic species threaten rivers and streams.[31]

References

1. http://www.answers.com/topic/freshwater.
2. http://www.oceansatlas.org/world_fisheries_and_aquaculture/html/ecosys/inland/nateco/rivers_and_streams.htm.
3. http://www.panda.org/about_wwf/what_we_do/freshwater/problems/river_decline/10_rivers_risk/mekong_lancang/index.cfm.
4. http://www.panda.org/about_wwf/where_we_work/ecoregions/indus_river_delta.cfm.
5. http://www.wwf.org.my/about_wwf/what_we_do/freshwater_main/freshwater_conserving_river_basins/threats_to_rivers/index.cfm .
6. Bambaradeniya, C. N. B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17**(11): 930-935.).
7. www.bbc.co.uk/nature/environment/conservationnow/global/freshwater/.
8. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/amazon/index.cfm.
9. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/brahmaputra/index.cfm.
10. http://www.power-technology.com/projects/ertan/#adEnd.
11. www.water-technology.net/projects/kukule/.
12. http://en.wikipedia.org/wiki/Electricity_in_India#Hydro_Power.
13. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/euphrates/index.cfm.
14. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/mekong/index.cfm.
15. http://www.grida.no/climate/ipcc_tar/wg2/261.htm.
16. http://ga.water.usgs.gov/edu/earthriverssed.html.
17. www.iespanchayat.net.in/pdf/vol_vi-no_iv-2003.pdf.
18. http://www.panda.org/about_wwf/what_we_do/freshwater/problems/river_decline/index.cfm.
19. http://www.kented.org.uk/ngfl/subjects/geography/rivers/RiverArticles/riversfortransport.htm.
20. http://en.wikipedia.org/wiki/Bulk_cargo.
21. Wong, C. M., Williams, C. E., Pittock, J., Collier, U. and P. Schelle (2007). *World's top 10 rivers at risk*. Gland, Switzerland: WWF International.
22. http://nature.ca/rideau/e/e2c-e.html.
23. http://www.ramsar.org/info/values_groundwater_e.htm.
24. assets.panda.org/downloads/wwfbookletthirstycrops.pdf.
25. http://en.wikipedia.org/wiki/Floodplain.
26. http://library.thinkquest.org/3950/
27. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/nile/index.cfm.
28. Clay, J. (2004). *World agriculture and the environment: A Commodity-by-Commodity Guide to Impacts and Practices*. Washington DC: Island Press.
29. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/ganga/index.cfm.
30. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/rivers/congo/index.cfm.
31. http://www.boloji.com/environment/175.htm.

Annex 10: Ecosystem services provided by and threats to lakes and ponds

Services	Description	Threats
Provisioning services (Goods)		
Food (Fish)	Lakes and ponds provide humans with fish, which are highly nutritious and are the primary source of protein in developing countries. Fish obtained from lakes and ponds include *Ka tle (Acrossocheilus hexagonolepis), Mahseer* (*Tor tor* and *T. putitora*), Brown trout (*Salmo trutta*), *Lenok (Brachymystax lenok*), Arctic grayling (*Thymallus arcticus*), Common carp (*Cyprinus carpio*), *Marinka (Schizothorax argentatus*), Silver perch (*Leiopotherapon plumbeus*), White goby (*Glossogobius giurus*) and Bighead carp (*Aristichthys nobilis*).[1] The Tonle Sap lake in Cambodia is one of the most productive inland fisheries in the world, supporting over three million people and providing over 75% of Cambodia's annual inland fish catch and 60% of the Cambodians' protein intake.[2]	More than half of the world's five million lakes are threatened by human activities.[3] Threats to lakes and ponds include pollution, eutrophication, excessive water extraction, invasive alien species such as Janitor fish (*Hypostomus plecostomus*), Thai catfish (*Clarias batrachu*s) and the Golden apple snail (*Pomacea canaliculata*) in the Laguna lake basin in the Philippines. Climate change and the practice of destructive fishing methods destroy breeding and feeding areas of fish.[4]
Freshwater	Only 3% of the water on earth is fresh. Approximately 0.3% of water is found on earth's surface and lakes contain 7/8th of this freshwater. Freshwater obtained from lakes and ponds is essential for drinking, sanitation, agriculture, industry, recreation and as a habitat for freshwater flora and fauna.[5] Lake Baikal, in Russia is the world's deepest lake and holds 20% of the earth's freshwater.[6] Lake Biwa is the largest lake in Japan and supplies water for 14 million people.[7]	Pollution by heavy metals, chemical waste and pesticides from agricultural run-off, sewage and industrial waste products pose severe threats to lakes and ponds. Nitrogen and phosphorus are added to lakes from domestic sources, livestock and poultry, industries and fertilisers causing eutrophication.[8] Other threats include excessive water extraction; invasive alien species such as Janitor fish (*Hypostomus plecostomus*), Thai catfish (*Clarias batrachus*) and the Golden apple snail (*Pomacea canaliculata*) in the Laguna lake basin in the Philippines; mining activities; climate change and the use of destructive fishing gear that destroy breeding and feeding areas of fish.[4]
Medicine	The Yunnan Lake is host to 15,000 species of plants, including 60% of the plants used in Traditional Chinese Medicine.[9]	Pollution by heavy metals, chemical waste and pesticides from agricultural run-off, septic pit and industrial waste products pose severe threats to lakes and ponds. Nitrogen and phosphorus are added to lakes from domestic sources, livestock and poultry, industries and fertilisers causing eutrophication.[8]

Annex 10: contd.

Services	Description	Threats
Supporting services		
Biodiversity	Lake Baikal supports 2,500 species of known plants and animals, of which 1,500 are endemic. This lake has hydrothermal vents at a depth of 400m that support reefs of living sponges, bacterial mats, snails, transparent shrimp and fish. The endemic Baikal seal (*Phoca sibirica*) is the only landlocked seal species in the world.[6] Lake Biwa hosts a number of endemic fauna such the Biwa trout (*Oncorhynchus masou rhodurus*), *Wataka (Ischikauia steenackeri), Honmoroko (Gnathopogon caerulescens)*, *Biwa higai (Sarcocheilichthys variegatus microoculus)*, *Abura higai (Sarcocheilichthys biwaensis)*, *Sugomoroko (Squalidus chankaensis biwae*), and the *Gengorou crucian* carp (*Carassius cuvieri*).[7] Lake Ganga in Mongolia is of great importance for breeding and stop-over water birds such as White-naped Crane (*Grus vipio*), Swan Geese (*Anser cygnoides*) and Great Bustards (*Otis tarda*).[10] Lake Inle in Myanmar is home to the endemic Inle swamp eel (*Chaudhuria caudata*) and Inle barb (*Sawbwa resplendens*).[11] Lake Victoria in Africa housed nearly 400 species of cichlid fishes, all of whom evolved with astonishing rapidity from five ancestral species, making this lake a living laboratory.	Pollution by heavy metals, chemical waste and pesticides from agricultural run-off, septic pit and industrial waste products pose severe threats to lakes and ponds. Nitrogen and phosphorus are added to lakes from domestic sources, livestock and poultry, industries and fertilisers causing eutrophication.[8] Invasive alien fauna that threaten lakes and ponds in Sri Lanka include the Clown knife fish (*Chitala chitala*), Plectosomus catfish (*Hypostomus plecostomus*), Guppies (*Poecilia reticulata*) and the Golden apple snail *(Pomacea canaliculata*).[12] Invasive alien flora that threaten lakes and ponds in Sri Lanka include the Water hyacinth (*Eichhornia crassipes*), Salvinia (*Salvinia molesta*), Hydrilla (*Hydrilla verticillata*) and the Leafy elodia (*Egiria densa*).[12] China's Hebei province has lost 969 of its 1,052 lakes as a result of water extraction. Diverting river water for crops in dry areas and dry seasons reduces the flow of water to lakes and when excessive groundwater extraction exceeds recharge from precipitation, water tables and lake levels fall.[3] Introduction of the Nile Perch (*Lates niloticus*) has caused the death of nearly 200 species of cichlid fishes in Lake Victoria, because it preyed on these cichlids.
Water purification	The vegetation in lakes and ponds have the capacity to remove high levels of nutrients especially phosphorus and nitrogen from agricultural run-off. The vegetation along the edge of Lake Victoria in East Africa was found to have phosphorus retention of 60-92%. *Typha* and *Phragmite* species (a species of reed) can filter and purify lakes from heavy metals such as cadmium, zinc, mercury and vanadium from mining areas.[13] Entire lakes and ponds have a natural capacity to cleanse themselves. These ecosystems have interlinked food webs in which organisms assimilate incoming nutrients, moving nutrients up from the simplest single cell bacteria to large fish. This process cleanses lakes and ponds from excess nutrients.[9]	Excessive nutrient loading overwhelms the ability of the entire ecosystem to assimilate nutrients. The addition of nitrogen and phosphorus leads to eutrophication and the rapid growth of algae which use up the lake resources thus depriving other freshwater species of oxygen and nutrients. The lake-wide algal bloom of *Microcystis sp*. in Laguna lake in the Philippines killed five million milkfish (*Chanos chanos*) in 1973.[4] Acid rain, caused by hydrated sulphur and nitrogen released by burning fossil fuels, is destroying thousands of lakes. Approximately 12,000km^2 of lakes in Norway have been acidified resulting in the loss of fish stocks. Sweden has 4,000 acidified lakes while in Canada, 14,000 lakes are acidified severely, threatening aquatic life.[3]
Water replenishment	Most of earth's freshwater is underground and collects in aquifers, which store 97% of the world's unfrozen freshwater. Water from lakes and ponds filters through layers of sand and gravel to recharge aquifers, renewing the underground water supply. People dig wells into these aquifers to pump out water for drinking, irrigation and industrial use.[14]	The lack of sustainable agricultural practices harms the environment by severely depleting water in lakes, rivers and underground water sources, increasing soil salinity and destroying its quality.[15]

Annex 10: contd.

Services	**Description**	**Threats**
Regulating services		
Flood regulation	Lakes and ponds fluctuate in volume according to rainfall and climate changes, thereby preventing floods. Floodplains are flat areas of land that lie adjacent to large lakes and are flooded with overflowing water during rainy seasons, thereby reducing the incidence of floods.[16] During the monsoon season, the Tonle sap river reverses its flow and pushes water into the Tonle sap lake increasing its area and depth and filling the floodplains. This process brings in nutrients and sediment to the floodplain providing a perfect breeding ground for fish.[17]	Deforested areas and farmland erode into lakes, increasing sediment and silt. This reduces the storage capacity of lakes and increases the risk of floods. The Hamoun Lakes in Iran are losing their ability to mitigate floods as they are drying from the damming of the Helmand River and years of drought.[3] The devastating flooding of China's Yangtze River in 1998, which wreaked more than 30 billion USD in damages, was attributed largely to deforestation and the loss of more than 13,000km^2 of lake area along the Yangtze's middle and lower reaches. The loss of 800 lakes deprived the river of water storage capacity and flood protection.[3]
Climate regulation	Lakes affect weather patterns by cooling surrounding regions. Within a 50-80km zone around Lake Victoria the climate is cooler, never exceeding 27^{o}C, compared to further regions.[18] Lakes stabilise regional climates by absorbing heat. Freshwater has a high specific heat capacity and so requires a large amount of heat energy for a small increase in temperature. Conduction, convection and currents mix this energy over a thick layer of water thus maintaining cool weather conditions. Exchanges of heat and moisture above lakes modify weather patterns.[19]	Increasing global temperatures will cause the ice cover in lakes to decrease with large changes in lake water levels. As increasing temperatures thin ice sheets on lakes, light which was blocked previously will penetrate surface waters causing shifts in the lake biota.[20] Nutrient cycling will be altered by climate change in ways that could worsen nutrient loading threats such as eutrophication. Wetter climates will likely increase the export of nutrient and sediment to lakes and a warmer climate will likely allow the invasion of new species of fish that will upset the ecological balance of biota.[21]
Cultural services		
Tourism and recreation	Lakes generate income as they are popular tourist attractions for fishing, camping, angling and boating activities. Important lakes in tourism include the Tonle sap lake in Cambodia,[22] Lake Inle in Myanmar,[23] the five Great Lakes in the US (Ontario, Huron, Erie, Michigan and Superior)[24] and Lake Baikal.[25]	Tourism threatens the well-being of lakes because of over-visitation, irresponsible trash disposal, increased extraction of freshwater from lakes for use by tourist lodges, oil pollution of lakes and disturbance of aquatic wildlife by tourist activities such as boating and fishing and inadvertent introduction of invasive alien species.[26]

References

1. http://www.fao.org/docrep/003/x2614e/x2614e09.htm#P5_0
2. http://en.wikipedia.org/wiki/Tonle_Sap
3. http://www.earth-policy.org/Updates/2005/Update47.htm
4. http://www.millenniumassessment.org/documents_sga/Philippine%20SGA%20Report.pdf
5. http://www.panda.org/about_wwf/what_we_do/freshwater/about_freshwater/index.cfm
6. http://www.panda.org/about_wwf/where_we_work/ecoregions/lake_baikal.cfm

7. http://www.panda.org/about_wwf/where_we_work/ecoregions/lake_biwa.cfm
8. http://www.waterencyclopedia.com/Oc-Po/Pollution-of-Lakes-and-Streams.html
9. http://www.panda.org/about_wwf/where_we_work/ecoregions/yunnan_lakes_streams.cfm
10. http://www.ramsar.org/wn/w.n.mongolia_five.htm
11. http://www.panda.org/about_wwf/where_we_work/ecoregions/lake_inle.cfm
12. Bambaradeniya, C. N. B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17** (11): 930-935.
13. www.millenniumassessment.org/documents/document.289.aspx.
14. http://www.ramsar.org/info/values_groundwater_e.htm
15. assets.panda.org/downloads/wwfbookletthirstycrops.pdf
16. http://en.wikipedia.org/wiki/Floodplain
17. http://en.wikipedia.org/wiki/Tonle_Sap
18. http://www.panda.org/about_wwf/where_we_work/ecoregions/rift_valley_lakes.cfm
19. Ackerman, S. A. and J. A. Knox (2003). *Meteorology: Understanding the Atmosphere*. Pacific Grove, California: Thompson Brooks Cole. 486 pp.
20. http://www.ipcc.ch/ipccreports/sres/regional/046.htm
21. http://www.grida.no/climate/ipcc_tar/wg2/262.htm
22. http://www.wcs.org/globalconservation/Asia/Cambodia/Cambodia_Eco-tourism
23. en.wikipedia.org/wiki/Inle_Lake
24. www.great-lakes.net/tourism/
25. en.wikipedia.org/wiki/Lake_Baikal
26. Hadwen. W. L., Arthington, A. H. and T. D. Mosisch (2003). The impact of tourism on dune lakes on Fraser Island, Australia. *Lakes & Reservoirs: Research and Management* **8**(1) 15-26.

Annex 11: Ecosystem services provided by and threats to swamps, marshes and peatlands

Services	Description	Threats
Provisioning services (Goods)		
Timber	Forested swamps and peat swamps are a source of timber species such as *Ramin* (*Gonystylus bancanus*), Paper bark tree (*Melaleuca cajeputi*), Red Balau (*Shorea balangeran*), *Jelutong* timber (*Dyera costulata*), Ant rattan *(Korthalsia flagellaris*) and Wild durian (*Durio carinatus*).[1]	*Ramin* is a valuable light hardwood species and is threatened severely by over-exploitation. Its distribution is restricted to Indonesia and Malaysia, whose peat swamp forests have been depleted severely.[2] Peat swamp forests are threatened by the expansion of forestry operations, which could lead to the over-exploitation of important species for timber and pulp such as Red Balau.[3]
Food (finfish, shellfish)	Common edible fish species in the east Kalimantan peat swamp forests include the Climbing Perch *(Anabas testudineus*), Snakehead murrel *(Channa striata),* Catfish *(Clarias sp*.) and Helicopter catfish *(Wallago leerii*). Prawn species - such as the Giant freshwater prawn *(Macrobrachium rosenbergii)* - are also a source of nourishment.[4] Fish species such as Tilapia (*Oreochromis esculentus and O. variabilis*) are found in the Yala swamp in Kenya and are used to meet the protein requirements of its human population.[5]	Over-exploitation of fish and shrimp species threatens the freshwater swamps in Irrawady, Myanmar.[1] The use of dynamite and toxic chemicals to capture either live or dead fish destroys habitats and kills other non-target organisms in swamps, peatlands and marshes.[6]
Non timber forest products (NTFPs)	Tube sedge (*Lepironia articulata*) - a reed found in the peatlands of Thailand - is woven to make baskets, mats, hats and sacks.[8] Forested swamps, marshes and peatlands are important sources of fruits - particularly berries - as well as mushrooms, latex, resins, tannins and fodder for animals.[9]	Viewed conventionally as wastelands, a vast number of swamps, marshes and peatlands have been destroyed and converted to agricultural lands for their nutrient rich fertile soil. In Indonesia, peat swamps forests are being cleared for timber plantations and cultivation of oil palm and other commercial crops.[10]
Peat (fuel)	Peat soil has been mined extensively in western Europe and South America for domestic and industrial fuel. Peat mining for use in the horticulture industry is a multi-million dollar industry in Europe.[11]	Human induced fires for the clearance of peatland for agriculture destroy peat, release stored carbon into the atmosphere - adding to global warming. They eliminate seed banks and destroy soil. All of this may take thousands of years to be replaced naturally.[12]
Medicine	Medicinal plants obtained from the east Kalimantan peat swamp forest have an economic value of 1,750 USD. Indigenous tribes in the peat swamps of east Kalimantan rely on traditional herbs such as *Kacip Fatimah (Labisia pumila*) and *Tongkat Ali (Eurycoma longifolia*).[13] Medicinal plants found in South American include *Chapeu de couro (Echinodorus macrophyllus*), which is used as a diuretic[14] and in Africa, *Ngoka (Thomandelsia laurifolia),* which is used to treat colic, fever and diarrhoea.[15]	Viewed conventionally as wastelands, a vast number of swamps, marshes and peatlands have been destroyed and converted to agricultural lands for their nutrient rich fertile soil. In Indonesia, peat swamps forests are being cleared for timber plantations and cultivation of oil palm and other commercial crops.[16]

Annex 11: contd.

Services	**Description**	**Threats**
Supporting services		
Biodiversity	Peat swamps are extreme habitats and support an array of diverse species adapted to living under such harsh conditions. The North Selangor Peat Swamp Forest of Malaysia is home to the Fighting fish (*Betta livida*), Blackwater snakehead (*Channa bankanensis*), Licorice gouramy (*Parosphromenus anjunganensis and P. ornaticauda*) and the Peat swamp barb (*Puntius rhomboocellatus*).[10] The peat swamp forests in Borneo are key habitats for the endangered Proboscis monkey (*Nasalis larvatus*), which is endemic to Borneo and the Asian arowana (*Scleropages formosus*), a popular aquarium fish.[3] The Irrawady freshwater swamp forests are important wetlands for migratory birds such as the Mongolian plover (*Charadrius mongolus*), Spoon-billed sandpiper (*Eurynorhynchus pygmeus*), Black-tailed godwit (*Limosa limosa*), Eurasian curlew (*Numenius arquata*), Temminck's stint (*Calidris temminckii*) and the Asian openbill stork (*Anastomus oscitans*).[1] Freshwater marshes support fauna such as the Vietnamese pond turtle (*Mauremys annamensis)* and flora such as reeds (*Phragmites australis*), prostrate grasses (*Aeluropus littoralis*) and Sawgrasses (*Cladium spp*).[11]	Viewed conventionally as wastelands, a vast number of swamps, marshes and peatlands have been destroyed and converted to agricultural lands for their nutrient rich fertile soil. In Indonesia, peat swamps forests are being cleared for timber plantations and cultivation of oil palm, rice and other commercial crops.[3] Invasive alien flora that threaten freshwater swamps and marshes in Sri Lanka include Salvinia (*Salvinia molesta*), Water hyacinth (*Eichhornia crassipes*), Canadian pondweed (*Elodia canadensis*) and Giant Mimosa (*Mimosa pigra*).[12] Invasive alien fauna that threaten swamps and marshes in Sri Lanka include the Clown knife fish (*Chitala chitala*), Plectosomus catfish *(Hypostomus plecostomus*), Guppy (*Poecilia reticulata*) and Western mosquito fish (*Gambusia affinis*).[12] Illegal hunting and habitat loss has led to the extinction of key species such as Swamp deer (*Cervus duvaucelii*) in the freshwater swamp forests of the Sunderbans.[13]
Absorption of pollutants	As water moves slowly through a marsh, sediment and other pollutants settle on vegetation and the marsh bed. Marsh vegetation and microorganisms absorb pollutants and excess nutrients - such as nitrogen and phosphorus - that would otherwise pollute the surface water. Cypress swamps in Florida, USA can remove 98% of the nitrogen and 97% of the phosphorus that would otherwise have entered the groundwater.[7]	Viewed conventionally as wastelands, a vast number of swamps, marshes and peatlands have been destroyed and converted to agricultural lands for their nutrient rich fertile soil. In Indonesia, peat swamps forests are being cleared for timber plantations and cultivation of oil palm and other commercial crops.[3]
Supplying water aquifers	Swamps and marshes replenish underground aquifers with freshwater and moderate stream flow by providing water to streams, which is a very important function in periods of drought. A 223,000ha swamp in Florida has been valued at 25 million USD per year for its role in storing water and recharging the aquifers.[15]	Same as above.
Carbon sequestration	Peatlands and swamps regulate and affect regional climates by sequestering carbon.	In addition to releasing carbon into the atmosphere and contributing to global warming, peat fires affect human health. In areas where peat fires are common, 30% of children under the age of five have respiratory illnesses and linked growth inhibition.[14]

Annex 11: contd.

Services	Description	Threats
Regulating services		
Flood regulation	The presence of marshes in watersheds prevents flooding by slowing down flood water and retaining it during wet seasons. Peatlands function as sponges and can soak up rainwater during rainy seasons and control water levels in rivers.[16]	Destruction of swamps, marshes and peatlands for agriculture destroys the natural water retention capacity of the land and results in the rapid release of water during wet seasons leading to devastating floods.[17]
Climate regulation	Swamps, marshes and peatlands that cover large areas contribute to local climates by absorbing heat and maintaining regional evapo-transpiration thus contributing to rainfall.[18]	Viewed conventionally as wastelands, a vast number of swamps, marshes and peatlands have been destroyed and converted to agricultural lands for their nutrient rich fertile soil. In Indonesia, peat swamps forests are being cleared for timber plantations and cultivation of oil palm and other commercial crops.[3]
Cultural services		
Home to indigenous people	Indigenous communities dependent on peat swamps include the *Orang Asli* and the *Orang Jakun* tribes living near the boundaries of the south east *Pahang* Peat Swamp Forest in Peninsular Malaysia.[4]	Same as above.

References

1, http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0116_full.html.
2. http://www.abc.net.au/4corners/content/2002/timber_mafia/resources/resources_ramin.htm.
3. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0104_full.html.
4. http://www.peatsociety.org/user_files/files/ramakrishna.
5. http://www.jaluo.com/wangwach/1106/Leo_Odera_Omolo112306.html.
6. http://www.adb.org/Documents/Policies/Fisheries/fish420.asp?p=policies.
7. http://www.millenniumassessment.org/documents/document.289.aspx.
8. http://www.iracambi.com/english/downloads/med_brief.pdf.
9. http://www.shc.usp.ac.jp/kuroda/medicinalplants.html.
10. http://www.dbs.nus.edu.sg/biodiversitii/bio/peat.htm.
11. http://en.tourduvalat.org/la_tour_du_valat/les_zones_humides/la_vegetation_et_la_faune.
12. Bambaradeniya, C.N.B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal.* **17** (11): 930-935.
13. http://www.worldwildlife.org/wildworld/profiles/terrestrial/im/im0162_full.html.
14. http://www.biofuelwatch.org.uk/peatfiresbackground.
15. http://www.ramsar.org/info/values_groundwater_e.htm.
16. http://www.epa.gov/owow/wetlands/types/swamp.html.
17. http://www.ramsar.org/info/values_floodcontrol_e.htm.
18. http://www.nwri.ca/threats2full/ch13-1-e.html.

Annex 12: Ecosystem services provided by and threats to mangroves

Services	Description	Threats
Provisioning services (Goods)		
Food (fin fish, shellfish, vegetables and other plant parts)	Mangroves are permanent or temporary habitats for many aquatic animals and are also hatching and nursery grounds for many marine fish. It is estimated that up to 80% of global fish catches are directly or indirectly dependent on mangroves.[1]	Over-exploitation (shrimp and other aquaculture, unsustainable fishing practices, overharvesting); habitat destruction though coastal development and land reclamation; and inland freshwater extraction.[2,3]
Timber and fuelwood	All over the world, the timber of mangrove flora is used to build houses, make furniture, rafters, fences, bridges, poles and boats. Mangrove wood is also used as fuelwood and still provides 90% of the fuel used in Viet Nam.[4]	Same as above.
Medicines	About 70 different mangrove flora are listed as having traditional medicinal uses for treatment of various ailments and diseases. In parts of Indonesia, traditional use of mangrove products contributes up to a half of income among the poorest households, and in southern Thailand is thought to generate products worth almost a quarter of per capita GDP among coastal villages.[4]	Same as above.
Other Non Timber Forest Products (NTFPs)	The leaves of species such as Water Palm (*Nypa)* and Screwpine (*Pandanus)* are used for thatching and weaving and light woods such as *Cerbera manghas* used to carve masks and puppets. The breathing roots of various *Sonneratia spp.* are used to make corks and fish floats. Mangrove plants are sources of sodium and the ash of some species such as *Avicennia* is used as soap. The barks of many species produce gums and tannins, which are still used in the Indian subcontinent for curing leather and fish nets. In the Bangladesh and India, honey from mangroves is an important local industry. Mangrove leaves, fruits, shoots and roots serve as vegetables and edible fruits in many parts of the region and other non-timber forest products such as sugars and drinks are extracted from different species.[4]	Same as above.

Annex 12: contd.

Services	Description	Threats
Supporting services		
Biodiversity	Because mangroves grow between the land and the sea, mangrove species are adapted uniquely to live in extreme and variable conditions. Mangroves, therefore, carry an unique assemblage of flora and fauna found in no other ecosystem.[5]	Mangrove deforestation for shrimp and other aquaculture; over-exploitation (unsustainable fishing practices, overharvesting); coastal development and land reclamation; inland freshwater extraction; pollution[2,3]; and spread of IAS are serious threats. Mangroves in the southwestern Sri Lanka are being affected by the spread of Alligator/Pond apple *(Annona glabra)* and *Wormia suffruticosa.*[5]
Protecting the shoreline	Mangroves act as physical buffers between the elements and the shore, and can absorb at least 70-90% of the energy of the waves, depending on their ecological condition.[6]	Mangrove deforestation for shrimp and other aquaculture; over-exploitation (unsustainable fishing practices, over-harvesting); coastal development and land reclamation.[2,3]
Promoting accretion	Mangroves function much like a living groyne to build up sediment, stabilising the ground and fixing mud banks. Therefore, they prevent erosion. They also protect coral reefs from sedimentation.[7]	Same as above.
Primary production	Estimated net primary productivity values of up to 7.5g C/m/day for mangrove forests in Florida, USA. In comparison, a heavily fertilised and managed sugarcane field has a maximum net productivity of 10g C/m/day.[8]	Same as above.
Enriching nutrients	It is estimated that every time the tide goes out, it takes with it as much as 12,500 tonnes of food for marine life each year.[8]	Same as above.
Regulating services		
Sequestering carbon	Mangroves are important carbon sinks, and sequester approximately 25.5 million tonnes of carbon every year.[8] They also provide more than 10% of essential dissolved organic carbon that is supplied to the global oceans from land.[9]	Same as above.
Trapping pollutants	Mangrove roots that help trap sediments also function as filters to sift out pollutants reaching the sea from inland waters.[6]	Same as above.
Reducing floods	Mangroves provide physical buffering to prevent floods.[6]	Same as above.
Cultural services		
Tourism	The foreign visitor recreational value of a mangrove ecosystem in the western coast of Sri Lanka is estimated at 1196 USD/ha/year.[5]	Over-visitation: user conflicts with traditional fishing practices (i.e, damage to by motor boats): irresponsible trash disposal.[5]
Supporting traditional fishing	Brush pile fisheries (traditional fishing methods in Bangladesh and Sri Lanka) and other traditional fisheries in south Asia are being sustained because of mangroves.	Mangrove deforestation for shrimp and other aquaculture; over-exploitation (unsustainable fishing practices, over-harvesting); coastal development and land reclamation.[2,3]

References

1. Sullivan, C (2005). The importance of mangroves www.vi<?> shandwildlife.com/ Education/FactSheet/PDF_Docs/28 Mangroves.pdf
2. Valiela, I, Bowen, J. L. and J. K. York (2001). Mangrove Forests: One of the World's Threatened Major Tropical Environments. *BioScience*, **51** (10): 807-815.
3. Environmental Justice Foundation (2005). *Mangroves: Nature's defence against Tsunamis - A report on the impact of mangrove loss and shrimp farm development on coastal defences.* London, UK: Environmental Justice Foundation. 32 pp.
4. Bandaranayake, W. M (1998) Traditional and medicinal uses of mangroves. M*angroves and Salt Marshes* **2**(3):133-148.
5. Bambaradeniya, C. N. B, Ekanayake, S. P., Kekulandala, L. D. C. B., Fernando, R. H. S. S., Samarawickrama, V. A. P. and T. G. M. Priyadharshana (2002). An Assessment of the Status of Biodiversity in the Maduganga Mangrove Estuary. *Occasional Papers of IUCN Sri Lanka (No. 1)*. Colombo: IUCN Sri Lanka.
6. UNEP-WCMC (2006) *In the front line: shoreline protection and other ecosystem services from mangroves and coral reefs*. Cambridge: UNEP-WCMC, UK. 33 pp.
7. Broom, S.W., Seneca, E.D. and W.W. Jr. Woodhouse (1981). *Planting marsh grasses for erosion control*. North Carolina: North Carolina University Sea Grant Program.11 pp.
8. Ong, J. E (1993) Mangroves – a carbon source and sink. *Chemosphere,* **27**: 1097-1107.
9. Dittmar, T., N. Hertkorn, G. Kattner, and R. J. Lara (2006), Mangroves, a major source of dissolved organic carbon to the oceans. *Global Biogeochemical Cycles* **20**. GB1012, doi:10.1029/2005GB002570.

Annex 13: Ecosystem services provided by and threats to coral reefs

Services	Description	Threats
Provisioning services (Goods)		
Lime	Lime is extracted from coral and used for construction. Largely illegal, large-scale mining of coral is ongoing in the region.[1,2]	Over-exploitation and damage to the entire coral reef because the reef is blasted for removal of calcium carbonate.[1,2]
Fish and other species for food	Every square kilometre of well-managed coral reef can yield an average of 15 tonnes of fish and other seafood every year.[3] The demand for fish has doubled in the last 50 years, and fish production would have to double again in the next 25 years to keep up with demand and population growth. In Southeast Asia, the live food trade (both as food fish and ornamentals), estimated at over a billion USD per year in mostly illegal trade.[4]	Over-exploitation: more than 25% of the world's fisheries are over-exploited, 50% are being fished to their full capacity and 75% need immediate action to ensure future supplies.[5] The Giant grouper (*Epinephelus lanceolatus*) and Humphead wrasse (*Cheilinus undulatus*) are listed in the 2006 IUCN Red List as Vulnerable and Endangered respectively as a direct consequence of over-fishing.[6] Spiny lobsters and sea cucumbers are over-harvested in Sri Lanka.[1] Activities such as coral mining and destructive fishing practices such as purse seining, fine-mesh fishing, 'moxy' nets, cyanide fishing and blast fishing are also depleting fish stocks.[5,7]
Aquarium fish	Harvest of coral, fish and other organisms for the aquarium is a major form of trade now.[7]	Same as above and large-scale mortality during transport.[5,7]
Medicines	Many species are collected for traditional medicine. In addition, bio-prospecting is ongoing for novel remedies in allopathic medicine.[8]	Over-harvesting of certain species (such as seahorses and some croakers) for traditional medicine, as well as other species by bio-prospectors.[8]
Curios/ornaments	Molluscs and marine turtles are collected for making curios or trinkets. Molluscs, dried sea stars and sea urchins, dried fish (seahorses and puffer fish) and dried lobsters are collected as souvenirs.[9]	Several species such as *Corallium* (a group of red coral) are now threatened with extinction due to over-harvesting.[10] Molluscs (chanks) (*Turbinella pyrum*) are over-exploited in Sri Lanka for export to Bangladesh.[1] Six out of seven species of marine turtles are listed as Endangered or Critically Endangered, partly as a result of over-exploitation for the use of their shells in the trinket trade.[6]
Supporting services		
Biodiversity	Coral reefs are extremely productive ecosystems and are called 'the rainforests of the sea.' Despite this, they are extremely delicate and their balance is disrupted easily and productivity decreases when species are over-harvested.[5]	Climate change and associated coral bleaching is a serious threat to coral reef ecosystems.[11] Sediment, nutrient and chemical pollution from inland development, coastal development including land reclamation and irresponsible tourism are also serious threats to the biodiversity of coral reefs.[5,12] Over-exploitation of certain species disrupts the balance of coral reef ecosystems, often with a decrease in species diversity.[13]

Annex 13: contd.

Services	Description	Threats
Supporting services contd.		
Primary production	Coral reefs have a primary productivity as high as that of tropical rain forests.[14]	Climate change[11], habitat destruction, pollution[5, 12] invasive alien species[15] and predator outbreaks[16] all affect the productivity of coral reefs.
Prevention of coastal erosion	Coral reefs dissipate the energy of waves and currents. Without the protective wall of coral reefs, the shoreline becomes more vulnerable to coastal erosion.[5]	Habitat change in the form of coral mining (including mining of inland deposits) and blast fishing destroys reefs.[1] Irresponsible coastal development is also a threat.
Beach accretion	Coral pieces are broken into smaller and smaller pieces and eventually become part of the beach.	Habitat change such as sand mining (both coastal and inland) and collection of corals and shells is reducing the amount of accretion, resulting in changes in beach morphology and wave hydraulics.[17]
Regulating services		
Protection from storms and tidal surges	Coral reefs provide a physical barrier – a wall – against tidal surges, extreme weather events, ocean currents, tides and winds.[5]	Coral mining (including mining of inland deposits) and blast fishing destroys reefs, as does irresponsible coastal development. Mining of inland resources such as sand is also destroying coral reefs and reducing their protective service function.[5,12]
Cultural services		
Recreation/tourism	Because of their easy access, visiting coral reefs is an important recreation for snorkellers, scuba divers, recreational fishermen and beach lovers.	Snorkelling, diving and boating can cause direct physical damage to reefs. Over-exploitation of reef species as food, for aquaria and as curios can threaten the survival of species. Careless and irresponsible building of infrastructure - sometimes directly onto reefs or too close to beaches, river mouths and lagoons - results in increased sedimentation and leaves the infrastructure vulnerable to damage from extreme weather events. Another indirect effect of tourism is often the irresponsible disposal of sewage and solid waste.[5, 18]

References

1 Rajasuriya, A., Zahri, H., Venkataraman, K., Islam, Z and J. Tamelander (2004). Status of coral reefs in South Asia: Bangladesh, Chagos, India, Maldives and Sri Lanka. Pp 213-233 in D. Souter and O. Linden (eds.) *Coral reef degradation in the Indian Ocean Status Report 200*4, Sweden: CORDIO.

2 Brown, B. E. Dunne, R. P. and T. P. Scofim (1995). Coral rock extraction in the Maldives, central Indian Ocean - limiting the damage, *Coral Reefs* **14**: 236.

3 http://www.panda.org/about_wwf/what_we_do/marine/blue_planet/coasts/coral_reefs/coral_importance/index.cfm

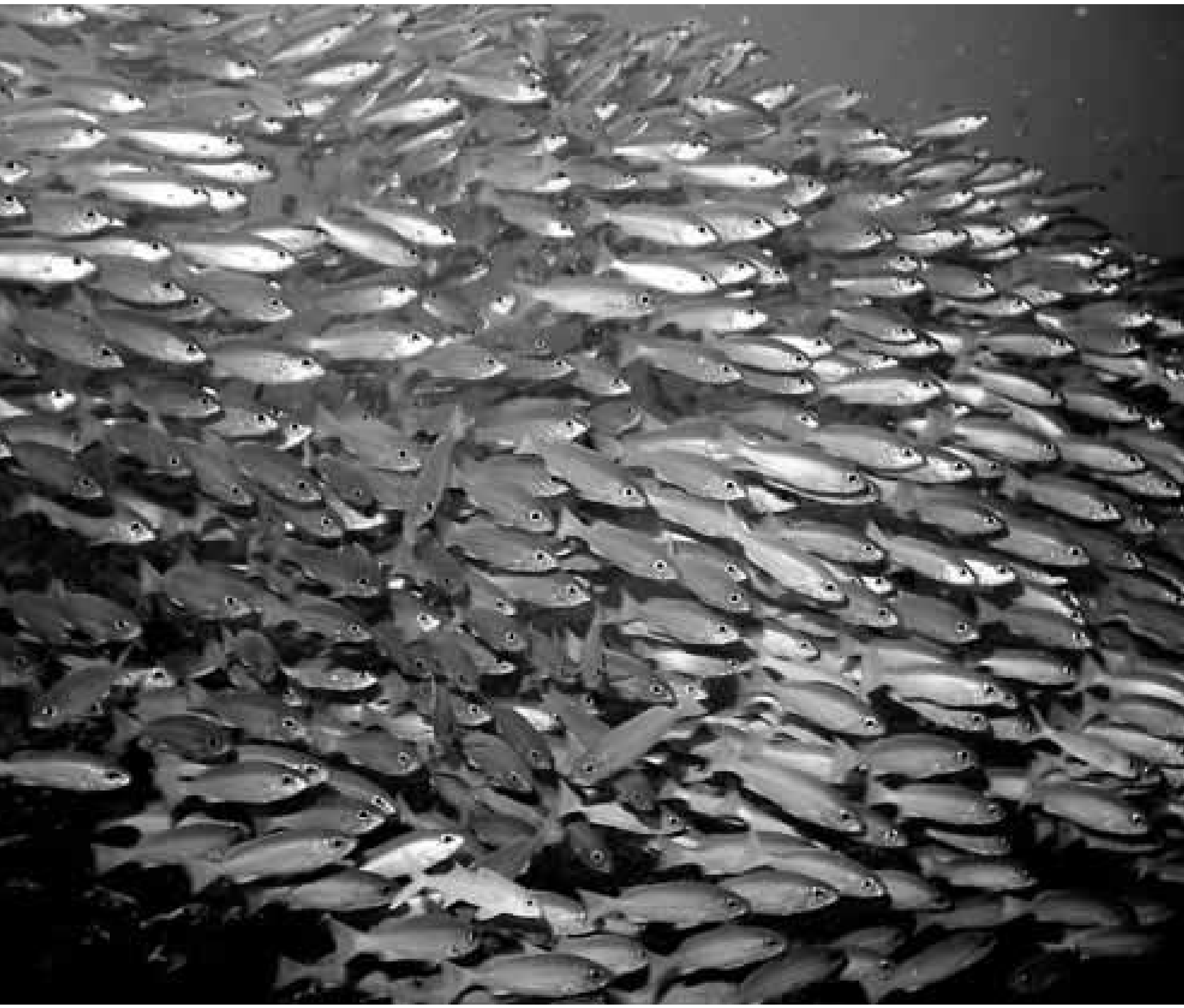
4 Sham, 1997 in TRAFFIC (1999). *The Hong Kong trade in live reef fish for food*. TRAFFIC East Asia and WWF.

5 Burke, L., Selig, L. and M. Spalding (2002). *Reefs at Risk in Southeast Asia*. Washington, DC.: World Resources Institute. 72 pp.

6 Baillie, J., and B. Groombridge (Compilers and Editors) (2007). *2007 IUCN Red List of Threatened Animals*. Gland, Switzerland and Cambridge, UK: IUCN.

7 Wabnitz, C., Taylor, M., Green, E. and T. Razak (2003). *From Ocean to Aquarium*. Cambridge, UK: UNEP-WCMC.

8 Hunt, B. and A. Vincent (2006). The use of marine organisms in traditional and allopathic medicine pp. 64-75 in S. Miththapala (ed.) *Conserving Medicinal Species: securing a healthy future*. Colombo: Ecosystems and Livelihoods Group Asia, IUCN. 184 pp.
9 Vincent, A (2006). Live food and non-food fisheries in coral reefs and their protection management. Pp 183-236 in *Coral Reef Conservation* I. M Côté and J. D. Reynolds (eds.). Cambridge: Cambridge University Press.
10 http://www.iucn.org/
11 Wilkinson, C (2004). *Status of Coral Reefs of the World, 2004* (Vol 1) Townsville, Australia: Australian Institute of Marine Science. xiv + 301 pp.
12 Nybakken, J. W (1993). *Marine Biology: an Ecological Approach*, 3rd ed. New York: Harper Collins. 579 pp.
13 Jackson, J. B. C and 18 others (2001). Historical over-fishing and the recent collapse of coastal ecosystems. *Science* **293** (5530):629 - 637.
14 Sorokin, Y. I (1995). *Ecological Studies Coral Reef Ecology* Vol. 102. Berlin: Springer- Verlag.
15 ten Hallers-Tjabbes, C (2004). Marine Biodiversity threatened by ballast water transported by ships; curbing the threat. In subtheme, Coping with Aliens, in Proceedings of *Biodiversity loss and species extinctions, managing risk in a changing world*. A global synthesis workshop convened at the IUCN World Conservation Forum 18-20 November 2004, Bangkok, Thailand.
16 Forbes, E (2006). C*oral Reefs and the Crown-of-Thorns Starfish*. http://jrscience.wcp.muohio.edu/fieldcourses06/Papers MarineEcologyArticles/CoralReefsandtheCrown-of-.html
17 http://www.icsf.net/icsf2006/uploads/publications/proceeding/pdf/english/issue_10/chapter84.pdf
18 Mastny, L (2001). *Travelling light*. www.gttp.org/docs/lisamastny.pdf



Annex 14: Ecosystem services provided by and threats to seagrass meadows

Services	Description	Threats
Provisioning services (Goods)		
Food	Seagrass meadows are nursery areas for many commercial fin and shell fish species as well as other species.[1] Fish, clams and mussels are harvested as a source of protein from seagrass meadows all over the world.[2]	Inland and coastal pollution, causing sedimentation and turbidity[3]; dredging and coastal development; eutrophication[4] - as a result of industrial and domestic pollution; port, jetty and harbour development[5]; mooring, propellers and jet skis[6]; invasive alien species (IAS)[7]; disease[7]; over-grazing[7] and climate change.[8]
For the aquaculture and aquarium trades	Polychaete worms are harvested from seagrass meadows as broodstock feed for aquaculture. Aquarium fish are also harvested.[9]	Over-exploitation and damaging collection practices.[9] Other threats same as above.
Housing insulation and thatching, stuffing and packing	Until the last century, in Europe, dried seagrass material was used as housing insulation. Until recently, sea-grasses were also used to thatch roofs in rural coastal areas in Europe and the UK as a substitute for straw. Before the advent of plastic, seagrasses were used as stuffing for pillows and upholstery and for packing.[10]	Not used currently.
For preventing erosion	Seagrasses were used to bind soil in embankments, such as in the dikes of the Netherlands. Presently, seagrasses are being used in sand dune restoration in Australia.[10]	No immediate threat.
Regulating services		
Preventing pollution and sedimentation of coastal waters	The leafy 'canopy' of seagrasses slows down water currents, trapping particles, nutrients and pollutants washed from inland waters to coastal seas.[11]	Over-exploitation and damaging collection practices;[9] inland and coastal pollution – causing sedimentation and turbidity[3]; dredging and coastal development; eutrophication[4] – as a result of industrial and domestic pollution; port, jetty and harbour development[5]; mooring, propellers and jet skis[6]; IAS[7]; disease[7]; over-grazing[7] and climate change.[8]
Stabilising the floor of coastal seas	The underground stems of seagrasses help stabilise the sea meadows preventing sand from being washed away and churned up by wave action.[12]	Same as above.

Annex 14: contd.

Services	Description	Threats
Supporting services		
Supporting coastal biodiversity	Because of their three-dimensional structure in the water, seagrass meadows provide protection for juvenile fish and many marine larvae. They house hundreds of other species as well, such as algae, sponges, round worms, marine worms and even threatened species such as manatees and dugongs that feed directly on them.[13, 14]	Over-exploitation and damaging collection practices;[9] inland and coastal pollution – causing sedimentation and turbidity[3]; dredging and coastal development; eutrophication[4] – as a result of industrial and domestic pollution; port, jetty and harbour development[5]; mooring, propellers and jet skis[6]; IAS[7]; disease[7]; over-grazing[7] and climate change.[8]
Primary production	Seagrasses rank with coral reefs and mangroves in their productivity.[14]	Same as above.
Enriching nutrients in coastal waters	Seagrasses are important in the detrital food chain. When all the organisms found in the three dimensional habitat of seagrasses, as well as the seagrasses die, the released nutrients enter the marine system as carbon and other nutrients.[3]	Same as above.
Cultural services		
Supports traditional fishing practices	In many countries, traditional fishing practices are supported by seagrass meadows. In Australia and Polynesia, Aboriginal and Polynesian traditional fishing and hunting techniques and rituals are associated with seagrass meadows.[14]	Mooring, propellers and jet skis are emerging as a major threat to seagrass meadows.[6] When boats – either for fishing or recreation – enter into areas where there are seagrass meadows, their propellers can slash leaves as well as the rhizomes of seagrass, leading to fragmentation of the habitat, which, in turn, leads to erosion.[3] Similarly irresponsible mooring and recreation can endanger these habitats. Blue crab dredging in Chesapeake Bay eastern USA has caused significant declines in seagrass cover.[6] Trampling or using fishing gear that rakes up the seagrasses is also damaging. For example, push nets and drag nets cause immense damage to seagrass meadows in coastal wetlands in Sri Lanka.[15]
Other services		
'Biological sentinels' and 'coastal canaries'	Like canaries that were taken into coal mines to test the quality of the air, seagrasses respond to changes in the quality of water, indicating deterioration of the environment by declining. What is important is that these changes are visible and very quickly so that it is possible to take management action.[7]	Over-exploitation and damaging collection practices;[9] inland and coastal pollution – causing sedimentation and turbidity[3]; dredging and coastal development; eutrophication[4] – as a result of industrial and domestic pollution; port, jetty and harbour development[5]; mooring, propellers and jet skis[6]; IAS[7]; disease[7]; over-grazing[7] and climate change.[8]

References

1. Heck, K. L., Hays, C., and R. J. Orth (2003). A critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series* **253**: 123–136.
2. Green E. P. and F. T. Short (2003). *World Atlas of Seagrasses*. xii+298 pp. Berkeley, CA: UNEPWCMC, University of California press.
3. http://www.sms.si.edu /IRLspec/ Seagrass _Habitat.htm.
4. Short, F. T., Kock, E. W., Magalhães, K. M., Fernandez, E. and J. L. Gaeckle (2006). Seagrass monitoring across the Americas: case studies of seagrass decline. *Marine Ecology* **27**: 277–289.
5. Spalding, M., Taylor, M., Ravilious. C., Short, F and E. Green (2003). The distribution and status of seagrasses. Pp 5- 26 in Green E. P. and F. T. Short (2003) *World Atlas of Seagrasses*. Berkely, CA: UNEP-WCMC, University of California press. xii+298 pp.
6. Fonseca, M. S., Kenworthy, W. J. and G. W. Thayer (1998). Guidelines for the Conservation and Restoration of seagrasses in the United States and Adjacent Waters. *Decision Analysis Series* **No. 12**. U.S.A: National Oceanic and Atmospheric Administration, Coastal Ocean Program.
7. Orth, R. J. and 14 others (2006) A global crisis for seagrass ecosystems. *BioScience* **56(**12):987-996.
8. Short, F. T. and H. A. Neckles (1999). The effects of global climate change on seagrasses. *Aquatic Botany* **63:** 169–196.
9. Kallesøe, M. F., Bambaradeniya, C. N. B., U. A. Iftikhar, Ranasinge, T. and S. Miththapala (2008). *Linking Coastal Ecosystems: and Human Well-Being Learning from conceptual frameworks and empirical results*. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii + 49 pp.
10. Hurley, L. M (1990). U.S. *Fish and Wildlife Service Field Guide to the Submerged Aquatic Vegetation of Chesapeake* Bay. Annapolis, MD: Chesapeake Bay Estuary Program. 51pp.
11. Short, F. T. and C. A. Short (1984). The seagrass filter: purification of estuarine and coastal water. Pp. 395–413. In V. S.Kennedy (ed.) T*he Estuary as a Filter*. Orlando: Academic Press.
12. Dahm, J., Jenks, G., and D. Bergin (2005). *Community-based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects: A Guide for Local Authorities*. www.lgnz.co.nz/projects/ClimateChange/Community Based DuneMangementpart1.pdf
13. Ruppert, E. E., Fox, R. S. and Robert D. Barnes (2003) *Invertebrate Zoology: A Functional Evolutionary Approach.* USA: Brooks Cole. 1008 pp.
14. Coles, R. G., McKenzie, L. J. Rasheed, M, Mellors, J. E., Taylor, H., Dew, K., McKenna, S., Sankey,T. L., Carter, A. B. and A. Grech (2007). *Status and Trends of seagrass habits in the Great Barrier Reef World Heritage Area*. Report to the Marine and Tropical Research Science Facility. Cairns: Reef and Rainforest Centre Limited. Pp 122.
15. Bambaradeniya personal communiation.

Annex 15: Ecosystem services provided by and threats to sand dunes

Services	Description	Threats
Provisioning services (Goods)		
Sand and other minerals	Sand is mined heavily in many parts of the region. Beach sand mining in the east coast of Sri Lanka is estimated at 500-1000m^3/km/year.[1]	Over-exploitation of both sand and river sand results in coastal erosion.[1]
Regulating services		
Stabilising the shoreline	The store of sediment in sand dunes protects the land behind them from storm erosion and potential sea level rise. Sand dune vegetation traps and prevents sand being blown further inland.[2]	Sand mining – inland or at the coast and resultant erosion[1]; beach infrastructure[3], artificial erosion defence structures, afforestation and other human influences – such as ports and jetties – are damaging or reducing the extent of sand dunes and with it, nesting habitats of endangered species.[4] Tourist infrastructure often destroys sand dunes.[3] Climate change is also a threat.
Flood protection	When there are storm surges and waves, sand dunes prevent flooding inland. Intact sand dunes were the most effective barrier against tsunami waves that affected the coastal zone of Sri Lanka in 2004.[5]	Same as above.
Supporting services		
Biodiversity	Sand dunes are essential components of coastal vistas and coastal biodiversity. They also harbour endangered species such as marine turtles – who must lay their eggs on sandy beaches and return to the sites where they were born. Coastal sand dunes with natural vegetation such as Goat's Foot (*Ipomea pescaprae)* and *Spinifex littoreus* are ideal nesting sites.[4]	Same as above. Excessive trampling of sand dune vegetation by tourists causes death of the flora and can result in erosion of dune sites. Species such as Prickly Pear (*Opuntia dillenii*) and Mesquite (*Prosopis juniflora*) are spreading in sand dunes and beaches and destroying natural vegetation.[5]
Cultural services		
Recreation	Beaches are popular for recreation and many people enjoy walking on the beach and paddling on beach fronts. Sand dunes can provide source sand for the maintenance of beaches. In many countries, coastal tourism relies on intact sand dunes and beach fronts as part of their marketing packages. Seventy percent of all hotels registered with Sri Lanka Tourist Board are located in the coastal zone.[1]	Tourist infrastructure often destroys sand dunes. A by-product of such development is the increase of sedimentation, solid waste and marine pollution.[4]
Supporting traditional fishing practices	In many countries, traditional fishing practices are supported by sand dunes. Because sand dunes can provide source sand for the maintenance of beaches, they indirectly support traditional fisheries. Traditional stilt fishery and beach seine fishery are supported indirectly in Sri Lanka by the combination of the presence of sand dune ecosystems and sandy sea beds.[6]	Sand mining – inland or at the coast – and resultant erosion[1]; beach infrastructure[3], artificial erosion defence structures, afforestation and other human influences – such as ports and jetties – are damaging or reducing the extent of sand dunes and with it, nesting habitats of endangered species.[4] Tourist infrastructure often destroys sand dunes.[3] Climate change is also a threat.

References

1. CCD (2004). *Revised Coastal Zone Management Plan, Sri Lanka*. Colombo, Sri Lanka: Coast Conservation Department, Ministry of Fisheries and Aquatic Resources. xiv+182 pp.
2. Dahm, J., Jenks, G., and D. Bergin (2005). *Community-based Dune Management for the Mitigation of Coastal Hazards and Climate Change Effects: A Guide for Local Authorities.* http://www.lgnz.co.nz/projects/ClimateChange/CommunityBasedDuneMangementpart1.pdf
3. UK Biodiversity Group (1999). *Tranche 2 Action Plans - Volume V: Maritime species and habitats.* http://www.ukbap.org.uk/ukplans.aspx?ID=66.
4. Choudury, B. C., Pandav, B., Tripathy, B., and H. V. Andrews (2003). *Sea turtle conservation: Eco (turtle) friendly coastal development. A GOI-UNDP project manual*. Tamil Nadu, India: Centre for Herpetology/Madras Crocodile Bank Trust. 44 pp.
5. Bambaradeniya, C.N.B., Perera, M. S.J. and V.A.M.P.K. Samarawickrama (2006). A rapid assessment of post-tsunami environmental dynamics in relation to coastal zone rehabilitation and development activities in Hambantota District of southern Sri Lanka. *IUCN Sri Lanka Occasional Paper No. 10*. Colombo, Sri Lanka: IUCN. 27pp.
6. Kallesøe, M. F., Bambaradeniya, C. N. B., Iftikhar, U. A., Ranasinghe, T and S. Miththapala (2008). *Linking Coastal Ecosystems: and Human Well-Being Learning from conceptual frameworks and empirical results*. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii + 49 pp.

Annex 16: Ecosystem services provided by and threats to lagoons and estuaries

Services	**Description**	**Threats**
Provisioning services (Goods)		
Food (Fish)	Lagoons and estuaries are important sources of fish and provide employment for coastal residents in the aquaculture industry and ornamental fisheries. The average annual fish production in the Rekawa lagoon, Sri Lanka, is 40kg/ha.[1] The Negombo lagoon has a high productivity for fisheries producing 150 kg/ha/yr and involving more than 3,000 families from 26 villages.[2] Estuaries - often called 'the nurseries of the sea' - are particularly important as nursery areas for fisheries because they are extremely fertile due to the abundance of nutrients brought in from upstream and tidal sources.[3] The most abundant and commercially important prawn species in the Rekawa lagoon is the White shrimp (*Penaeus indicus*).[1]	Major threats to lagoons and estuaries include pollution by wastewaters from urban areas, industries and agricultural run-off; eutrophication, which results in oxygen depletion and death of flora and fauna; invasive alien species; climate change and habitat destruction.[4] The construction of the Kapuhenwala causeway in the Rekawa lagoon has reduced greatly the volume of water entering and leaving the lagoon. The causeway impedes sea water entering the lagoon reducing the production and quality of shrimp and fish, thus affecting the livelihoods of fishermen.[1]
Timber and fuelwood	Estuaries provide timber resources for building houses, making furniture, rafters, fences, bridges and boats and fuelwood for populations living in coastal areas.[3]	Major threats to lagoons and estuaries include pollution by wastewaters from urban areas, industries and agricultural run-off; eutrophication, which results in oxygen depletion and death of flora and fauna; invasive alien species; climate change and habitat destruction.[4]
Supporting services		
Biodiversity	Organisms found in lagoons and estuaries are unique as they can tolerate both freshwater and varying levels of salinity. The five lagoons of the Bundala wetland in Sri Lanka are important internationally as homes to large populations of migratory birds, that visit from regions as far away as Siberia.[5] Resident and migratory birds include the Greater flamingo (*Phoenicopterus ruber*), the Spot-billed pelican (*Pelecanus philippensis*), the Lesser adjutant (*Leptoptilos javanicus*) and the Black-necked stork (*Xenorhynchus asiaticus*).[6] Fish species found in the lagoons of Bundala National Park include the Short-finned Eel (*Anguilla bicolor*), the Snake-head glass perchlet (*Ambassis gymnocephalus)*, Milk fish (*Chanos chanos*) and Murrel (*Channa striata*). The Bundala lagoons are also home to the largest reptiles in Sri Lanka, the Mugger crocodile (*Crocodylus palustris*), the saltwater crocodile (*C. porosus*), the Indian Python (*Python molurus*) as well as the Leatherback Turtle (*Dermochelys coreaceae)*.[7]	Invasive alien species that threaten the lagoons and estuaries of Sri Lanka include Pond weed (*Najas marina*), Cattail (*Typha angustifolia*) and Pond apple (*Annona glabra)*.[8] In New Zealand, invasive species have displaced commercially important mussel beds, causing significant economic losses to mussel farmers.[3] Global warming and climate change will result in the rise of sea levels. Salinity in lagoons and estuaries will increase and affect species composition, favouring some species while damaging others.[9] Estuaries in close proximity to urban areas are affected by land alterations such as infilling, dredging, channelling and installations of harbor works including seawalls and groynes.[3]

Annex 16: contd.

Services	Description	Threats
Provisioning services (Goods) contd.		
Trapping nutrients and filtering pollutants	Estuaries trap nutrients brought in from the ocean, inflowing rivers and land. These nutrients are dispersed throughout the estuary by tidal movement, wind and currents and this constant mixing of nutrients creates a productive habitat for flora and fauna.[10] Estuary plants and microorganisms filter pollutants and sediments by filter feeding activity and break down of heavy particles.[4]	The dredging and diversion of rivers decreases the volume of water entering lagoons. When lagoons are not flushed periodically, deposited silt and sediment builds up creating an acidic environment. Shrimps require a habitat with a pH of 8 and a sandy bed for growth. Most organisms in lagoons are adapted to saline, basic conditions and the increase in acidity is unsuitable for their growth.[1]
Primary production	Coastal lagoons are extremely productive aquatic ecosystems and can reach net primary production values of 7000g carbon/m2/yr. The primary productivity of lagoons and estuaries is supported by phytoplankton and large plants.[11]	Major threats to lagoons and estuaries include pollution by wastewaters from urban areas, industries and agricultural run-off; eutrophication, which results in oxygen depletion and death of flora and fauna; invasive alien species; climate change and habitat destruction.[4]
Carbon sequestration	The productive phytoplankton and large plants in lagoons and estuaries sequester carbon. Rivers bring organic rich sediments that accumulate on the beds of estuaries which function as an important carbon sink.[12]	Higher temperatures caused by global warming will change patterns of phytoplankton growth, affecting productivity and ecosystem balance. They will lead to eutrophication in lagoons and estuaries damaging the quality of water and causing a reduction in fish yields. This will affect food security and livelihoods.[9]
Regulating services		
Flood regulation	Wetlands that fringe many estuaries act as natural buffers between land and the ocean, absorbing flood waters and dissipating storm surges. Estuarine plants stabilise shorelines preventing soil erosion and flood damage.[4]	Rising sea levels due to climate change can also flood lagoon banks. The loss of protective and regulative function of lagoons and estuaries will leave coastal communities more vulnerable to natural disasters.[9]
Climate regulation	Estuaries and lagoons regulate the climate by their capacity to sequester carbon and their high primary productivity.[12]	Increased precipitation caused by climate change will increase flooding of lagoons and estuaries and reduce their protective and regulatory functions.[9]
Cultural services		
Tourism	Estuaries and lagoons are important tourist attractions for recreational activities. Popular tourist destination associated with lagoons and estuaries include the Bundala National Park,[6] the Hooghly River Estuary in India[13] and the Meghna River Estuary in Bangladesh.[14]	Tourist activities - such as irresponsible trash disposal, introduction of exotic species, over-visitation and disturbance of wildlife, pollution from jet-skis and boats - threaten lagoons and estuaries.[15]

References

1 janathakshan.net/files/Kapuhenwala.pdf
2. www.iucn.org/dbtw-wpd/edocs/2005 047.pdf
3. http://www.millenniumassessment.org/documents/document.288.aspx.pdf
4. http://www.epa.gov/nep/about1.htm
5. http://www.iwmi.cgiar.org/About_IWMI/Strategic_Documents/Annual_Reports/1998/Bundala.pdf
6. http://www.info.lk/srilanka/srilankanature/srilanka_parks/bundala.htm
7. http://www.pdn.ac.lk/socs/zaup/reptiles/images/ruchira/bundala.pdf
8. Bambaradeniya, C. N. B. (2002). The status and implications of invasive alien species in Sri Lanka. *Zoos' Print Journal* **17** (11): 930-935.
9 http://www.ipcc.ch/
10. http://public.metrovancouver.org/about/publications/Publications/BiodiversityFactSheetEstuary.pdf
11. http://www.eoearth.org/article/Coastal_lagoon
12. Brevik, E. C. and J. A. Homburg (2004). A 5000 year record of carbon sequestration from a coastal lagoon and wetland complex, Southern California, USA. *Catena* **57** (3): 221-232.
13. www.britannica.com/EBchecked/topic/271249/Hooghly-River
14. www.britannica.com/EBchecked/topic/373096/Meghna-River
15. http://www.aaee.org.au/docs/WAbugs/cs5.pdf

Photocredits

Page number	Caption	Credit
Frontpiece	Reefscape.	© Jerker Tamelander/IUCN
iv & v	Prawn fishing, Sri Lanka.	© Vimukthi Weeratunge
4	Mangroves in northwestern Sri Lanka.	© Sriyanie Mththapala
7	Top to bottom: Musk deer, the musk of which is used in Traditional Chinese Medicine; deforestation in Sri Lanka; solid waste accumulation, Sri Lanka; *Pistia stratiotes*, as invasive alien species in Viet Nam; floods in the Philippines.	Top to bottom: © Susan Earle; © Gehan de Silva Wijeyeratne; © Ranjit Galappatti; © Alvin Lopez; © Efren Mariano, CARE Sri Lanka
8	Vendors in the northwestern coast of Sri Lanka.	© Sriyanie Mththapala
11	Water palm (*Nypa*) in the Sunderbans, Bangladesh.	© Raquibul Amim
12	Lowland tropical rain forest, Sri Lanka.	© Vimukthi Weeratunge
14	Destruction of tropical rain forests in Sri Lanka.	© Gehan de Silva Wijeyeratne
15	Montane forests, Sri Lanka.	© Vimukthi Weeratunge
16	Broad-leaved deciduous forest, India.	© Eric Wikramanyake
17	Scrub forest, Sri Lanka.	© Nadeera Weerasinghe/Jetwing Hotels
18	Tropical coniferous forest, Nepal.	© Eric Wikramanyake
21	Subtropical grasslands, Nepal.	© Eric Wikramanyake
24	River in central Sri Lanka.	© Vimukthi Weeratunge
25	Tonle Sap lake, Cambodia.	© Sun Visal, Ministry of Environment, Cambodia
26	Coral reef, Similan island, Thailand.	© Nishan Perera
27	*Corallium* necklace for sale in Hanoi, Viet Nam.	© Sriyanie Mththapala
28	Mangroves, Sri Lanka.	© Vimukthi Weeratunge
30	Seagrass meadows in Sanur, Bali, Indonesia.	© Rudi Yoshida, Seagrass-Watch HQ
31	Sand dunes in southern Sri Lanka.	© Thushan Kapurusinghe
33	Top to bottom: Hotel extended to beach front, sothern Sri Lanka; groyne, southwestern Sri Lanka; coastal erosion, Sri Lanka; speeding jet ski, Sri Lanka; Prickly Pear (*Opuntia dillenii*) spreading in southern Sri Lanka.	© Channa Bambaradeniya; © CRMP; © CRMP, © Luxmanan Nadaraja; © Channa Bambaradeniya
34	Fishermen in northwestern Sri Lanka.	© Sriyanie Mththapala
38	Floods and landslides in Mt. Pinatubo, Central Luzon Philippines.	© Nico Sepe
46	Dried lava from a volcano forming a mountain, Yogyakarta, Indonesia.	© Sriyanie Mththapala
54	Earthquake damage in Pakistan.	© Karl Schuler/ IUCN
57	Top to bottom: Earthquake damage in Pakistan, 2005; tsunami damage to sand dunes southern coast, Sri Lanka; floods in Bangladesh; typhoon damage in the Philippines, 2006; salinisation of fresh water after the tsunami, Thailand.	© Karl Schuler/IUCN; © Asanka Abayakoon/ IUCN Sri Lanka; © CNRS, Bangladesh; © Efren Mariano /CARE; © IUCN, Thailand
58	Cleaning up the Tasman Spirit oil spill, Pakistan.	© Ali Raza Rizvi
60	Coastal scene Sibolga, Indonesia.	© Nishan Perera
69	Woman collecting firewood from a mangrove, Sri Lanka.	© Sanjeewa Lellwalla
78	*Rafflesia arnoldii*, which produces the largest single flower in the world, is endemic to the rainforests of Indonesia and insular Malaysia.	© Karl Lehmann
82	Rhinoceros-horned lizard (*Ceratophora stoddartii*),endemic to montane regions of Sri Lanka.	© Nadeera Weerasinghe, Jetwing Hotels
89	Leopard (*Panthera pardus kotiya*) in scrub forest, Sri Lanka.	© Luxmanan Nadarajah
92	Asiatic black bear (*Ursus thibetanus*) threatened by trade for its gall bladder for use in Traditional Chinese Medicine.	© TRAFFIC East Asia
96	Lesser panda (Ailurus fulgens) found in the temperate mixed forests of China.	© Ann Batdorf, Smithsonian's National Zoo
100	Plateau Pikas (*Ochotona curzoniae*) in Qinghai Province, China.	© Andrew T. Smith
112	Fishermen in Tonle Sap lake, Cambodia.	© Sun Visal, Ministry of Environment, Cambodia
118	The wood of Native frangipani (*Cerbera mangus*) - found in mangroves - is used to make traditional masks in Sri Lanka.	© Sriyanie Mththapala
121	Shoal of fish, Koh Bon, Thailand.	© Nishan Perera
124	Hawksbill turtle (*Eretmochelys imbricata*).	© Peter Richardson, MCS
126	Sand dunes, Palatupana, Sri Lanka.	© Gehan de S. Wijeyeratne

The IUCN Asia region covers 23 countries, stretching from Pakistan in the West to Japan in the East, Indonesia in the South to Mongolia in the North. IUCN maintains offices in Bangladesh, Cambodia, China, Lao PDR, Nepal, Pakistan, Sri Lanka, Thailand and Viet Nam. The Asia Regional Office is in Bangkok, Thailand.

IUCN's seven regional thematic programmes, known collectively as the Ecosystems and Livelihoods Group (ELG), are based in two clusters: one in Colombo, Sri Lanka (environmental economics, marine and coastal, species conservation), and one in Bangkok, Thailand (environmental law, forests, protected areas, wetlands and water resources).

Ecosystems and Livelihoods Group Asia

IUCN
4/1 Adams Avenue
Colombo 4
Sri Lanka
Phone: + 94 11 2559634
Fax: +94 11- 2559637
E-mail: coastalinfo@iucnsl.org
http://data.iucn.org/places/asia/coastalinfo/

Integrating environmental safeguards into Disaster Management: a field manual

Volume 2: The Disaster Management Cycle

Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

Integrating environmental safeguards into Disaster Management: a field manual

Volume 2: The Disaster Management Cycle

Integrating environmental safeguards into Disaster Management: a field manual

Volume 2: The Disaster Management Cycle

Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

This document was produced under the project 'Rehabilitating coastal ecosystems in a post-tsunami context: Consolidation Phase' carried out with financial support from the Autonomous Organisation for National Parks (*Organismo Autónomo Parques Nacionales* - OAPN) of the Ministry of Environment of Spain.

Published by: Ecosystems and Livelihoods Group Asia, IUCN, International Union for Conservation of Nature and Natural Resources.

Citation: Miththapala S (2008). Incorporating environmental safeguards into disaster risk management. Volume 2: The Disaster Management Cycle. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii+43 pp.

ISBN: 987-955-8177-87-7

Cover Photo: Aftermath of typhoon Reming, Albay, Philippines © Efren E. Mariano, CARE

Design: Sriyanie Miththapala

Produced by: Ecosystems and Livelihoods Group Asia, IUCN.

Printed by: Karunaratne & Sons (Pvt) Ltd.
67 UDA Industrial Estate
Katuwana Road
Homagama
karusons@sltnet.lk

Available from: Ecosystems and Livelihoods Group, Asia
IUCN
4/1, Adams Avenue
Colombo 4
Sri Lanka
Phone: +(9411) 255 9634-5
Fax: +(9411) 255 9637
email: coastalinfo@iucnsl.org
website: http://data.iucn.org/places/asia/coastalinfo/

Contents

List of Figures

Foreword

The devastation caused by the 2004 Asian tsunami and the subsequent world response were unprecedented. IUCN acted promptly and undertook many initiatives to combat the destruction of local ecosystems. IUCN Asia led this process and many of its country offices and programmes played their due role. Since then, the Ecosystems and Livelihoods Group of IUCN Asia, based in Colombo, has continued to play an important role in the post-tsunami scenario. The interventions have now evolved from emergency response and rapid environmental assessments to disaster risk reduction programming. Disaster risk reduction for most organisations is a relatively new area, though mainstream aid and humanitarian organisations are adept at disaster response. While most of us are working at different levels of the DRR spectrum, the objective remains a common one: ensuring human well being.

IUCN Asia is working in the DRR sector with a two-pronged approach: to infuse environmental safeguards into the mainstream disaster risk reduction programme; and to integrate disaster risk reduction into conservation and sustainable development programming.

Over the years, varied methodologies, frameworks and approaches have been used towards this end. We have had many successes and also failures in this process and keep learning and modifying our strategies. Here, the key is to continue sharing our lessons learned and helping each other in incorporating these in our respective strategies.

We are happy to share that in the course of the above process, IUCN has developed a manual, 'Incorporating environmental safeguards into disaster risk management' through the financial support of OAPN, Ministry of Environment, Spain. This manual comprises three-volumes detailing ecosystem linkage with human well-being; presenting approaches to integrate environmental considerations into mainstream disaster management programmes; and providing tools, including worksheets, for planning and implementation of environmentally-infused disaster risk management initiatives.

In addition, we are exploring the possibilities of developing hazard-specific modules to help incorporate environmental safeguards into community-based disaster management initiatives aiming at enhancing community resilience for disaster management.

We are grateful to Dr. Sriyanie Miththapala whose dedicated research, commitment and determined efforts made it possible to produce this three-volume manual.

The manual is a working document, your comments and feedback will be received gratefully. We intend to keep working to make this as relevant, practical and user-friendly as possible. We do hope that this manual will contribute positively towards achieving the main objective of all the organisations and agencies involved in this sector which is sustainable human well being.

Ali Raza Rizvi
Regional Group Head
Ecosystems and Livelihoods Group Asia, IUCN
Colombo, Sri Lanka

Acknowledgments

Many people assisted with the preparation and production of this manual. The author expresses her grateful thanks to Saima Baig, Channa Bambaradeniya, Lucy Emerton, Janaki Galappatti, Ranjit Galappatti, Mikkel Kallesøe, Sanjeewa Lellwala, Maeve Nightingale, Thushara Ranasinghe, Ali Raza Rizvi, Rebecca Roberts and Devaka Weerakoon for content inputs and comments.

Eric Wikramanayake helped generate some GIS maps used for illustration in this volume. Anouchka Wijenaike and Irushinie Wedage proof-read the document.

Many people generously provided photographs for use. They are credited individually at the end of the book.

This document was produced and published with financial support from the through a grant made from the Autonomous Organisation for National Parks (*Organismo Autónomo Parques Nacionales* - OAPN) of the Ministry of Environment of Spain - to IUCN.

Executive summary

This volume presents the Disaster Management Cycle and its phases: Prevention, Mitigation, Preparedness, Response, Recovery and Rebuilding. It uses one of the main lessons learned after the Indian ocean tsunami of December 2004 - the lack of coordination among agencies - to recommend an integrated approach that uses assessments (including biodiversity, ecosystem, livelihood and economic valuation) to ensure that a holistic picture is obtained during the disaster management cycle. It emphasises that it is only when a holistic approach is used that reducing all types of vulnerability (physical, environmental, social and attitudinal vulnerability) becomes possible. Therefore, in the long term, it is only through integrated assessments that risk can be minimised. A holistic approach also allows for identification of gaps throughout the disaster management cycle. In addition, an integrated approach in disaster management demands involvement and collaboration not among local sectors but also at national and regional levels.

Models of both non-integrated and integrated assessments are described briefly. The process for integrated assessments (how it should be done), sourced directly from Springate-Baginski, et al. (in press), is also presented in the form of a framework and steps to be followed.

Using the framework of the Millennium Ecosystem Assessment, which links clearly ecosystem well-being and human well-being, and the main drivers of the loss of ecosystem services (over-exploitation, invasive alien species, habitat degradation, pollution and climate change), this volume presents steps that must be followed during each phase of the disaster management cycle. It emphasises that policy decisions and actions taken during prevention and mitigation have enormous and far reaching impacts on all stages of post disaster management. All decisions and actions taken after a disaster will be justified based on information gathered and actions taken during the pre-disaster phases of prevention and mitigation. Therefore, the success of post disaster management depends entirely on pre-disaster management.

This volume stresses how critically important it is, therefore, to plan and implement actions to reduce the impacts of natural disasters during pre-disaster phases to minimise impacts after a disaster. The end result should be that environmental safeguards are incorporated into every stage of the disaster management cycle, as well as into general development.

The second volume of this manual deals with each of the components of the disaster management cycle, lists steps and raises questions that must be asked at each step in order to integrate environmental concerns into disaster management. The steps and questions are designed round the framework of the Millennium Ecosystem Assessment and its identified threats.

The Disaster Management Cycle (the DRM cycle)

The Indian Ocean tsunami of December 26, 2004 was one of the most horrific tragedies of recent human history. The details of the tsunami's immediate impacts in coastal countries of Asia and Africa were shocking: 186,983,000 people died and 42,883 were reported missing. There was a massive displacement of populations, as well as extensive damage to infrastructure and coastal natural resources. In India, 235,377 homes were reported to have been damaged or destroyed; in Indonesia, 141,000; in Sri Lanka 103,836; in the Maldives, 8,074; in Thailand, 4,806; in the Seychelles, 500 and in Somalia 1,400; and. In the province of Aceh, Indonesia alone, 600,000 people lost their livelihoods (http://www.un.org/News/Press/docs/2005/hab196.doc.htm; http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake).

In addition to this enormous toll on human lives and livelihoods, the tsunami also damaged ecosystems that provided vital protection to coastal communities. Terrestrial coastal ecosystems and wetlands, as well as key marine ecosystems - such as coral reefs and sea-grass beds - suffered seriously from the tsunami. The loss of these ecosystems resulted in the loss of ecosystem services and thereby reduced the options of people to rebuild their livelihoods.

'Four provinces of Andaman Sea coast of Thailand impacted by the tsunami - namely Trang, Krabi, Phang Nga and Ranong - were selected and a rapid assessment was carried out to review indicative costs associated with the loss of ecosystem services including environmental goods, reef-based fisheries (a joint value of mangroves, reefs and sea grasses) as well as the costs of physical rehabilitation of damaged ecosystems.

The results of the study showed that there were significant economic costs related to damages to coastal ecosystems. In particular, Phang Nga, which suffered the highest damages to its coastal ecosystems, also suffered the highest economic costs ranging from 10.47-11.15 million USD. Damages to non-timber forest products from mangroves were 607,010 USD; damages to reef fisheries 262,060-942,650 USD; the loss of coastal protection by damage to coral reefs was 9,213,000 USD and to mangroves, 286,470 USD. It was estimated that the economic costs of damages to mangroves in Phang Nga to almost 6.1 million USD, in Net Present Value.[1]'

This study showed empirically that ecosystem services are not only of direct value to people, but also offer tremendous indirect benefits in terms of supporting and regulating services (IUCN/UNEP, 2006).

The devastation caused by the tsunami has served to highlight the dangers of other, recurrent natural hazards - such as intense rainstorms, cyclones, floods, fires, and worsened droughts - which are predicted to increase in the future. (Refer to section on Climate change in Volume 1.) Because natural hazards cannot be stopped, learning to reduce vulnerability to these hazards and reducing/eradicating natural disasters that stem from these recurrent natural hazards becomes important. Learning to manage these disasters – disaster management – therefore, becomes critically important.

The goals of disaster management are to

1. 'Reduce, or avoid, the potential losses from hazards
2. Assure prompt and appropriate assistance to victims of disaster and
3. Achieve rapid and effective recovery' (GDRC, 2008).

[1] Net Present Value is the sum of discounted net benefits - i.e. benefits minus costs - which shows whether a project generates more benefits than it incurs costs.

In order to achieve the first goal, it is necessary to prevent, prepare for, mitigate and minimise effects of a natural disaster. Therefore, before a natural disaster, the phases of Prevention, Mitigation, and Preparedness are essential.

Before a natural disaster:

Prevention

Prevention includes the safeguards that you establish to stop the effects of a disaster. These include policies and legislation that affect urban planning and are not damaging to human and ecosystem well-being.

It is usually difficult to prevent entirely a natural disaster and therefore, the next two steps become important.

Mitigation

Mitigation reduces risk from natural disasters. Zoning and proper land use management – for example, building with a set-back on a coastline or leaving intact stands of mangroves and public education – are examples of mitigation.

Preparedness

Preparedness aims to reduce to the minimum level possible, the loss of human lives and damage to built and natural infrastructure through the prompt and efficient actions to response and rehabilitation. Effective preparedness allows communities and institutions to provide a quick, organised response to disasters and include early warning systems, planned evacuation routes and sites etc.

After a natural disaster:

Achieving the second and third goals occurs after a natural disaster. Response (Relief), Recovery, and Rebuilding then become essential.

Response (Relief)

Response (Relief) is the collective actions carried out immediately after a disaster with the objective of saving lives, alleviating suffering and reducing economic losses. For example, relief includes getting people to safe locations, provision of food and clothing etc.

Recovery

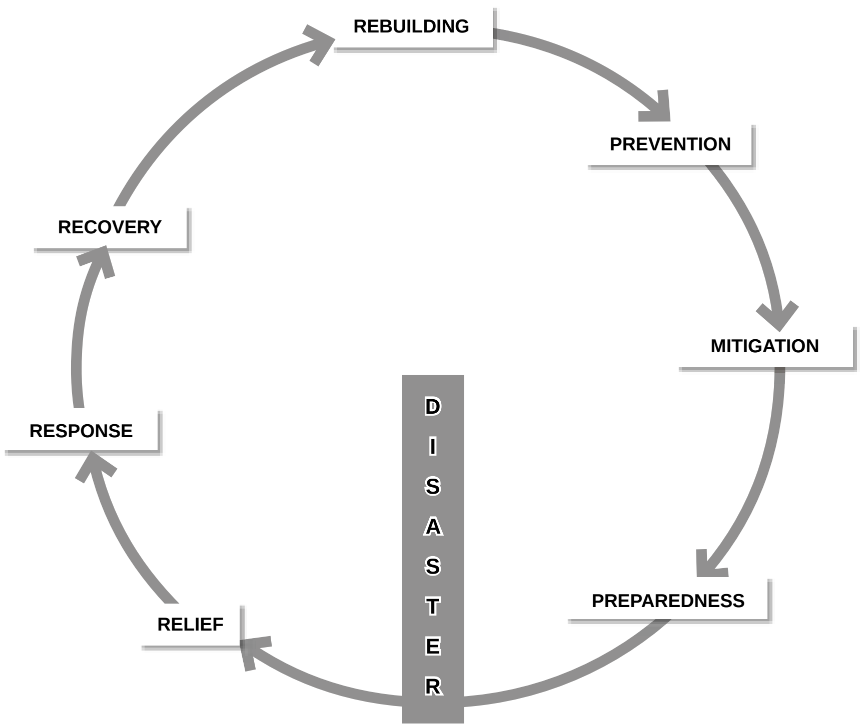
Recovery is the activity that returns humans and built infrastructures to minimum living/operating standards and guides long-term efforts designed to return life to normal levels after a disaster. This includes building temporary housing and provision of basic household amenities.

Rebuilding

Rebuilding is the long term response to a disaster. In this phase, permanent infrastructures are rebuilt, ecosystems are restored and livelihoods are rehabilitated (GDRC, 2008).

All these disaster management phases are inter-linked and are cyclic – i.e., one phase cannot be effective in isolation of the others. In other words, the phases before an event – prevention, preparedness and mitigation – are as important as response, recovery and rebuilding.

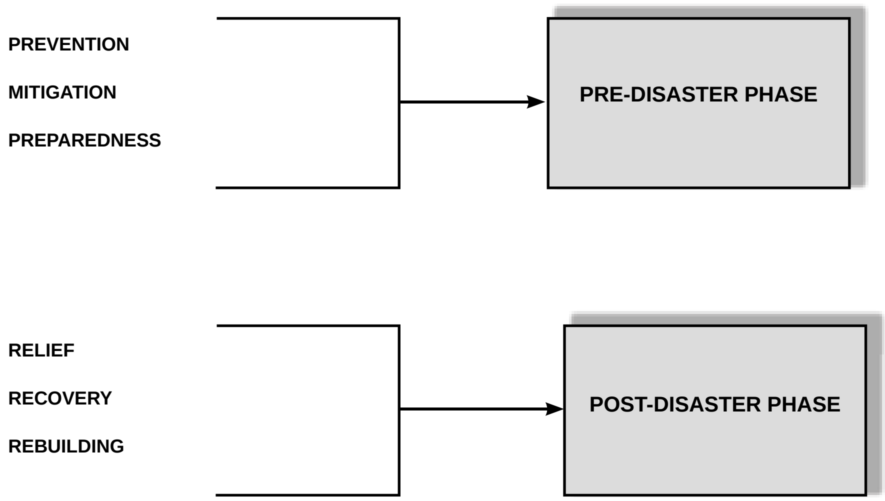
Figure 1: The Disaster Management Cycle (Source: GDRC, 2008)



Because of the cyclic nature of DRM, a lot of steps that need to be taken in one phase are repeated in another. For emphasis, this repetition is preserved in this volume.

Each step can be grouped into two phases as follows:

Figure 2: Phases in the Disaster Management Cycle

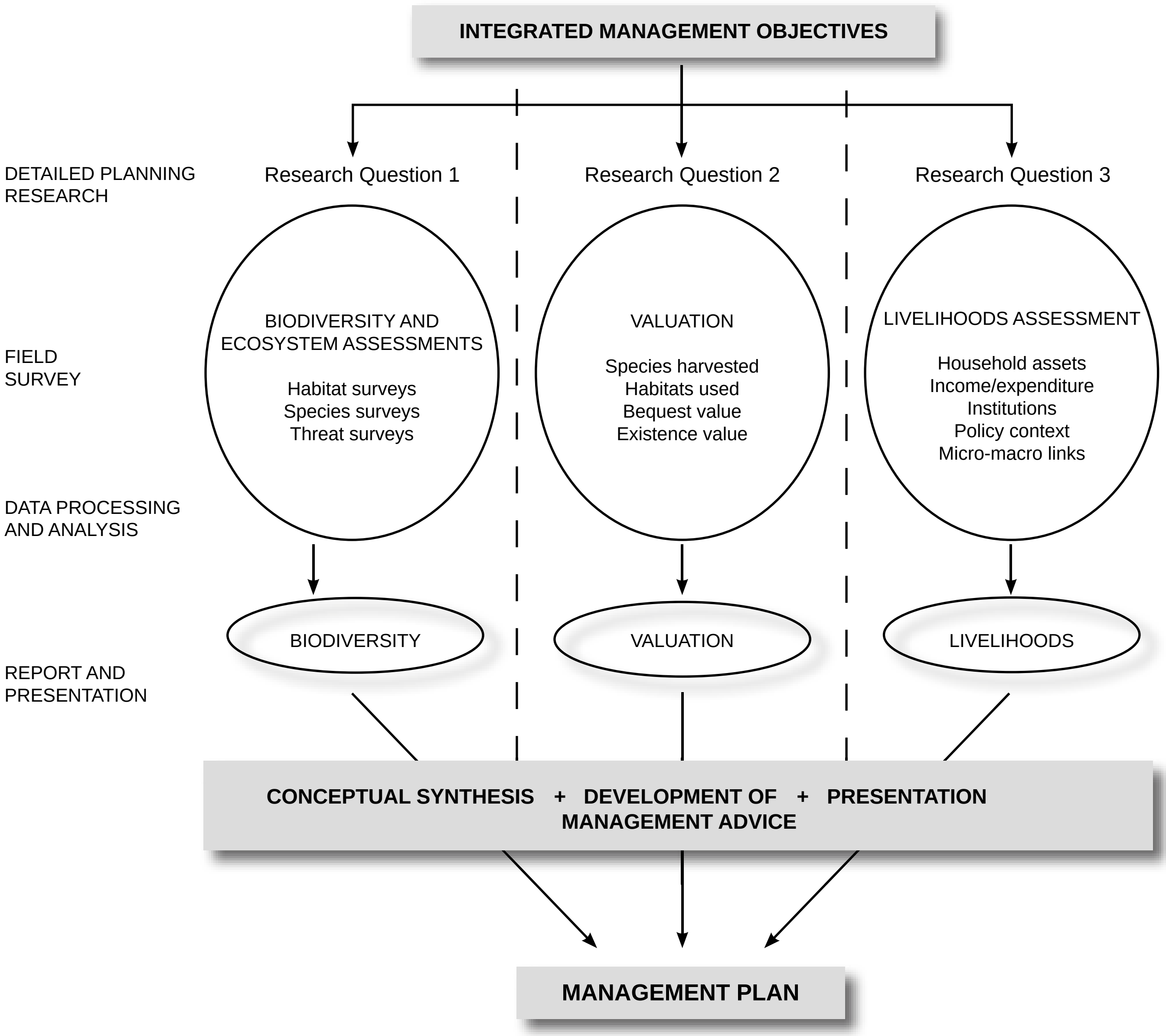


The importance of integrated assessments in DRM (Why?)

In the rush to provide relief and aid in the aftermath of the Indian Ocean tsunami of December 2004, not only were environmental concerns ignored but it was also apparent that many institutions worked in isolation, leading to omissions, duplications in research and implementation, piecemeal results and a lack of accountability. An integrated approach that includes biodiversity, ecosystem, livelihood and economic valuation is recommended to ensure that a holistic picture is obtained during the disaster management cycle.

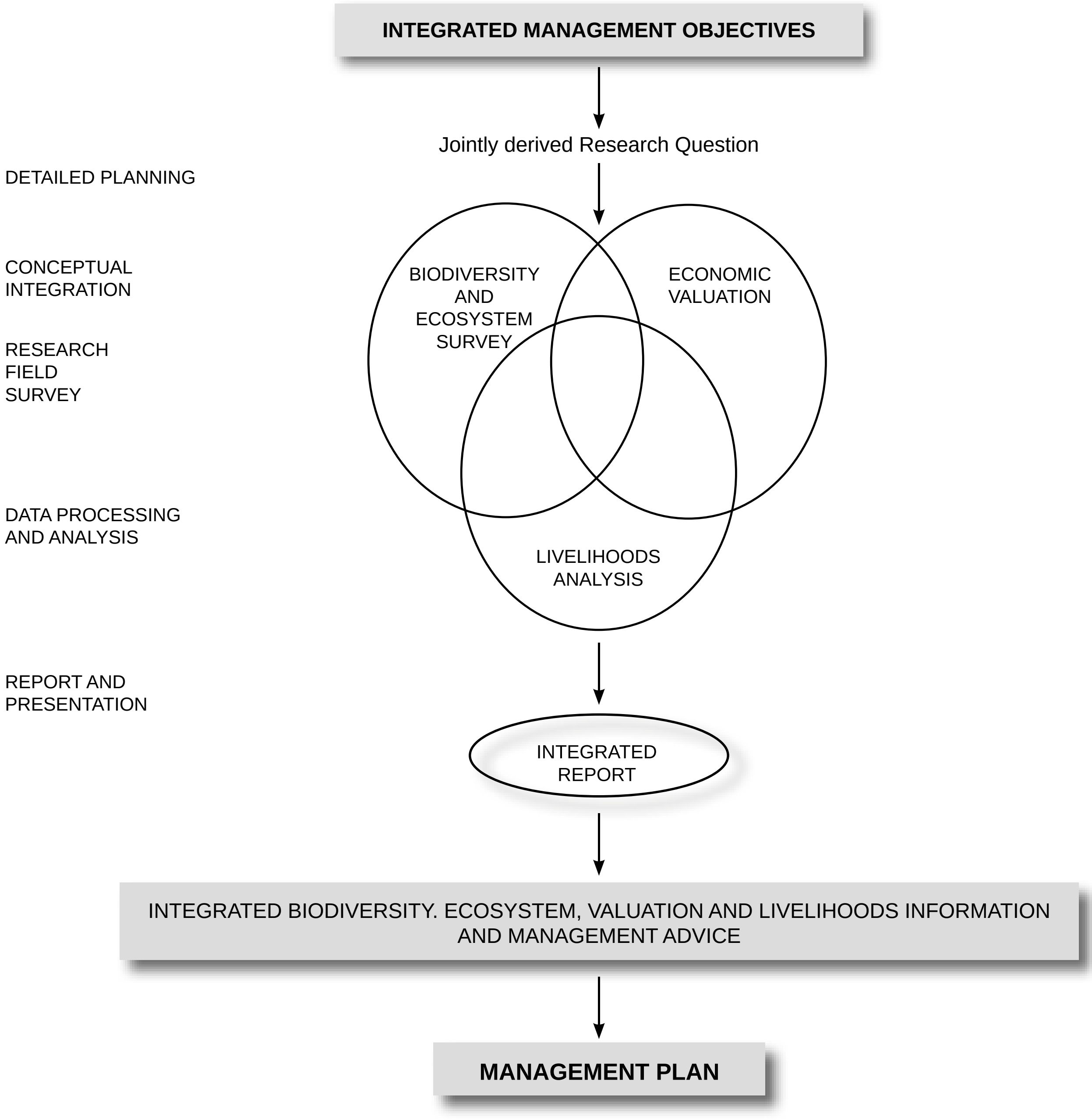
Figure 3 below shows a non-integrated assessment model while Figure 4 shows an integrated assessment module.

Figure 3: Schematic diagram of a non-integrated assessment model
(Sourced directly from Springate-Baginski, et al., in press)



‘The fully integrated assessment model (Figure 4) presented below has the advantage that exchange of ideas takes place at all stages from defining objectives, through carrying out fieldwork, to data analysis and presentation. Its disadvantages may include the time and difficulty it takes to plan and conceptualise and the intellectual and professional demands it places on participants. This model helps environmental conservation and development stakeholders to move away from a situation where they are making decisions on the basis of a series of biodiversity assessments, economic valuations and social development reports that have been carried out by different groups of people, who were commissioned separately by programme or project planners, did not consult one another, worked in different places and at different times to each other, using different methods, analytical tools and scales of working, and were each able to provide only a part of the information required and who left gaps which had to be filled by information derived from guesswork, inapplicable generalisations or vested interests’ (Sourced directly from Springate-Baginski,et al., in press).

Figure 4: Schematic diagram of an integrated assessment model
(Sourced directly from Springate-Baginski, et al., in press)



It is only when a holistic approach is used that reducing all types of vulnerability (physical, environmental, social and attitudinal vulnerability) becomes possible. It is only through integrated assessments that risk can be minimised in the long term. A holistic approach also allows for identification of gaps throughout the disaster management cycle. In addition, an integrated approach in disaster management demands involvement and collaboration not among local sectors but also at national and regional levels.

The process for integrated assessments (How?) (Quoted directly from Springate-Baginski, et al., in press)

A framework for integrated assessments and steps to be followed in such an assessment are given below.

A. Preparation	1	Identifying the management context and questions to be addressed.
	2	Forming a multi-disciplinary team.
	3	Identifying the information required.
	4	Framing the study and take sampling decisions.
	5	Planning within the constraints.
	6	Collation of secondary data and pre-existing literature.
B. Field assessment	7	Conducting the fieldwork.
C. Analysis, Write-up and Presentation	8	Integrated data management and storage.
	9	Integrated data analysis.
	10	Integrated presentation of results.

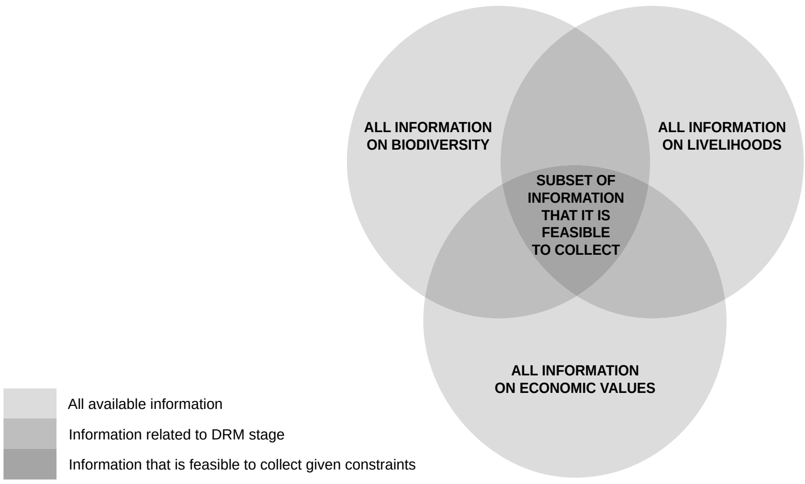
A. Preparation involves:

1. Identifying the management context and questions to be addressed.
   - This focuses the assessment and
   - involves multiple stakeholders.
   - The management issue should encompass both environmental and social issues.
   - From this general issue, specific questions should be developed.

2. Forming a multi-disciplinary team:
   - This team should involve both specialists and generalists. Ideally, the team leader is in the latter category
   - Together they should bring the following expertise:
     i. biodiversity and ecosystem surveying,
     ii. economic valuation,
     iii. livelihoods surveying and participatory research methods,
     iv. possibly ethnobiological methods and
     v. geo-referencing and spatial mapping.
     vi. All should recognise the value-addition of the integrated approach and be willing to stretch themselves in order to achieve it.

3. Identifying the information required:
   - The information should provide adequate data to answer questions identified.
   - The information should be the subset of all information which forms the intersection of biodiversity/livelihood /economic values relevant to the overall management issue.
   - The information should be feasible to collect.

Figure 5: Identifying the information required
(Sourced directly from Springate-Baginski, et al., in press)



4. Framing the study and taking sampling decisions:

   Framing is

   - Defining the assessment boundaries (defining the methodology);
   - Defining the geographic boundary (defining space); and
   - Defining a temporal boundary (defining time).

   Sampling is

   - Selecting species groups to survey;
   - Defining the socio-economic boundaries; and
   - Identifying which ecosystem values to quantify.

5. Planning within the constraints:

   There are many constraints within which integrated assessments have to be carried out.

   - Time constraints (deadlines, other obligations);
   - Funding constraints (budget);
   - Expertise constraints (skills and experience of team);
   - Political constraints (permits, permissions, access, conflicts);
   - Institutional constraints (networks etc.);
   - Social, cultural constraints (festivals, languages, customs); and
   - Natural constraints (seasonal factors and risks).

6. Collating secondary data and existing literature:

   It is important during a survey to gather existing information.

   a. Gathering Information:

   - Types of information:
     - Species information should aim to include information on taxonomy, geographic range, population size and trends;
     - Trade and value of species or species products: CITES, livelihoods reports;
     - Resource use: livelihoods reports, FAO;
     - Wealth/poverty status: census data, livelihoods reports, government/district data, health statistics (from health organisations) or studies from NGOs/medical centres in the area;
     - Livelihoods information: World Health Organisation, government agencies;
     - Maps: government mapping agency, aerial photography companies, NGOs that have produced maps as part of their reports.
   - Sources: reports and 'grey literature' of government and other agencies, government data and maps, online databases ('red list', books and miscellaneous materials).
   - Follow an integrated search - materials may be relevant to one or more disciplines.
   - Refer to key informants/experts for help.

   b. Reviewing Information:

   Clarify current state of knowledge and information gaps.

B. Field assessment:

7. Conducting the fieldwork:

   - Develop an integrated fieldwork plan;
   - Develop and adapt integrated field tools;
   - Train the fieldwork team and pilot the plan and tools;
   - Do the fieldwork;
   - Maintain rapport with respondents based on mutual respect. Observe research ethics;
   - Maintain field team networking and communication.

C. Analysis, Write-up and Presentation:

8. Integrated data management and storage protocols:
    - Data should be carefully and systematically compiled into a user-friendly archive, inter-referenced and backed up.
    - Data loss is a surprisingly common problem. In an age of effortless back-up it is hardly professional. It is easy to avoid by establishing a regular back-up system.
    - The ‘clean’ dataset should be kept separate from sets used for analysis.

9. Integrated data analysis:
    - Each aspect of the assessment should be analysed
    - Then the analysis should be integrated through team discussions.

10. Integrated presentation of results. This should include:
    - Recommendations from analysis of results;
    - Internal feedback;
    - Local feedback;
    - National feedback.

The importance of integrated assessments in disaster management

An integrated approach that includes biodiversity, ecosystem, livelihood and economic valuation is essential to ensure that a holistic picture is obtained during the entire disaster management cycle.

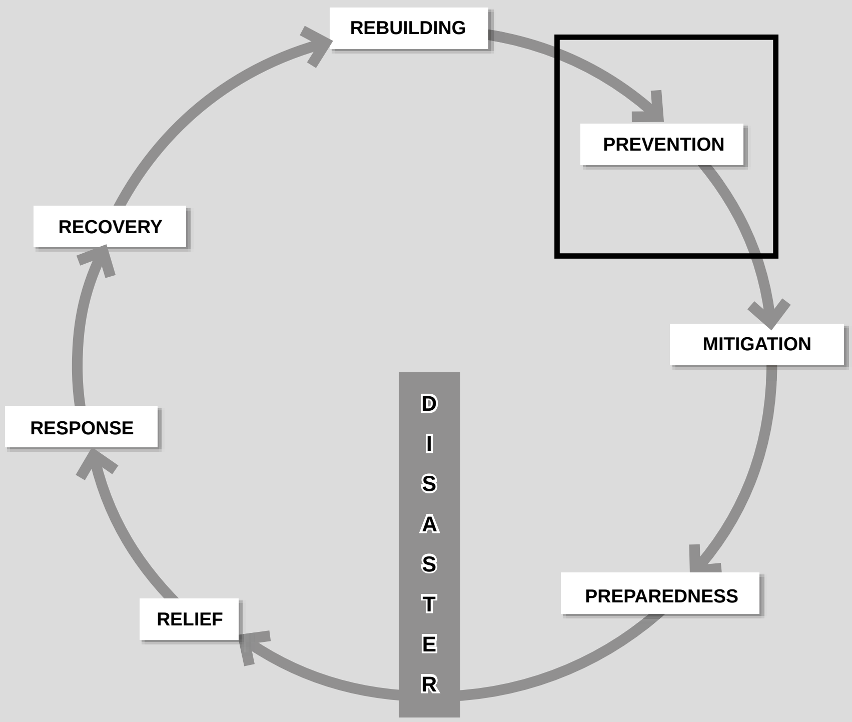
It is only when a holistic approach is used that reducing all types of vulnerability (physical, environmental, social and attitudinal vulnerability (see Volume 1) - becomes possible. It is only through integrated assessments that risk can be minimised in the long term. A holistic approach also allows for identification of gaps throughout the disaster management cycle. In addition, an integrated approach in disaster management demands involvement and collaboration not among local sectors but also at national and regional levels, leading to development that is geared at a landscape level, yielding the ‘big picture.’ This ultimately, is the most effective approach.

‘After the Indian ocean tsunami of 2004, a serious problem that emerged was a lack of coordination among agencies: between government and non-government agencies, among donors and between national and local governments.

This lack of coordination extended to various sectors as well. For example, the fisheries sector had little influence on national governments regarding the issue of boats (see page 33, this volume). Meanwhile, environmental organisations tried to convert the converted by reaching out only to the environmental community, developing guidelines and checklists which few outside their sector, value or even read. They found it difficult to accept the unfortunate fact that the very word ‘environment’ is viewed by the mainstream development sector as an ill-afforded luxury. Architects designed houses that did not reflect cultural needs or were environmentally friendly; builders paid scant respect to existing laws and environmental standards.’

The end result was, largely, confusion, duplications and omissions, that retarded recovery and hindered restoration (IUCN, 2006).

Pre-disaster management: Prevention



Prevention includes the safeguards that you establish to stop the effects of a disaster. These include assessments, policies and legislation that affect urban planning and are not damaging to human and ecosystem well-being.

Policy decisions and actions taken during prevention and mitigation have enormous and far reaching impacts on all stages of post disaster management. All decisions and actions taken will be justified based on information gathered and actions taken during prevention and mitigation. The success of post disaster management depends entirely on pre-disaster management. It is critically important, therefore, that great attention is paid during these pre-disaster phases to minimise impacts after a disaster.

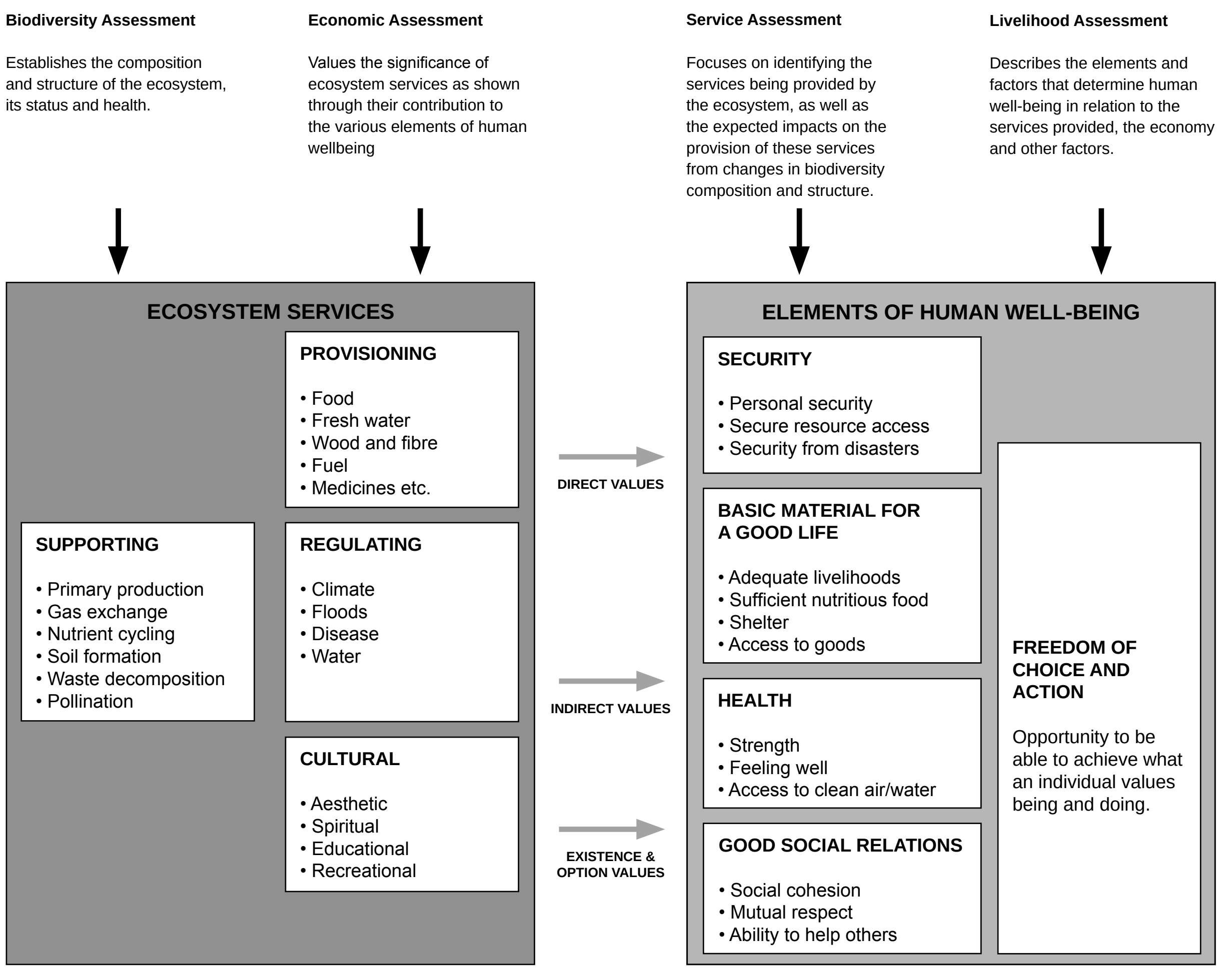
In the pre-disaster phase, it is essential to map all natural and socio-economic resources. In this way, a community's dependence on a resource and its use of the ecosystem services provided can be assessed. The mapping should be carried early enough so that it can serve practically as an important contribution to the decision-making process and will not be used to justify a decision already made.

It is also important to carry out this mapping in such a way that allows for comparisons across time and space so that changes can be monitored. This means that we must be able to measure our knowledge (assess) and also be able to describe (map) it. With reference to natural disasters, we need to collect and integrate baseline information so that comprehensive comparisons can be made after a disaster.

A framework has been proposed that includes four sub-assessments: on biodiversity; ecosystem services; economic values; and on livelihoods and human well-being (Kallesøe et al, 2008). (See Figure 1 page 2 of Volume 1.)

'The Biodiversity Assessment establishes the composition and structure of the ecosystem, its status and health. The Ecosystem Service Assessment focuses on identifying the services being provided by the ecosystem, as well as the expected impacts on the provision of these services from changes in biodiversity composition and structure. The Livelihood Assessment describes the elements and factors that determine human well-being in relation to the services provided, the economy and other factors. Finally, the Economic Assessment values the significance of ecosystem services as shown through their contribution to the various elements of human well-being' (Kallesøe et al, 2008).

Figure 6: Framework for an integrated assessment
(Source: Kallesøe et al, 2008)



A combined integrated assessment of all four components allows managers to establish a baseline on the status of ecosystem well-being and human well-being in order that informed and planned decisions are made in relation to management interventions.

A working checklist for an integrated assessment is presented in Annex 1, but the steps listed below should be followed in the process of collecting information:

a) Biodiversity Assessment: (see Volume 3 for detailed techniques)

Step 1: Identify the extent and type of natural habitats.

- What is the type of ecosystem: lowland rain forest, coral reef, sand dune, mangrove?
- What is the distribution and extent of habitats within these ecosystems?

Step 2: Identify species diversity (species richness[2] and abundance[3]) of plants and animals.

- How many different species of animals?
- How many different species of plants?
- How many individuals per species of animal?
- How many individuals per species of plant?

b) Ecosystem Services Assessment:

Step 3: Identify ecosystem services provided: for example,

- What are the provisioning services: i.e., what are the goods provided by the ecosystem – food, timber, fuelwood, medicines, other non timber forest products (NTFPs), water etc. What is the number of households/individuals that use/depend on the above services?
- What are the supporting services: i.e., how much primary production is there? In addition, the yield (amount of fish catch, fruit yield) also indicates the how good the supporting service is.
- What are the regulating services: i.e., is the ecosystem providing protection from natural hazards, such as prevention of floods and sequestering carbon?
- What are the cultural services provided by the ecosystem? Is it used for recreation/tourism/education?

Step 4: Use indicators to assess the above. For example,

- The quality and quantity of fish, vegetables and fruits, for example, indicate the extent of the ecosystem's provisioning services.
- Species diversity and quality of vegetation indicate the extent of the ecosystem's supporting services.
- The extent of tree cover (i.e. number of trees per km^2, height and the width of the trunk etc.), vegetation stands, protection by vegetation of built infrastructure etc. indicates the extent of the ecosystem's regulating services.
- Assess the demand for recreation and education: i.e., the number of tourist-related built infrastructure and educational facilities such as outreach stations indicate the extent of the ecosystem's cultural services. In addition, the extent of traditional knowledge practiced also indicates the extent of the ecosystem's cultural services.

Step 5: Assess direct drivers of ecosystem loss. For example,

- Is there over-exploitation? Are there harmful fishing practices (dynamiting, small net fishing), illegal felling of trees, coral mining, overuse of a single resource? (This can be assessed if a reduction of numbers is noted in Step 4.)
- Is there habitat destruction? Is there clear-felling, filling of wetlands, land reclamation, road and infrastructure building or any other alternative use?
- Are invasive alien species spreading?
- Is there pollution? Has solid waste accumulated? Is there water pollution: foul smell, foaming, eutrophication?

[2] Species richness is the number of different species in a habitat.
[3] Species abundance is the number of individuals of each species.

c) Socio-economic Assessment (Livelihoods and Economics):

Step 7: Assess household benefits from ecosystem services.

- Does the household benefit from any provisioning services? If so, which and for what purposes?
- Does the household benefit from any supporting services? If so, which?
- Does the household benefit from any regulating services? If so, which?
- Does the household benefit from any cultural services? If so, which?

Step 8: Identify livelihood dependence on provisioning services.

- For provisioning services, list how much of the household cash and non-cash income is obtained from natural resources as part of their whole income.
- From where do households get the cash and non-cash income that is not obtained from the provisioning services of ecosystems (what are the other livelihoods)?
- What is the proportion of cash and non-cash income from provisioning services to cash and non-cash income from livelihoods not related to natural resources?
- For provisioning services, list how much (what percentage) of natural resources are used by the household and how much (what percentage) is proportion is sold/traded.
- Is there seasonal variation in provisioning services during the year? If so, when?

Step 9: Assess the impacts from ecosystem loss on human well-being.

- What are the impacts of ecosystem losses on the livelihood of dependent households/individuals/ communities?
- Would the safety (food security, adequate and safe water supply, protection from extreme weather events etc) of households/individuals be affected by ecosystem loss?
- Would the health of their households be affected negatively by ecosystem loss (through loss of provisioning/supporting/regulating services)?
- Would the social relations of their households suffer with ecosystem loss? (i.e., reduce time allocated for community common work, initiate/increase conflict with each other for resource extraction etc)?
- Would their freedom of choice and action be reduced with ecosystem loss?
- Would their household lose basic materials for good life with ecosystem loss?
- Will government expenditure on social welfare and security increase due to loss of environmental services?

Step 10: Ensure that gender sensitivity is mainstreamed into the above steps, as relevant.

- For example, traditionally, it is women who collect fuelwood and women who collect water. Therefore, they are likely to know best about use, quantities and quality.

Once integrated assessments have been carried out, mapped assets have to be ranked. Ranking, however, is country-specific exercise, although three general criteria may be used a) uses and economic value, b) uniqueness, and c) pre-existing threats.

The following questions may be asked based on the above criteria:

1. Which species/ecosystem has the most number of uses?
2. Which species/ecosystem is the most economically valuable?
3. Which species/ecosystem is the most over-exploited?
4. Which is the greatest threat to ecosystem services?
5. Which is the ecosystem service that impacts the most number of people?
6. Which sector of the community is most affected by the above?

- Assets which serve a greater number of uses and produce economic value may be assigned a higher importance rank than those which serve less uses and produce less economic value.
- Unique assets are more important than those which are more common (and hence easier to replace). the post-disaster scenario than those which were not under threat.
- After this, policy and legislation protecting ecosystems and services become important. Both local legislation and international treaties have impacts on the conservation of the natural environment.

The next phase in prevention is risk analysis and hazard mapping.

Hazard Mapping Assessment

Hazard maps show where a natural hazard is likely to occur. They also map the intensity of occurrence.

Most often hazard mapping is defined as 'the process of establishing geographically where and to what extent particular phenomena are likely to pose a threat to people, property, infrastructure, and economic activities' (Coburn et al., 1994). However, this omits the integral need to assess threats to ecosystems as well.

Therefore, with the integration of environmental issues into disaster management, this definition should read to mean that hazard mapping is the process that establishes where and to what extent a natural hazard is likely to pose a threat to humans, biodiversity, property and infrastructure (both natural - ecosystems and man-made), to livelihoods and economic activities.

The following questions need to be asked

- What: what kind of hazard occurs? For example, a heavy rain causes a flood, a landslide or a debris flow.
- Where: where does the hazard occur? For example, tidal surges affect coastal areas; landslides are more common on hill slopes. Which ecosystems are affected?
- How large is the scale of the hazard?
- How intense is it? For example, there is a heavy rain of 500mm in one day, or lava flow of $300,000m^3$.
- How does the phenomenon develop or spread? Is it rapid, slow onset or cyclic?
- When does it occur or when is it likely to occur?
- What is the frequency or probability of occurrence? For example, there is a heavy rain that occurs once for 30 years, or a great volcanic eruption that occurs once for 200 years.
- Who suffers from a disaster?
- How high is the grade of disaster?
- How many deaths, building damage or collapse?
- How much is the total loss?

Using spatial information to plan for disaster management:

Disasters have a spatial nature and hence, the use of geographical data at various points in the disaster management cycle can serve as a powerful tool for more effective and efficient planning and response at various points in the disaster management cycle.

Management of spatial information used in disaster management is carried out through a Geo-Spatial Information System (GIS), which is a collection of computer hardware, software, and geographic data for capturing, managing, analysing, and displaying all forms of geographically referenced information. There are various kinds of spatial data used to increase disaster risk understanding including various types of multilayered geographically referenced information such as aerial photographs, satellite imagery and digital maps (R. Roberts, personal communication).

Spatial data can be used in a GIS to produce visual displays of hazard risk and vulnerability to facilitate planning to reduce the impacts of disasters on humans and infrastructure. Hazard maps can also show where major public works, roads, hospitals, schools and other major infrastructure are situated to reduce the degree of risk. In newly developing areas, hazard maps can be crucial in ensuring that key infrastructure, human settlements and tourism facilities are located out of high risk zones. In already developed areas, while complete avoidance of hazardous areas may not be possible, hazard maps can be very useful in planning for evacuation and for employing different or additional design standards for structures to ensure that they can withstand shocks or to ensure that only non-critical components are lost to such hazards. GIS can be used also to identify ecologically sensitive areas.

Hazard maps can be also very important in identifying the sources and causes of hazards at a location that increase the degree of potential damage from various types of disasters. For instance, using a simple GIS model, land cover maps, overlaid with risk and topography maps can be used to identify and further test linkages between vegetation cover and flood or storm surge risk in disaster prone areas. More complex GIS applications can provide an important analysis for instance, of the increased landslide or flood threat as a result of the construction of a highway into a fragile hilly environment.

Models can be used to evaluate future aspects of disaster risk, for example for a set of land-use planning scenarios towards developing a prior understanding of the potential risks and for arriving at the best possible alternatives, within the given constraints. These can be prepared based on the historic data of any past similar events and modeling for the dispersion of disaster impacts. Such an analysis can be coupled with information on the changes in demographics and socio-economic profiles of a region - such as population concentration, degree of poverty, land-use, wild-life attributes - to identify clearly and demonstrate the linkages between ecological damage and worsening of the impacts of natural disasters.

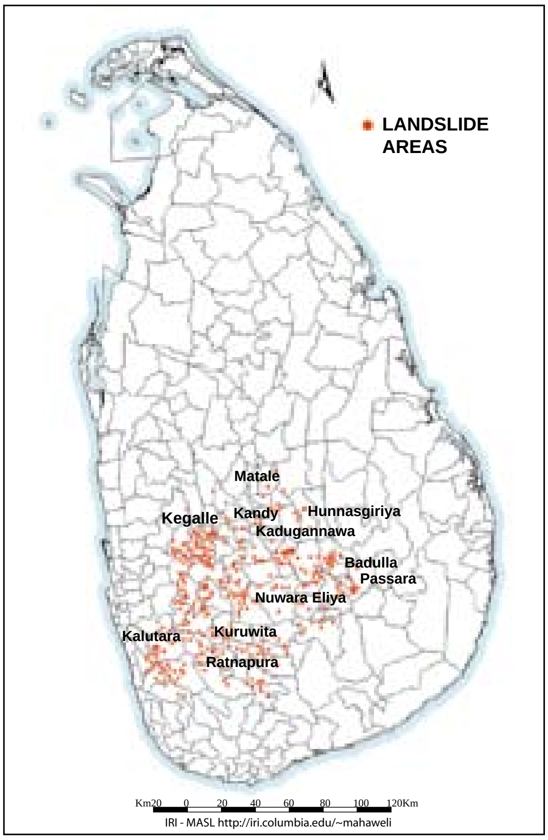
In the aftermath of a disaster, spatial information is very useful in damage assessment to provide information for rehabilitation and construction. Economic evaluation can be carried out to assess the percentage damage or cleaning/reconstruction cost; pollution/contamination concentration ranges, especially in the case of damaged sewage works or industrial complexes. Following a disaster, the results of such models could also provide information towards the analysis of long-term impacts of disasters, such as impacts on wildlife or fish stocks that would, in turn, impact the tourism and fisheries sectors, and thereby, the capacity and amount of time required by local communities to recover from a disaster (R. Roberts, personal communication).

Evacuation analysis

During the disaster phase, GIS can be used to support emergency response in the provision of timely and appropriate humanitarian assistance to save lives and protect livelihoods of the poor and vulnerable households against shocks and food emergencies. For instance, a catastrophic spatial model can be used for a region to: identify a) the exact geographical location; b) which population groups are affected and how many people may be in the area; c) the duration of the intervention; d) store emergency management-related departments' locations; e) provide online systems for tracking and communication of the hazard and damage spread; f) identify natural resources and critical infrastructure at risk; and g) mobilise available resources for response (R. Roberts, personal communication).

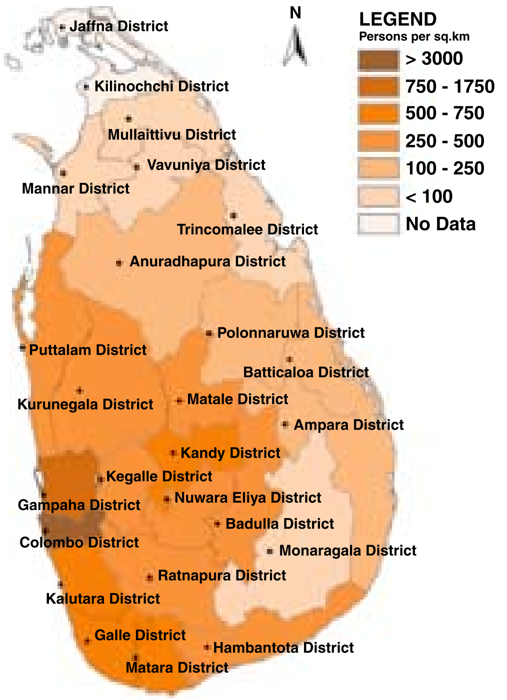
Using the above data, it is possible to generate a hazard map using basic GIS technology as shown below. The data used were landslide incidence in Sri Lanka (Figure 7a).

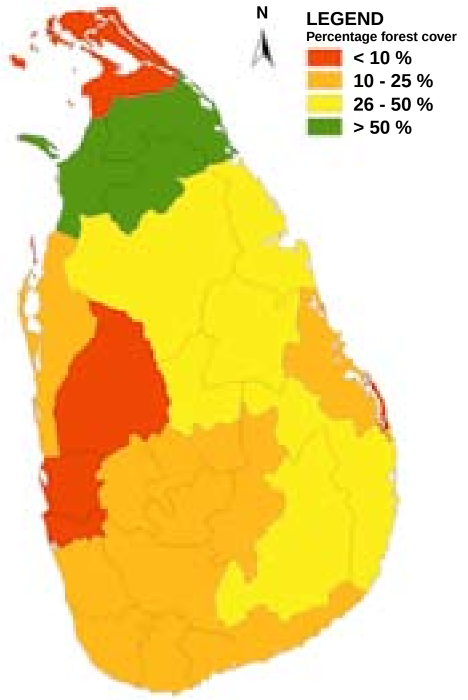
Figure 7: a) Landslide incidence in Sri Lanka (Source: Zubair & Ralapanawe 2008)



Next, a vulnerability map is needed. Population density, industrial regions, concentration of economic activities, livelihoods, infrastructure (ecosystems and man-made), income levels etc. all indicate vulnerability. Presented below are maps of human population density and the forest cover of Sri Lanka - the latter, important natural infrastructure.

Figure 7: b) Population density in Sri Lanka (Source: Zubair & Ralapanawe 2008), c) Forest cover in Sri Lanka (Source: Data sourced from IUCN and MENR, 2007, map compiled by Eric Wikramanayake, 2008)





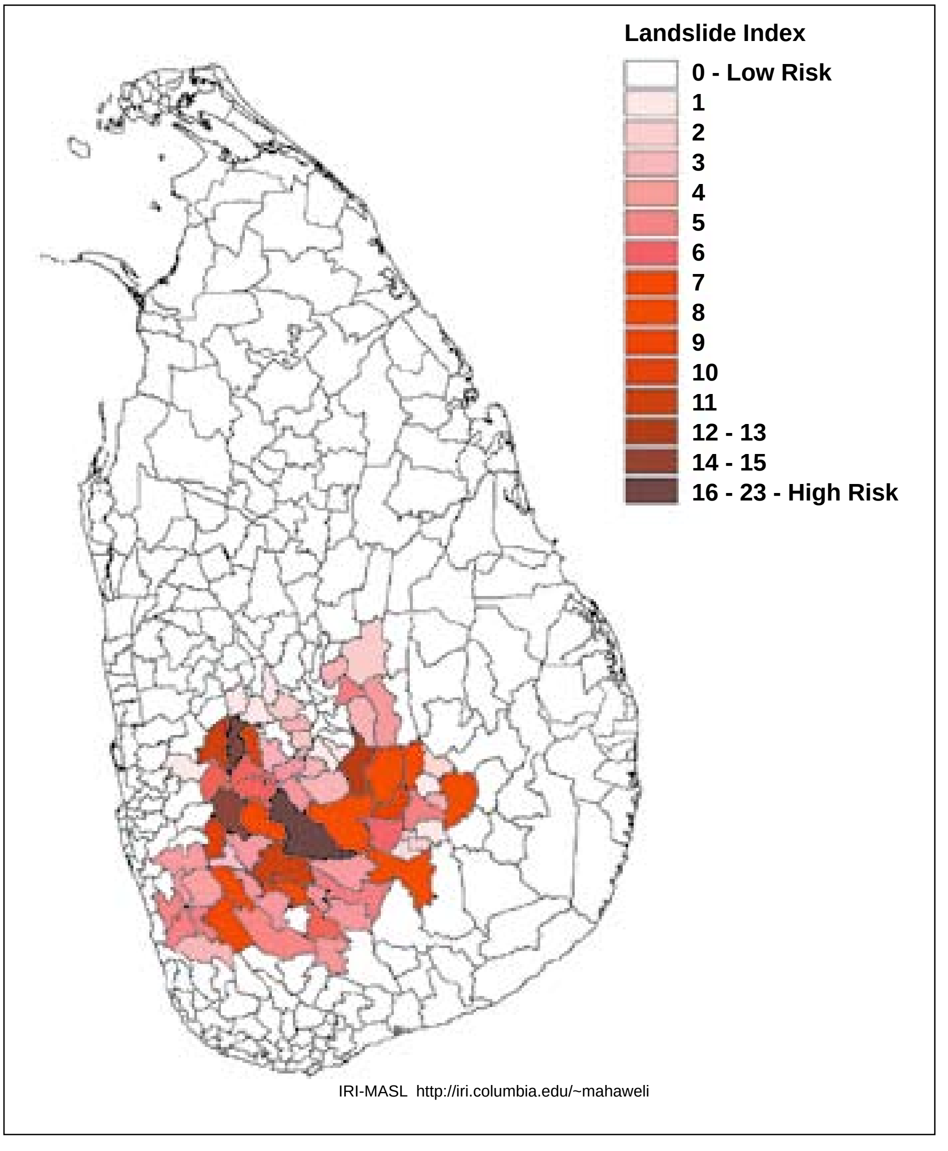
Risk analysis

Risk analysis is ‘the systematic use of available information to determine how often specified events may occur and the magnitude of their consequences’ (www.riskmanagement.qld.gov.au/info/guide/gls.htm). Again, this is a huge topic which is used for a range of topics, from assessing risk for car and other insurance to analysing risk in business ventures and disaster risk management.

Simply stated, risk analysis estimates the likelihood of a hazard occurring.

The simplest way of analysing risk using GIS technology would be to overlay the hazard map over the vulnerability map to generate a risk map. An overlay of Figure 7a and b will generate a map similar to the one presented below, which shows landslide risk in Sri Lanka.

Figure 8: Landslide risk map of Sri Lanka (Source: Zubair & Ralapanawe 2008)

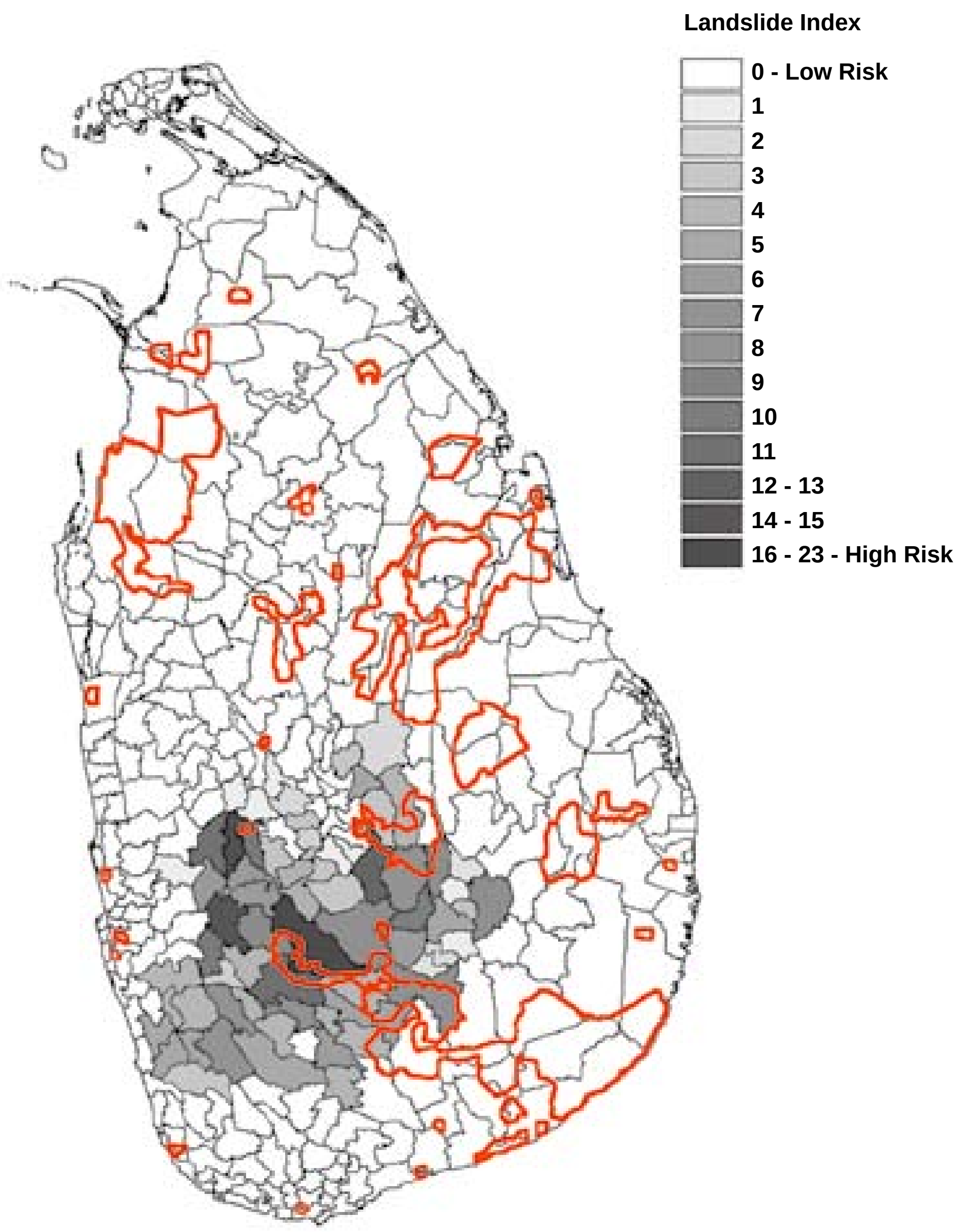


The International Research Institute for Climate and Society (IRI) is engaged currently in identifying global natural disaster risk hotspots in Sri Lanka. It is examining water resource management, climate predictions, flood, drought and landslide to map and identify high risk areas. Through extensive literature surveys and research, high resolution hazard maps, vulnerability maps (based also on previously published work), and risk maps are being generated with the intention of sharing these data with relevant disaster management agencies in Sri Lanka (http://iri.columbia.edu/~mahaweli/disaster/concept.html).

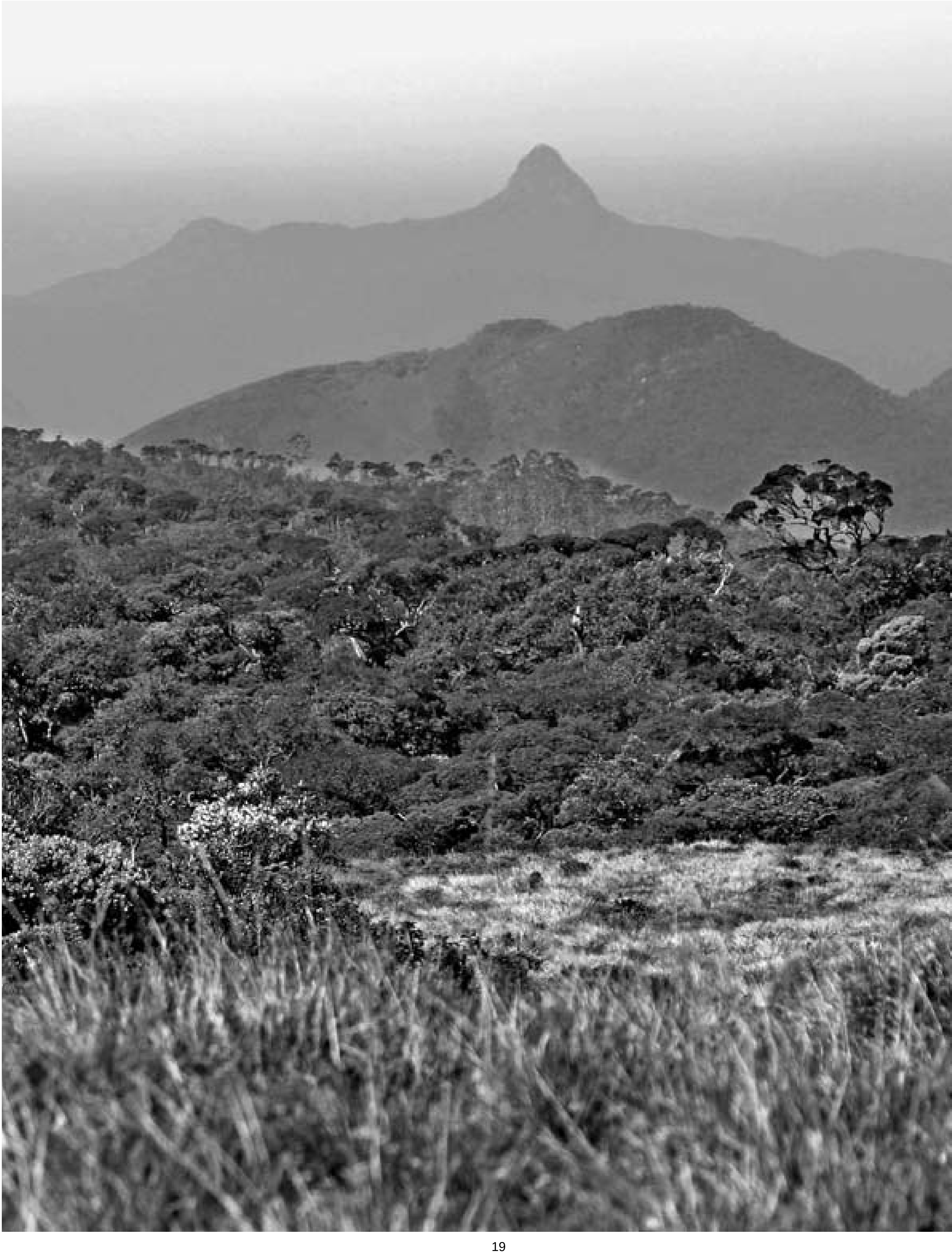
IUCN defines a protected area an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.(http://www.unep-wcmc.org/protected_areas/ categories/ index.html). Protected areas are extremely important in mitigating the effects of disasters.

Overlaying protected areas over risk maps clearly reveal their importance.

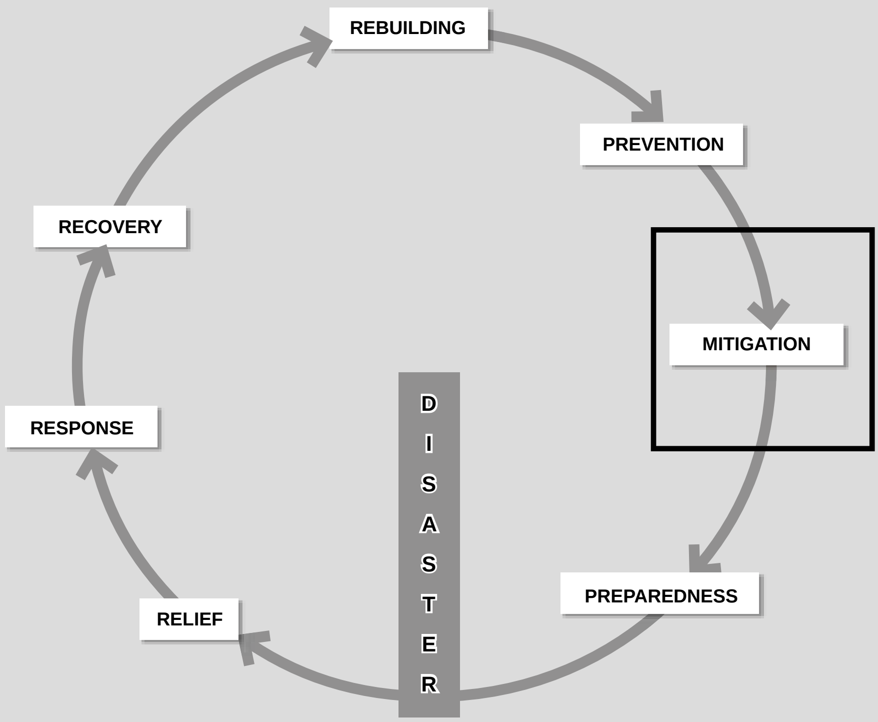
The map below shows a landslide risk map of Sri Lanka (the darkest shades are the high risk areas) overlaid with the larger protected areas under the jurisdiction of the Department of Wildlife Conservation. This map shows how critical protected areas are in areas of high landslide risk, because of their services of flood attenuation.



Source of base map: Zubair & Ralapanawe 2008.
Source of protected areas: Department of Wildlife Conservation, Sri Lanka)



Pre-disaster management: Mitigation



Mitigation reduces risk from natural disasters. Zoning and proper land use management – for example, building with a set-back on a coastline or leaving intact stands of mangroves and public education are examples of mitigation.

Prevention - although the ideal for management - can be achieved rarely in a real-life situation. Mitigation strives to reduce risk from natural disasters. The mitigation phase, like rebuilding, is different from other phases because it focuses on long-term measures for reducing risk.

Much of the measures that are taken during mitigation are also the same measures that are taken during rebuilding and therefore, there is overlap in the steps to be followed.

Mitigation can be categorised into structural and non structural actions.

Structural mitigation:

Building infrastructure that has design standards to withstand earthquakes in earthquake prone areas, floods in flood prone areas, tropical cyclones in cyclone prone areas and so on are examples of structural mitigation.

In all these actions, it is necessary to assess continually the impacts on species and ecosystem services, in order to minimise impacts on human well-being.

In the process of structural building to mitigate the effects of hazards these steps should be followed. All these steps prevent or reduce damage to natural ecosystems and therefore, their different ecosystem services. These services, in turn, all affect human well-being.

Step 1: Ensure that there is no over-exploitation of species.

- For example, is timber use sustainable? Or is it being obtained from unmanaged forests/protected areas?

Step 2: Minimise habitat change.

- Check whether sensitive areas (identified in the previous chapter) are being cleared for buildings.
- Check whether coastal/river morphology is being changed by built infrastructure.

Step 3: Minimise pollution.

- Check whether the area is being polluted by the process.
- Check whether there is collection of non-biodegradable solid waste.
- Check how solid waste is being collected and disposed.
- Check whether an effort is being made to reduce, reuse and recycle waste.
- Check whether the air is being polluted by the process.
- Check whether air pollution control measures are in place.
- Check whether the water around is being polluted by the process.

Step 4: Prevent the spread of invasive alien species.

- Ensure that the spread of invasive alien species is not increased. (Building equipment is known to be a mechanism through which IAS spread.)

Step 5: Ensure that measures are taken to mitigate the impacts of and adapt to climate change.

- Ensure that energy conservation measures are being adopted. For example, is there through-flow ventilation in hot climates? Are energy saving bulbs and alternate energy sources - such as solar power - being used where ever possible?
- Ensure that water conservation measures are being adopted.
- Ensure that waste water is managed hygienically. Are toilets being built at safe distances from drinking water sources?
- Ensure that environmentally-friendly materials are used as much as possible.
- Ensure that efforts are made to replant and landscape during structural changes.

Non Structural mitigation:

Non structural mitigation includes policy, legislation, insurance and awareness.

Policies that integrate environmental concerns into development and include building and zoning codes are essential.

In some countries, new legislation may need to be enacted, but in others, it is important that existing environmental legislation is followed.

It is important to know the following

- Know *what* you may build.
- Know *where* you may build.
- Know which activities *are prohibited* where you propose to build.
- Know which activities *require a permit* and from which government department.
- Know which activities may be conducted *without a permit.*

The box on the opposite page show laws related to coastal reconstruction in Sri Lanka. The large number of the relevant laws exemplifies why disaster management is so complex, and reinforces the need for a holistic approach and integrated assessments.

Laws relevant to reconstruction in Sri Lanka

- Agrarian Development Act No. 46 of 2000 Section 32 of this Act prohibits the conversion of paddy land for a purpose other than agricultural cultivation without the written permission of the Commissioner General shall be a punishable offence under this Act.
- Antiquities Ordinance No. 9 of 1940 as amended provides for the Director General of Archaeology to declare certain areas as Archaeological Reserves. Encroachment of any kind, for whatever purpose is deemed an offence under Section 34 of the Ordinance.
- Antiquities (Amendment) Act No. 24 of 1998 Section 40 (g) empowers the Director General of Archaeology to conduct an Archaeological Impact Assessment of areas that may be affected by development, industrial or other projects proposed by the Government or any person and implement any mitigatory measures that may be required. Sections 43 (A) and 43 (B) govern the Impact Assessment Procedure to be complied with in the event the Director General deems it necessary.
- Coast Conservation Act No. 57 of 1981 (CCA) as amended (Section 42 of the CCA) defines the coastal zone.
- Coast Conservation Act No. 57 of 1981 (CCA) as amended (Section 14 of the CCA) lists activities that are prescribed within the coastal zone.
- Coast Conservation Regulation No. 1 of 1982 as set out in Gazette Notification No. 260/ 22 – 1983 sets out in details the regulations pertaining to development activities that are permitted and prohibited.
- Common Law of Sri Lanka.
- Customary Laws of Sri Lanka.
- Criminal Procedure Code No 15 of 1979 Section 98 in concurrence with Section 261 of the Penal Code further elaborates on Public Nuisance.
- Fauna & Flora Protection Ordinance No. 2 of 1937 as amended, (FFPO) specifies the areas under the jurisdiction of the Department of Wildlife Conservation in which no construction or developmental activities can occur.
- Fauna & Flora Protection Ordinance No. 2 of 1937 as amended, (FFPO) specifies the areas under the jurisdiction of the Department of Wildlife Conservation in which a permit is required from the Director of Wildlife Conservation for construction or developmental activities can occur.
- Fauna & Flora Protection Ordinance No. 2 of 1937 as amended, (FFPO) specifies activities which are prohibited within national, reserves, sanctuaries and buffer zones as well as fauna and flora that are protected nationally.
- Forests Ordinance No. 16 of 1907 as amended specifies the areas and activities prohibited in designated forest areas. The felling of tress, cultivation and the construction of buildings and roads are prohibited activities together with poaching, cattle grazing etc.
- Fisheries and Aquatic Resources Act No. 2 of 1996 Section 36 specifies areas that are demarcated and protected as Fishery Reserves. Any development activity in a fishery reserve requires the permission and approval of the Director of Fisheries and Aquatic Resources.
- Land Acquisition Act No. 9 of 1950 as amended should be complied with when considering land use and allocation.
- Land Development Ordinance No. 19 of 1935 as amended should be complied with when considering land use and allocation.
- Land Grants (Special Provisions) Act No. 43 of 1979 as amended should be complied with when considering land use and allocation.
- Land Settlement Ordinance No. 20 of 1931 as amended should be complied with when considering land use and allocation.
- Marine Pollution Prevention Act No. 59 of 1981 authorises the Marine Pollution Prevention Authority (MPPA) to implement and take necessary steps to prevent Marine Pollution.
- Municipal Councils Ordinance No. 29 of 1947 should be complied with when considering land use and allocation.
- National Environmental Act No. 47 of 1980 as amended, Gazette No. 772/ 22 – 1993 sets out in detail the projects and undertakings for which approval is required and Environmental Impact Assessments necessary, whether they be wholly or partly outside the Coastal Zone as defined by the CCA.
- National Environmental Act No. 47 of 1980 as amended. Section 33 defines pollution and waste.
- National Heritage Wilderness Act, No 3 of 1988 defines areas of exceptional ecological value that need protection.
- National Housing Development Authority Act No. 17 of 1979 as amended empowers the National Housing Development Authority it in terms of Section 4 of the Act to engage in all housing and construction issues at a National level and its powers and functions are more specifically set out in Section 5 of the Act.
- Nuisance Ordinance enacted in 1862 with provisions to protect pollution and public nuisance.
- Penal Code enacted in 1880 Section 261 provides for environmental protection where any person/ s is prohibited from causing public nuisance such as noise, odour, and other irritant that causes harassment to society.
- Pradeshiya Sabha Act No. 15 of 1987 should be complied with when considering land use and allocation.
- Acquisition of Land Act No. 33 of 1950 as amended should be complied with when considering land use and allocation.
- State Lands Ordinance No. 8 of 1947 as amended should be complied with when considering land use and allocation.
- State Lands (Recovery and Possession) Act No. 7 of 1979 as amended should be complied with when considering land use and allocation.
- Urban Development Authority Law No 41 of 1978 as amended. The area lying within the limits of one kilometre (1 km) landwards of the Mean High Water line of the sea is suitable for development and by order of the Government of Sri Lanka declared to be an Urban Development Area.
- Urban Development Authority Law No 41 of 1978 as amended promotes integrated planning and implementation of economic, social and physical development in areas declared as urban development areas, all development activity within the said areas as set out in Section 8 of the UDA Law shall fall within the purview of the UDA.
- Urban Councils Ordinance No. 61 of 1939 as amended should be complied with when considering land use and allocation.
- Urban Development Authority Planning and Building Regulations 1986 as set out in Gazette No. 392/ 9 sets out the regulations covering any development activity, including reconstruction and rebuilding within the area demarcated as falling within One kilometre landwards from the Mean High Water line as set out in Gazette No. 223/ 16 – 1982 as mentioned more specifically above.

(Source: EFL 2005, in IUCN 2005)

It is also important to know which international treaties have been ratified by a respective country and to follow these.

For non-structural mitigation, the following steps need to be followed.

Step 1: Enforce strictly design standards and building codes.

Step 2: Enforce strictly zoning legislation.

- Is zoning legislation that steers development away from ecologically sensitive areas being adopted?
- Is zoning legislation that steers development away from hazard prone areas obtained from hazard mapping or areas subject to flooding, storm surge or coastal erosion being adopted?
- Have set backs that have been legislated been maintained? This is particularly relevant for coastal areas.

Step 3: Enforce strictly existing laws and policies related to environmental management.

- Are existing laws and policies that relate to environmental management and protection being followed?
- Is clearance of natural habitats such as mangroves, scrubland and forests being avoided?
- Is building on/filling lowland wetlands and watershed areas being avoided?
- Is destruction by clearing only for the essential, minimal area per building?
- Is it being ensured that natural water courses, watershed areas, flood plains etc. are not blocked by construction?

Step 4: Actively restore and conserve ecosystems.

- Are efforts being made to restore and conserve ecosystems as part of the reconstruction process?
- Are Environmental Impact Assessments required?
- Have native species been chosen actively in place of exotics?
- Are IAS being eradicated actively and prevented from spreading?
- Are multi-use, locally beneficial species being introduced?
- Are mono-cultures being avoided?

Mitigation related to Climate Change

The term mitigation in relation to climate change has a different, distinct meaning. *Mitigation in climate change relates specifically to reduction in carbon emissions.* Stringent energy saving measures, improving energy supplies, optimising equipment to work at 100% efficiency - all reduce the quantity of CO_2 emitted. Hydropower, wind and solar power emit no CO_2 and are, therefore, *carbon clean*.

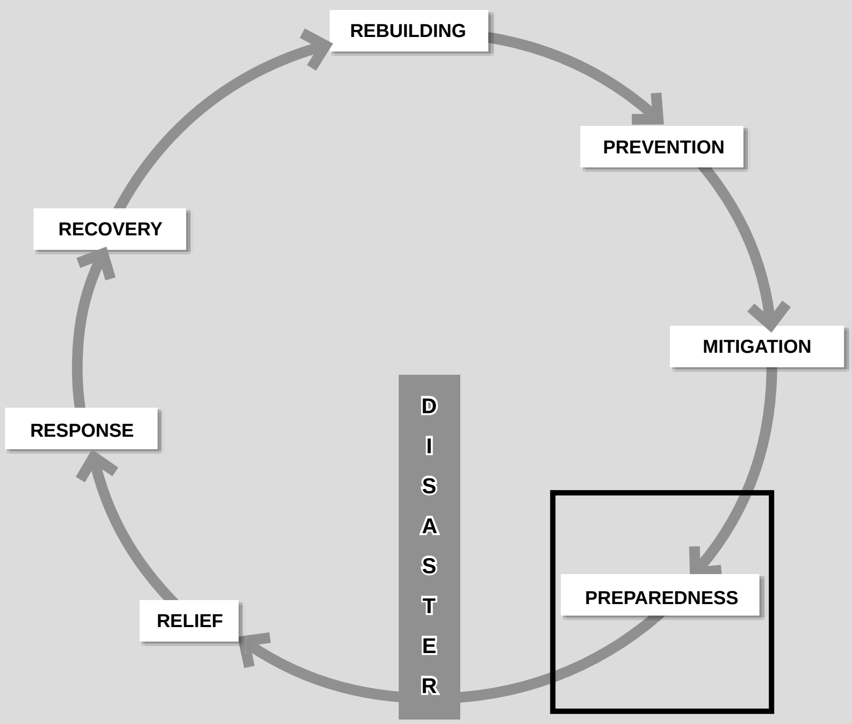
Another option is to use *carbon neutral* energy such as dendro power (energy generated by burning plants grown for the purpose) and bio-fuels (fuels obtained from plants, animals and their by-products: manure, garden waste and crop residues). In carbon neutral energy processes, plants absorb the same amount of CO_2 that is emitted into the air on burning. However, the increase in the use of carbon neutral energy has given rise to considerable debate and conflict. Deforestation to grow monocultures of energy generating crops and competition for land use between agricultural and energy crops negates the advantages of growing crops to generate bio-fuels.

It is also important to ensure that there is reduction of carbon emissions when mitigation is practised in disaster management.

- Are energy conservation measures in place?
- Is carbon clean energy (hydropower, wind and solar power) being used as possible options for energy?
- Is carbon neutral energy (dendro power) being used judiciously as possible options for energy?
- Are carbon offsets being established - i.e. is there a definite effort to replant and reforest particularly if trees have been cut down?

The number of vehicles in Asia doubles every five to seven years, increasing by three times by 2030 the energy consumption in the transport sector. Alternate fuel and higher efficiencies that generate simultaneously local and global benefits (i.e., reducing congestion as well as air pollution) are essential in the region. The Asian Development Bank is working in 11 Asian cities (including Changzhou and Harbin in China; Colombo, Sri Lanka; Dhaka, Bangladesh; and Kathmandu, Nepal) on pilot urban transport projects to address this (ADB, 2007).

Pre-disaster management: Preparedness



Preparedness aims to reduce - to the minimum level possible - the loss of human lives, damage to built and natural infrastructure, through the prompt and efficient actions to response and rehabilitation. Effective preparedness allows communities and institutions to provide a quick, organised response to disasters and include early warning systems, planned evacuation routes and sites etc.

Preparing for a disaster involves a long process of planning what the response should be to a natural disaster. Understanding what hazards are, what the risks are, setting up early warning systems – i.e., becoming informed - is the first step. Information and decisions made under the Prevention and Mitigation phases will form the basis on which the Preparation phase is planned.

Planning for an emergency – how you would respond (i.e., what are the early warning systems), when and with whom, preparing emergency checklists, assembling emergency kits are the next steps in preparedness. Knowing where to evacuate to is the final stage in preparedness. It is not within the purview of this manual to detail these areas and there are many other manuals that describe them (http://secap480.un.org/search?q=early+warning+systems&Submit=Search&ie=utf8&site=un_org&output=xml_no_dtd&client=UN_Website_English&num=10&proxystylesheet=UN_Website_English&oe=utf8; http://www.redcross.org/).

In all these steps, again, it is vital that environmental concerns are incorporated; otherwise, much damage can be inflicted in the next, Response phase.

There is overlap in the steps that are taken at this stage and at the prevention phase, but specifically, the following steps should be followed.

Step 1: Identify clearly where temporary shelters will be put up in the event of a natural disaster.

- Ensure that environmentally sensitive areas are not cleared in the event of a disaster.
- Ensure that protected areas are not encroached up in the event of a disaster.
- Ensure that coastal morphology is not changed when temporary shelters are set up in the event of a disaster.

Step 2: Identify the sources from which natural resources such as timber and fuelwood will be obtained in the event of a disaster.

- Ensure that timber is not sourced illegally but instead, obtained from sustainably managed forests.
- Ensure that fuelwood will not be obtained illegally from protected areas.

Step 3: Identify locations at which sanitation facilities will be built/put up in the event of a disaster.

- Will toilets be built at safe distances from drinking water sources?
- Will toilets be built without contaminating ground water or water sources such as streams and rivers?
- How will waste water be managed in the event of a disaster?

Step 4: Identify locations at which solid waste will be disposed of in the event of a disaster – both from post disaster debris and from shelters.

- Ensure that locations are identified for use in the event of a disaster for the safe dumping of solid waste.
- Know where hazardous materials can be disposed of in the event of a disaster.

Step 5: Ensure that emergency kits minimise disposable waste.

Step 6: Ensure that gender sensitivity is incorporated into all the above steps.

Climate Change

As detailed in Volume 1, climate change is increasing the frequency and intensity of natural disasters. Dealing with climate change, therefore, becomes an integral part of disaster management. Dealing with climate change involves two approaches: the first is climate change *mitigation* - the reduction of carbon emissions - dealt with under the previous phase.

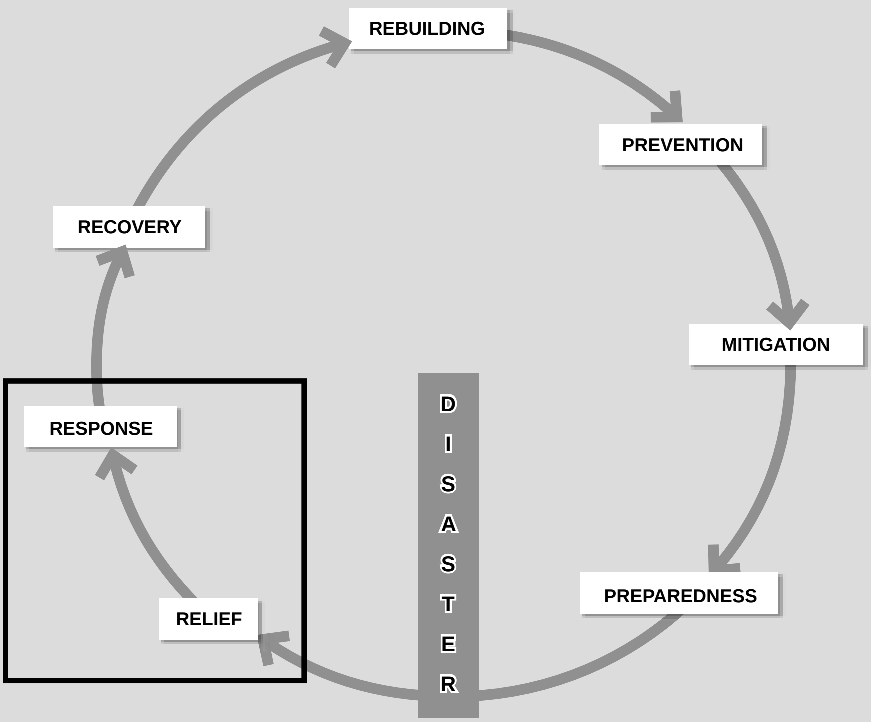
However, climate change mitigation alone will not be enough. Even if green house gas emissions are reduced drastically, the current effects of climate change will be felt for several decades more. It will also take 20-30 years for carbon offsets to become effective, as trees have to grow and mature. Therefore, a second strategy for dealing with climate change – *adaptation* – also becomes essential. Simply stated, adaptation is accepting that climate change - and natural disasters - will occur, and preparing for them. At a local level, the single most important response to climate change is adaptation.

Anticipating climate change, planning in advance to minimise damage from an extreme weather event and responding to it in a pre-planned manner that minimises risk is critical. Adaptation also entails using innovative agricultural methods – such as selecting different crops that absorb more carbon. Collecting rain water in a drought-prone area is another adaptation to climate change; installing proper insulation in buildings, designing/constructing building infrastructure that is disaster resistant are others methods of adaptation.

It is, therefore, essential to ensure that measures are taken to integrate adaptation measures in disaster management.

- Are water conservation measures in place? For example, are rainwater collection tanks built in dry areas?
- Are innovative agricultural methods being used? For example, in Bangladesh, farmers have learned to make floating beds out of an invasive alien plant and they grow vegetable and herb crops on these floating beds during the monsoons, when regular plating areas become flooded.
- Are traditional methods of agriculture - crop rotation, leaving land to fallow - being practised?
- Are building designs suited to local climates: i.e., in hot climates, is there proper ventilation and through-flow?
- Are buildings constructed with appropriate climate-proofing in mind? For example, in flood prone areas, are houses built on raised platforms and in earthquake areas, are they built with reinforcements to withstand minor earthquakes?
- When houses are painted, are appropriate colours - such as light colours to reflect the heat in hot climates - used?
- Is landscaping used as a means to provide natural shade and cooling in hot climates?

Post-disaster management: Relief and Response



Relief and Response are the collective actions carried out immediately after a disaster with the objective to save lives, alleviate suffering and reduce economic losses. For example, relief includes getting people to safe locations, provision of food and clothing etc.

The Relief/Response phase is the period during which saving human lives, alleviating suffering and reducing economic loss take priority. During this phase, emergency needs, water supplies and sanitation, food aid, setting up shelters, health needs must be supplied in the shortest possible time.

Environmental issues are never considered during this phase. Barring rapid environmental assessments that are carried out in the aftermath of a disaster, at best, the role of biologists is minimal; at worst, non-existent during this period. At this stage, environmental concerns are seen as an unwanted luxury. This view is held even by many biologists concerned with environmental issues.

However, it can not be over-emphasised that during this phase, much environmental damage can be caused, endangering the sustainability of recovery and, in turn, rebuilding. During this phase, there can be a great deal of over-exploitation (for example, of timber) and much habitat destruction (for example, clear-felling forests to make temporary shelters) because the immediate goal is to get roofs over people's heads, at whatever cost. Also during this phase, the rush to get food and other emergency supplies also results in much environmental damage. Often, these supplies have to be packed in non-degradable packing such as plastic. Irresponsible disposal of large quantities of such waste can create enormous ecological and health problems. Debris created by the hazard is often cleared into ecologically sensitive habitats - such as lagoons and wetlands - that sustain livelihoods, or protected areas - that provide other ecosystem services - causing further damage.

Again, the cyclic nature of disaster management is exemplified clearly in actions that are carried out under this phase. If pre-disaster management has been effective in incorporating environmental safeguards, then damage during this phase will be minimised. If pre-disaster management has included integrated assessments and integrated planning, then biologists will be included to assist in this phase.

As mentioned before, it is during this phase that the cyclic nature of disaster management becomes very clear. Without Prevention (i.e., without mapping and valuing assets, without identifying resource use, dependency and livelihoods) it is not possible for Mitigation and Preparedness to be effective. Without Mitigation and Preparedness (i.e., without clear, empirically and analytically derived policies) the Relief/Response phase can cause great environmental damage, leading to settlements that are unsustainable in the long term and cause great damage in the short term.

For example, if environmentally sensitive areas have been identified in the Prevention stage and zoned for no building in the Mitigation phase, then during the Preparedness phase, alternative areas will be identified for putting up shelters in the Relief/Response phase.

The following steps should be followed in the Response phase.

Step 1: Avoid over-exploitation of natural products.

- Ensure that fuelwood and timber are obtained according to plans set during the Preparedness phase.
- Ensure that natural resource extraction for shelter and food is carried out according to existing legislation.

Step 2: Avoid unplanned habitat change.

- Put up shelters only in areas that have been identified for the purpose.
- Avoid clearing natural habitats if they have not been identified for clearance in the Prevention phase.

Step 3: Minimise solid waste pollution.

- Dispose of solid waste at locations identified in the previous phase.
- Start a process of separating degradable from non-degradable waste and recyclable and reusable waste.
- Ensure that incineration is not used as a method of waste disposal, as this contributes to global warming and air pollution.
- Actively train persons at shelters to dispose of waste responsibly.

Step 4: Minimise water pollution.

- Build toilets only in locations identified in the Preparedness phase.
- Manage waste water only in the manner identified in the previous phase.

In the Asian region, debris management and waste disposal after natural disasters has been a significant weakness during the Relief/Response phase.

After the tsunami of December 2004:

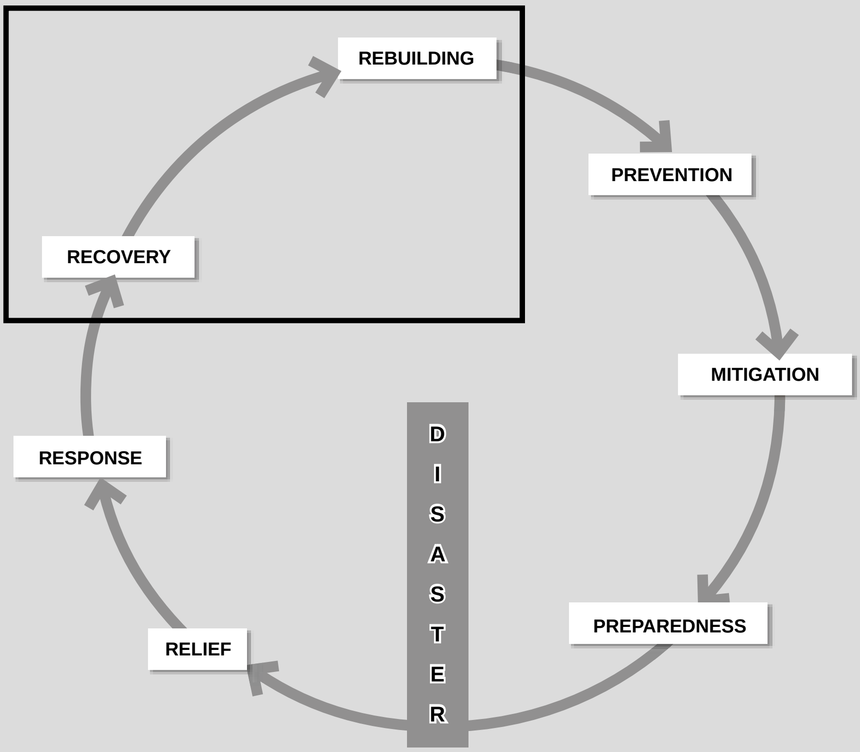
- ‘In the city of Banda Aceh alone, it was estimated that 7-10m^3 of waste was generated. When the tsunami hit, the domestic waste was first carried inland, some was then washed back, while some was mixed with debris. Routine collection of municipal solid waste was hampered after the tsunami by the loss of landfill sites, equipment and staff. In any case, landfill sites were not run according to internationally accepted standards before the disaster.

- The extent of debris created in Sri Lanka as a result of the tsunami was enormous – estimated at some 500+ million kilograms of rubble. The disposal of this waste proved to be a huge problem in terms of volume and costs. Emergency efforts resulted in haphazard disposal of debris along roads, playgrounds and sensitive ecosystems. Previously identified landfills were not available in each district at the time of the disaster. Irresponsible waste disposal from resettlements after the Indian Ocean tsunami in southern Sri Lanka has led to the formation of large garbage dumps. Dumps in some settlements sited in migratory pathways of elephants attract wildlife – even elephants. The non-degradable waste such as plastic can pose a threat to such animals.

- In the Maldives, it is estimated that the tsunami created approximately 290,000m^3 of debris, which contaminated groundwater supplies and the coastal environment. Efforts to clean up the debris after the tsunami did not improve conditions, and in some cases, worsened them.

- In Somalia, the debris contained a mix of hazardous materials and non-toxic waste. Rapid clean-up efforts resulted in inappropriate disposal, such as open dumping of asbestos, open-air burning. It is reported that Somalia’s coastline has long been used as a dumping ground for other countries’ nuclear and hazardous wastes. The impact of the tsunami stirred up this hazardous waste, causing health and environmental problems to the surrounding local fishing communities. Many people in Somalia’s tsunami affected areas complained about unexpected health problems such as acute respiratory infections, mouth bleeds and skin conditions’ (UNEP, 2005).

Post-disaster management: Recovery and Rebuilding



Recovery is the activity that returns humans and built infrastructure to minimum living/operating standards and guides long-term efforts designed to return life to normal levels after a disaster. This includes building temporary housing and provision of basic household amenities.

Rebuilding is the long term response to a disaster. In this phase, permanent infrastructure is rebuilt, ecosystems are restored and livelihoods are rehabilitated.

Recovery deals with short term responses and Rebuilding, with long term responses. In the short term, temporary housing sites, temporary housing material, arranging for safe removal of debris, decontamination of water etc. are needed.

In the long term, permanent solutions for housing and sanitation, as well as the basic amenities of life are needed.

In both these phases, it is essential to keep in mind the five major drivers of ecosystem loss: over-exploitation, invasive alien species, habitat degradation, pollution and climate change. Every effort must be made to reduce impacts from these threats.

The Indian Ocean tsunami of 2004: a missed opportunity

The Indian Ocean tsunami of 2004 was a disaster of unprecedented proportions and sparked off a massive process of reconstruction, which aimed to meet the urgent need to rebuild shattered settlements and infrastructure. In many cases, these efforts were carried out with little regard for the environment and with little coordination amongst agencies. Yet post-tsunami reconstruction did not create these environmental problems – it merely brought a series of long-term issues sharply into focus. The rapid pace of post-tsunami reconstruction has meant that since January 2004, many of the environmental impacts of haphazard coastal zone development have been illustrated graphically over a short period of time. Although the tsunami provided an opportunity to demonstrate a truly environmentally sustainable approach to coastal zone development, and to apply the many lessons and best practices that have been learned over recent decades, in reality, these critically-needed inputs were most often lacking. This is despite the fact that many people had recognised publicly the need to incorporate environmental concerns into the reconstruction process, and a massive rise in public awareness about ecosystem values (IUCN, 2006).

Numerous guidelines and recommendations were provided to coastal developers, and despite the fact that some tsunami-affected countries have a comprehensive set of laws and regulations governing development in the coastal zone, these do not for the most part seem to have been followed in the post-tsunami reconstruction process.

Indiscriminate dumping of tsunami debris in wetlands has decreased fish catch; decreased water depth and diminished water storage during the drought period. A sudden increase in the extraction of timber and land requirements for housing units has resulted in deforestation. This, in turn, has resulted, in some areas, in habitat loss for species such as elephants, thereby increasing human-elephant conflict, and not only depleting livelihoods (damaging crops) but also causing deaths of both humans and elephants. Increased sand mining for building is another issue that has the potential to severely affect coastal morphology. The over-supply of boats and fine-meshed nets, and consequential over-fishing has the potential to wreak havoc on the fisheries sector. Improper management of solid waste at the shelter sites is a serious and ever-increasing health hazard. These environmental concerns were overridden either to achieve rapid results on the ground or by some cosmetic work to satisfy internal environmental standards, if any. That sound environmental conditions are essential to the sustainable revival of communities and to long term livelihoods and economic security has been ignored largely. Frequently, the environment is seen as a stumbling block to rehabilitating efficiently disaster victims. In addition, governmental environment agencies have little influence in decision-making processes (IUCN, 2006).

Although post tsunami reconstruction has wound down, as described in Volume, 1 natural disasters will recur. It is essential that we learn from the missed opportunity of post-tsunami reconstruction and ensure that present and future disaster management incorporate environmental safeguards as integral components of their work plans and strategies (IUCN, 2006).

The following steps should be followed in the processes of both recovery and rebuilding (short-term and long-term responses).

Step 1: Ensure that you carry out a post-disaster integrated assessment in order to obtain a complete picture of the state of the ecosystem well-being and human well-being after the disaster.

- Comparison of these data with the baseline data obtained in the Prevention stage will allow for clear analysis and informed decision-making. Refer to Volume 3 for a worksheet that can be adjusted to suit this stage. The economic valuation and livelihoods data from pre and post disaster assessment will feed into the ecosystem and biodiversity assessment data.

Step 2: Ensure that there is no over-exploitation of species.

- For example, is timber and sand extraction sustainable and legal?

In Aceh, the 800,000ha Gunung Leuser National Park - part of a World Heritage Site - is a biodiversity hotspot, with some 700 different animal species and about 4,500 plant species. It is home to some 4% percent of all known bird species. The ecosystem is also rich in tropical hardwood trees, which fetch a high price on international markets.

After the 2004 tsunami, workers were illegally logging timber for temporary shelters. All Indonesian forests are over-logged by a factor of three, mostly through illegal logging. Eight million cubic metres of timber was needed for rebuilding (equal to four times the size of Singapore) WWF, Conservation International and others started a 'Timber Aid' programme. British Red Cross, Oxfam, and Premiere Urgence imported sustainably-logged timber from Australia and New Zealand, instead of using timber from unmanaged forests (WWF, 2005).

Step 3: Ensure that existing legislation is followed.

- Sometimes there are only a few laws related to building and protected areas; in contrast, sometimes there are a plethora of relevant laws as shown in the box under the Mitigation section. (See page 23.)

The Indian ocean tsunami of December 2004 served to highlight the lack of proper regulatory policies and laws in affected Asian countries. 'Only India and Sri Lanka have laws or regulations in force specifically governing the coastal zone. India's Coastal Regulation Zone Notification totally prohibits development in mangrove ecosystems, but for various reasons the Notification is not enforced consistently. In Sri Lanka, the Coast Conservation Act governs the coastal zone, but mangroves are governed by the Forest Act, which opens the door to conflicts of jurisdiction under the two laws and inadequate enforcement of both. In July 2006, Thailand finalised a draft ICM law, which may be considered for adoption in 2007. Indonesia is in the process of preparing an ICM law. The Maldives does not currently have a regulatory regime for ICM or for mangroves' (IUCN, 2006).

Step 4: Ensure that proper design standards are followed.

- Avoid using designs that are not appropriate and lack use of environmentally-friendly materials and climate-proofing.
- Avoid forcing culturally unsuitable designs onto communities. i.e., designs should be drawn up with community input.
- Ensure that gender concerns are integrated into designs, while making them environmentally-friendly and climate-proof.

In 2001, an earthquake hit Bhuj city in Gujarat, in India. Good seismic codes of practice exist in India, but they were not enforced nor was building construction inspected properly, leading to heavy damage of 179 high-rise buildings in Ahmedabad, 230km from the epicentre.

In contrast, in 1977, a group of volunteers from AWARE built 1,500 houses in Andra Pradesh, India, following a cyclone that damaged coastal areas. These houses used government cyclone-proof designs, and of these, 98% withstood a stronger cyclone that hit the region in 1990 (http://www.proventionconsortium.org/themes/default/pdfs/tools_for_mainstreaming_GN12.pdf).

A major challenge after the Indian ocean tsunami of 2004 was an increase in fishing capacity and an ensuing state of over-fishing in a region already over-exploited for fisheries resources. Throughout the region, more small fishing boats were replaced than were lost, expanding fishing fleets to a size greater than they were before the disaster.

It is estimated that 19,000 boats were destroyed in Sri Lanka by the tsunami of 2004. Two and a half years later, some fishermen had not yet fully restored their livelihoods despite assurances from the Reconstruction and Development Agency (RADA) that 90% of the boats have been replaced and that catch levels were then 70% of what they were before the tsunami.

Only 30% of large weight boats had been replaced at that time – although these big boats accounted for a third of the overall catch in Sri Lanka before the tsunami. In contrast, there was an excess of small boats that were distributed *ad hoc* by well-wishers, small NGOs and other small donors. It is estimated that over 3,000 small boats were donated, causing over-exploitation of coastal fish. In southern Sri Lanka, some fishermen now complain that they do not catch any fish at all on certain days. In addition, the ready availability of small boats has resulted in new people turning to fisheries as a livelihood in an already overcrowded coastal fishing industry.

An FAO survey carried out one-year after the tsunami, revealed that on 28% of the required nets were donated to fishermen in need, 63% of the boats replaced had no fishing gear, and 19% had inadequate gear; less 50% who received boats were not fishermen (http://www.irinnews.org/report.aspx?ReportId=72857).

Step 5: Minimise habitat change.

- Ensure that sensitive areas/ecologically and economically valuable areas (identified in the Prevention stage) are not cleared for buildings or resettlements.
- Ensure that coastal/mountain morphology is not changed by built infrastructure.

Some post tsunami permanent settlements in Southern Sri Lanka have been sited in areas known to be used as migratory pathways by elephants. This has likely worsened the human-elephant conflict: deaths, damage to crops and houses (IUCN, 2006).

Step 6: Minimise pollution.

- Check whether the area is being polluted by the process.
- Check whether there is collection of non-biodegradable solid waste.
- Check how solid waste is being collected and disposed.
- Check whether an effort is being made to reduce, reuse and recycle waste.
- Check whether the air is being polluted by the process.
- Check whether air pollution control measures are in place.

Step 7: Be careful about disposal of debris.

- Before disposing debris, contact the relevant authorities for identification of recommended disposal sites.
- Prevent irresponsible dumping of waste.
- Provide safety training and involve communities in sorting waste.

Step 8: Create awareness among communities about responsible disposal of waste.

- This is very important for long term mitigation.

Tsunami debris in Koh Phra Thong, Thailand generated large quantities of solid and liquid waste, from damaged sewage tanks, cesspits and overflowing mains, together with waste material blocking water drainage systems and sewers, increasing the threat of water borne diseases.

‘Deeply concerned about the waste disposal mechanism and its cascading effect, the International Union for the Conservation of Nature (IUCN) took up the challenge of creating awareness about solid waste disposal among community members. IUCN has, to date, trained over eighty people in waste management practices in the island of Phra Thong, to say “no”’ to plastic bags, to separate waste into recyclable, non-recyclable and reusable waste, to sell waste for income generation and to use fruit scraps and other organic garbage to make detergents’ (IUCN, 2006).

Step 9: Prevent the spread of invasive alien species.

- Check whether IAS are spreading. Building equipment is known to a mechanism through which IAS spread.

In southern Sri Lanka, Prickly Pear (*Opuntia dillenii*) has spread in sand dunes and beaches after the tsunami, preventing the regeneration of natural beach vegetation such as *Spinifex*. *Salvinia* and Water hyacinth (*Eichhornia crassipes*) have spread in lagoons and estuaries (Bambaradeniya et al., 2006).

Step 10: Ensure that water is not polluted.

- Are resources protected from further contamination, such as faecal waste?
- Are organic and inorganic debris disposed of in a proper manner so that water bodies are not polluted?
- Do housing and new construction ensure good sanitation facilities and sewage systems?
- Do construction designs ensure good drainage systems in place as approved by relevant local authorities?

Various development and humanitarian agencies were responsible for setting up new settlements after the tsunami. Although each organisation adhered to standards that required sewage collection tanks to be sited a certain distance from buildings, because of a lack of coordination, the distance between the tanks built by one organisation and the houses built by another did not meet the minimum required standard. This was observed in northern Sri Lanka (Ali Raza Rizvi, personal communication).

Step 11: Ensure that measures are taken to mitigate the impacts of and to adapt to climate change.

- Are communities that are most vulnerable to natural disasters identified? (See Hazard and Risk mapping, this volume.)
- Have women been identified as an important group for climate change mitigation and adaptation?
- Are energy conservation measures being adopted? For example, is there through-flow ventilation in hot climates? Are energy-saving bulbs and alternate energy sources-such as solar power-being used where ever possible?
- Are water conservation measures are being adopted? For example, in drought prone areas, is there provision for rain water harvesting?
- Is waste water managed hygienically? Are toilets being built at safe distances from drinking water sources?
- Are environmentally-friendly materials used as much as possible?

In Rajastan, India, village communities are trained to build rainwater cisterns. During the monsoons, rainwater is collected by channels which run into the cisterns. Each cistern can store 40,000 litres and is shared by three families. When full, the cistern can provide drinking water for these families all year round. It can also be used to store water brought in by tankers in times of drought (Reid & Simms, 2007).

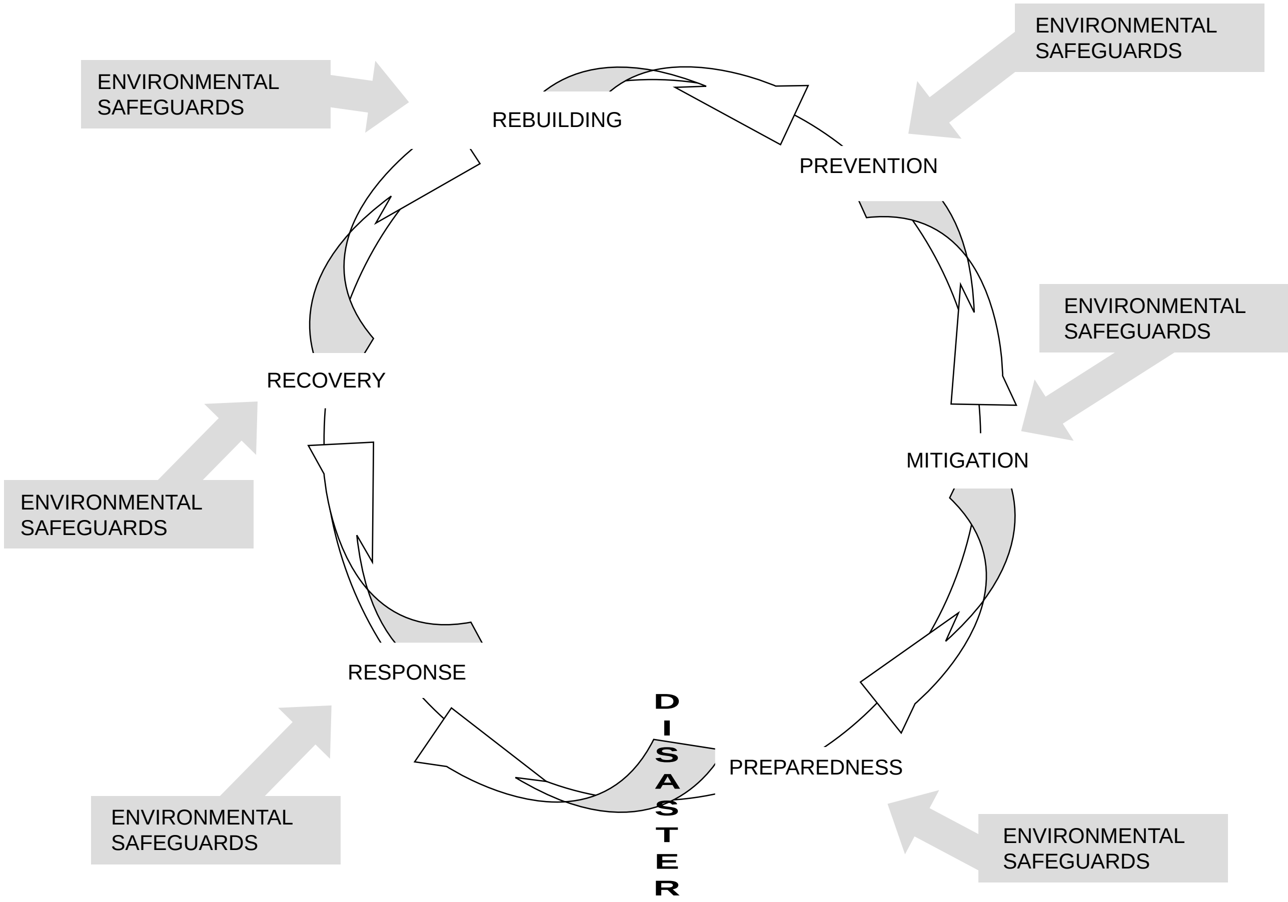
Step 12: Ensure that ecosystems and natural habitats are conserved, restored and created.

- Are efforts being made to replant and landscape during structural changes?
- Is ecosystem restoration being carried out with reference to existing national laws and with reference to existing resource maps?
- Is ecosystem restoration being carried out by matching local needs and priorities the services that ecosystems provide, rather than implementing land use patterns in a top-down manner?
- Are native, multiple-use and locally beneficial species being used while carrying out restoration?
- Are efforts being made to ensure that replanting is carried out only in suitable areas? For example, mangrove replanting in many areas in Asia was carried out in areas where there previously had been no mangroves or where sand dunes - essential for the prevention of coastal erosion - were flattened for this purpose.
- Are efforts being made to ensure that only indigenous species - native to the specific area - being used? For example, using plant species found in the wet zone of Sri Lanka to replant areas of the dry zone will be doomed to fail, as these plants will lack xeromorphic[4] adaptations necessary for the dry zone.
- Are efforts in place to ensure that identified IAS are never used?
- Are all relevant government departments - such as the Forest Department, the Coast Conservation Department, Environmental Authority, Urban Authority and the Department of Wildlife Conservation - consulted from the beginning and do they play a central role in restoration together with the local communities?
- Is a landscape approach to restoration adopted? Ecosystems do not function as closed units but as open systems that are affected by ecological process that occur on a larger scale. Because of this, it is necessary to look at the broader picture, not just the specific restoration site alone.

[4] Xeromorphic adaptations allow plants to conserve water.

The end result of incorporating environmental safeguards is presented below in Figure 9.

Figure 9: The end result of incorporating environmental safeguards



There should be a checklist of environmental safeguards for every step of disaster management. These checklists can be for a given location or a given hazard, but should use the steps provided in this manual as a guideline.

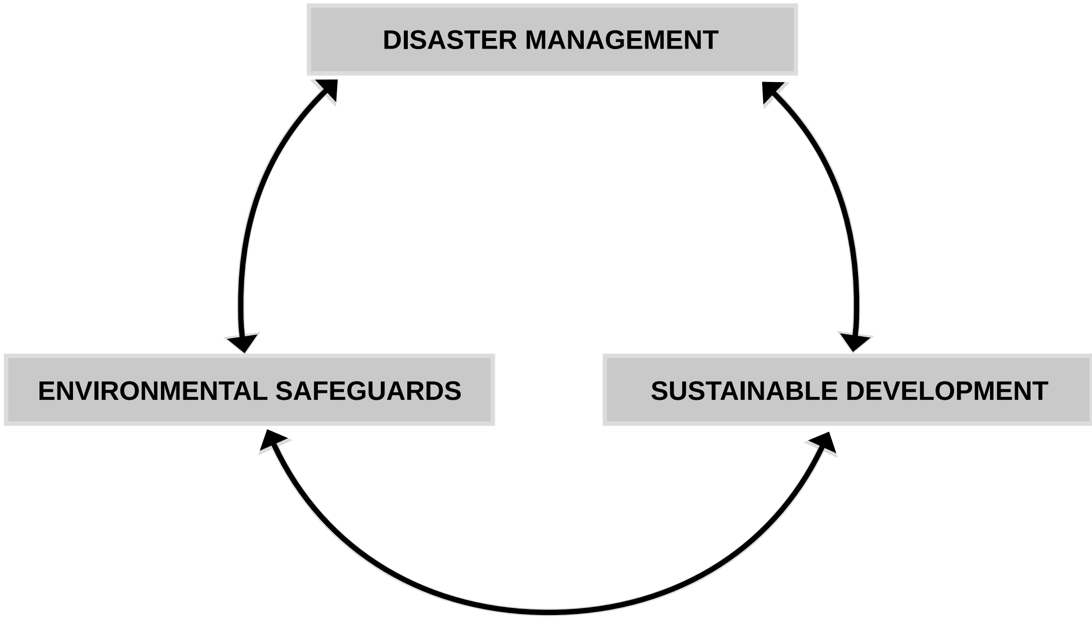
The ultimate goal is to incorporate environmental safeguards into both disaster management and sustainable development.

The entire global community or civil society - which includes, *inter alia,* donors, policy makers, governments, communities, development agencies, humanitarian agencies, the private sector, media and academics - must be sensitised to this need. In order to do this, advocacy, awareness and science-based knowledge generation - that result in changes in governance - are essential. Empowerment through capacity building, institutional strengthening and training makes this possible.

A knowledgeable and empowered civil society will know how

- to sustain healthy ecosystems that facilitate the reduction of natural disasters;
- to facilitate sound practices of land use planning;
- to reduce social, physical, attitudinal and environmental vulnerability to natural disasters;
- to safeguard livelihoods;
- to ensure human well-being;
- to empower highly vulnerable groups;
- to enhance overall resilience; and
- to have access to the right to information and services.

The end result should be that environmental safeguards are integrated not only into disaster risk management but also into every facet of development.



References

Asian Development Bank (2007). *Regional Technical Assistance Report.* Project Number: 40292 http://www.adb.org/Documents/TARs/REG/40292-REG-TAR.pdf

Bambaradeniya, C. N. B., Perera, M. S.J. and V. A. M. P. K. Samarawickrama (2006). A rapid assessment of post-tsunami environmental dynamics in relation to coastal zone rehabilitation and development activities in Hambantota District of southern Sri Lanka. *IUCN Sri Lanka Occasional Paper No. 10*. Colombo, Sri Lanka: IUCN. 27pp.

Coburn, A. W., Spence, R. J. S. and A. Pomores (1994). *Disaster Mitigation.* 2nd ed. Cambridge: Cambridge Architectural Research Ltd. pp 64.

GDRC (2008) http://www.gdrc.org/uem/disasters/1-dm_cycle.html

http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake

http://iri.columbia.edu/~mahaweli/disaster/concept.html

http://secap480.un.org/search?q=early+warning+systems&Submit=Search&ie=utf8&site=un_org&output=xml_no_dtd&client=UN_Website_English&num=10&proxystylesheet=UN_Website_English&oe=utf8

http://www.irinnews.org/report.aspx?ReportId=72857

http://www.proventionconsortium.org/themes/default/pdfs/tools_for_mainstreaming_GN12.pdf

http://www.redcross.org/

http:// www.riskmanagement.qld.gov.au/info/guide/gls.htm

http://www.unep-wcmc.org/protected_areas/ categories/ index.html

http://www.undp.bg/uploads/documents/1196_638_en.pdf

http://www.un.org/News/Press/docs/2005/hab196.doc.htm

IUCN (2006). *Coastal Ecosystems 2*: November 2006. http://data.iucn.org/places/asia/coastalinfo/docs/Coastal_Ecosystems_newsletter2.pdf

IUCN (2006a). *Environmental stories after the Tsunami.* http://data.iucn.org/places/asia/coastalinfo/docs

IUCN (2005). *Series on Best Practice Guidelines (Sri Lanka) After the Tsunami: Knowing about Environmental Policies and Legislation Information Paper No. 9* http://data.iucn.org/places/asia/coastalinfo/docs/Best_practice_guidelines_9_environmental_laws.pdf

IUCN and UNEP (2006) *Counting the Environmental Costs of Natural Disasters: Evaluating Tsunami-Related Damages to Coastal Ecosystems in Thailand.* Prepared by Usman A. Iftikhar. Colombo: Ecosystems and Livelihoods Group Asia, The World Conservation Union (IUCN). 36 pp.

Kallesøe, M. F., Bambaradeniya, C. N. B. , Iftikhar, U. A., Ranasinghe, T. and S. Miththapala (2008). *Linking Coastal Ecosystems and Human Well-Being: Learning from conceptual frameworks and empirical results.* Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii + 49 pp.

OECS (2003) Technical Manual for Post-disaster Rapid Environmental Assessments, Volume 1 & 2. http://www.caribank.org/titanweb/cdb/webcms.nsf/AllDoc/9E2B73C29C5CB1A1042573D100546360/$File/OECSManualVolume_1_Final.pdf

Reid, H., Simms, A. and V. Johnson (2007). *Up in smoke? Asia and the Pacific. The threat from climate change to human development and the environment. International Institute for Environment and Development*. 95 pp.

Springate-Baginski, O., Darwall, W., Emerton, L., Allison, E., McIvor, A. and C. Bambaradeniya (in press). *A Toolkit for Integrated Wetland Assessment.* Cambridge: Freshwater Biodiversity Assessment Unit, International Union for Conservation of Nature.

UNEP (2005). *After the Tsunami: Rapid Environmental Assessment*. http://www.unep.org/tsunami/situation_rpt.asp. 140 pp.

Wikramanayake, E (2008). *Forest cover in Sri Lanka.* Unpublished map.

World Widlife Fund (2005). *One Year After the Tsunami: Building Back the Right Way.* http://www.worldwildlife.org/who/media/press/2005/WWFPresitem823.html

Zubair, L. and V. Ralapanawe (2008) *Identification of Global Natural Disaster Risk Hotspots - Sri Lanka Case Study* http://iri.columbia.edu/~mahaweli/disaster/concept.html

Photocredits

Page number	Caption	Credit
Frontpiece	Earthquake damage, Pakistan.	© Karl Schuler, IUCN
iii	Tsunami damage, east coast Sri Lanka.	© IUCN Sri Lanka
iv	Mangrove destruction by the tsunami, southern Sri Lanka	© Vimukthi Weeratunge
vi	Erosion as a result of floods in Bangladesh.	© Mahbubur Rahman Masum, IUCN Bangladesh
vii	Earthquake damage in Pakistan.	© Karl Schuler, IUCN
9	Fisherman casting net, Sri Lanka.	© Luxmanan Nadarajah
13	Sprats for sale in Sri Lanka.	© Sriyanie Miththapala
19	Adam's Peak, in Peak Wilderness Sanctuary, Sri Lanka	© Gehan de Silva Wijeyeratne
22	Rebuilding after the tsunami, southern Sri Lanka.	© IUCN Sri Lanka
25	Traffic and crowds in Hanoi, Viet Nam.	© Sriyanie Miththapala
29	Floating beds, Bangladesh.	© Haseeb Irfanullah/IUCN Bangladesh
31	People looking for shelter after floods, Bangladesh.	© Mahbubur Rahman Masum, IUCN Bangladesh
33	Elephants near garbage dump, southern Sri Lanka.	© Prithiviraj Fernando
37	Donated boats, west coast of Sri Lanka.	© Hasantha Lokugamage, Jetwing Hotels
41	Fisherwomen, Viet Nam.	© IUCN Viet Nam
43	Community based mangrove restoration, southern Sri Lanka.	© Vimukthi Weeratunge

The IUCN Asia region covers 23 countries, stretching from Pakistan in the West to Japan in the East, Indonesia in the South to Mongolia in the North. IUCN maintains offices in Bangladesh, Cambodia, China, Lao PDR, Nepal, Pakistan, Sri Lanka, Thailand and Viet Nam. The Asia Regional Office is in Bangkok, Thailand.

IUCN's seven regional thematic programmes, known collectively as the Ecosystems and Livelihoods Group (ELG), are based in two clusters: one in Colombo, Sri Lanka (environmental economics, marine and coastal, species conservation), and one in Bangkok, Thailand (environmental law, forests, protected areas, wetlands and water resources).

Ecosystems and Livelihoods Group Asia

IUCN
4/1 Adams Avenue
Colombo 4
Sri Lanka
Phone: + 94 11 2559634
Fax: +94 11- 2559637
E-mail: coastalinfo@iucnsl.org
http://data.iucn.org/places/asia/coastalinfo/

Integrating environmental safeguards into Disaster Management: a field manual

Volume 3: Tools, techniques and relevant resources

Compiled by Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

Integrating environmental safeguards into Disaster Management: field manual

Volume 3: Tools, techniques and relevant resources

Integrating environmental safeguards into Disaster Management: field manual

Volume 3: Tools, techniques and relevant resources

compiled by Sriyanie Miththapala

Ecosystems and Livelihoods Group, Asia, IUCN

This document was produced under the project 'Rehabilitating coastal ecosystems in a post-tsunami context: Consolidation Phase' carried out with financial support from the Autonomous Organisation for National Parks (*Organismo Autónomo Parques Nacionales* - OAPN) of the Ministry of Environment of Spain. The designation of geographical entities in this technical report, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of IUCN or OAPN concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries. The views expressed in this publication do not necessarily reflect those of IUCN or OAPN.

Published by: Ecosystems and Livelihoods Group Asia, IUCN, International Union for Conservation of Nature and Natural Resources.

Citation: Miththapala S (2009). Incorporating environmental safeguards into disaster risk management. Volume 3: Tools, techniques and other resources. Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. viii+142 pp.

ISBN: 978-955-8177-88-4

Cover Photo: Damage from the Indian Ocean tsunami of 2004, eastern coast, Sri Lanka © IUCN, Sri Lanka.

Design: Sriyanie Miththapala

Produced by: Ecosystems and Livelihoods Group Asia, IUCN.

Printed by: Karunaratne & Sons (Pvt) Ltd.
67 UDA Industrial Estate
Katuwana Road
Homagama
Sri Lanka
info@karusons.com

Available from: Ecosystems and Livelihoods Group, Asia
IUCN
4/1, Adams Avenue
Colombo 4
Sri Lanka
Phone: +(9411) 255 9634-5
Fax: +(9411) 255 9637
email: coastalinfo@iucnsl.org
website: http://www.iucn.org/about/work/initiatives/about_work_global_ini_mangr/oapn/index.cfm

Contents

List of Figures

List of Tables

Foreword

The devastation caused by the 2004 Asian tsunami and the subsequent world response were unprecedented. IUCN acted promptly and undertook many initiatives to combat the destruction of local ecosystems. IUCN Asia led this process and many of its country offices and programmes played their due role. Since then, the Ecosystems and Livelihoods Group of IUCN Asia, based in Colombo, has continued to play an important role in the post-tsunami scenario. The interventions have now evolved from emergency response and rapid environmental assessments to disaster risk reduction programming. Disaster risk reduction for most organisations is a relatively new area, though mainstream aid and humanitarian organisations are adept at disaster response. While most of us are working at different levels of the DRR spectrum, the objective remains a common one: ensuring human well being.

IUCN Asia is working in the DRR sector with a two-pronged approach: to infuse environmental safeguards into the mainstream disaster risk reduction programme; and to integrate disaster risk reduction into conservation and sustainable development programming.

Over the years, varied methodologies, frameworks and approaches have been used towards this end. We have had many successes and also failures in this process and keep learning and modifying our strategies. Here, the key is to continue sharing our lessons learned and helping each other in incorporating these in our respective strategies.

We are happy to share that in the course of the above process, IUCN has developed a manual, 'Incorporating environmental safeguards into disaster risk management' through the financial support of OAPN, Ministry of Environment, Spain. This manual comprises three-volumes detailing ecosystem linkage with human well-being; presenting approaches to integrate environmental considerations into mainstream disaster management programmes; and providing tools, including worksheets, for planning and implementation of environmentally-infused disaster risk management initiatives.

In addition, we are exploring the possibilities of developing hazard-specific modules to help incorporate environmental safeguards into community-based disaster management initiatives aiming at enhancing community resilience for disaster management.

We are grateful to Dr. Sriyanie Miththapala whose dedicated research, commitment and determined efforts made it possible to produce this three-volume manual.

The manual is a working document, your comments and feedback will be received gratefully. We intend to keep working to make this as relevant, practical and user-friendly as possible. We do hope that this manual will contribute positively towards achieving the main objective of all the organisations and agencies involved in this sector which is sustainable human well being.

Ali Raza Rizvi
Regional Group Head
Ecosystems and Livelihoods Group Asia, IUCN
Colombo, Sri Lanka

Acknowledgments

Many people assisted with the preparation and production of this manual. The author expresses her grateful thanks to Saima Baig, Channa Bambaradeniya, Lucy Emerton, Janaki Galappatti, Ranjit Galappatti, Usman Ifthikar, Mikkel Kallesøe, Soosaipillai Karunakaran, Sanjeewa Lellwala, Maeve Nightingale, Thushara Ranasinghe, Ali Raza Rizvi and Devaka Weerakoon for content inputs and comments. Shehani Peris proof-read the document.

Many people generously provided photographs for use. They are credited individually at the end of the book.

This document was produced and published with financial support through a grant made from the Autonomous Organisation for National Parks (Organismo Autónomo Parques Nacionales - OAPN) of the Ministry of Environment of Spain - to IUCN.

Executive summary

The first two volumes of this field manual focused on providing background reference material and detailing steps that should be taken during the disaster management cycle in order to integrate environmental safeguards into disaster management. In the second volume, the importance of carrying out integrated assessments was described.

In this volume, a worksheet is presented in a way that it can be copied and used in the field. Initially, a list of needs for carrying out integrated assessments is itemised. Technical documents that describe assessment techniques for each of the sections of integrated assessments - *viz* biodiversity and ecosystem services, environmental impact assessments, livelihoods and economic valuation - follow as resource material.

Simple methods for analysing data obtained from integrated assessments are presented.

Also presented in this volume is the methodology for Rapid Environmental Impact Assessments and a summary about Strategic Environmental Assessments. Another tool for use - the CRISTAL tool for community-based risk assessment - is also described briefly.

Reproduced in this volume is a series of best practice guidelines prepared after the Indian Ocean tsunami by the International Union for the Conservation of Nature (IUCN, Sri Lanka Office) to make post tsunami restoration work environmentally sound and sustainable. The guidelines present the issues, impacts, the needs, guiding principles and key steps to follow for a series of 14 topics: 1) Where to build; 2) Invasive alien species; 3) Materials for reconstruction; 4) Beach clean ups; 5) Solid waste management; 6) Recovery of marine ecosystems; 7) Restoring tourism; 8) Preparing for natural disasters; 9) Environmental laws; 10) Restoring terrestrial ecosystems; 11) Water pollution; 12) Restoring wetlands; 13) Restoring home gardens and 14) Safeguarding marine protected areas. These guidelines can be adapted easily to fit a specific situation at a specific locale.

Briefs about the Cairo Principles, the Hyogo Framework of Action and Sphere Humanitarian Charter and Minimum Standards in Disaster Response are also presented. Background information on the Emergency Personnel Network (EPN) and the Disaster Environment Working Group for Asia (DEWGA) is also given. The UNHCR handbook for emergencies is also summarised. Finally, guidelines for gender sensitive disaster management are also reproduced as reference material.

Volume 1 of this manual presented background reference material about terminology related to disaster management as well as information about hazards and ecosystems. Volume 2 examined the disaster management cycle, described integrated assessments and used the Millennium Ecosystem Assessment as a framework to present steps that must be followed at each stage of the disaster management cycle.

Recognising that field practitioners – such as protected area and coastal managers – may not always have ready access to the Internet for reference, Volume 3 of this manual presents summarised resource material that is useful for such practitioners.

This material covers a range of subjects - from technical papers on biodiversity and economic valuation, to the description of tools such as Rapid Environmental Impact Assessments (REA) and CRISTAL (for community-based risk assessment) - as well as international principles and frameworks, such as the Cairo Principles and the Hyogo Framework of Action, as well as various guidelines.

Therefore, it is hoped, that, for example, protected area managers who may already know about REAs have easy access to a summary of the UNHCR guidelines for emergencies; or, in contrast, field officers engaged in humanitarian work will have, at hand, information about REAs and biodiversity techniques.

It is hoped that the breadth of these topics in Volume 3 will reiterate the importance of a holistic approach to disaster management.

Needs for integrated assessments

Prior to carrying out any assessment, it is necessary that some ground work is laid to ensure good rapport with communities in the area.

Step 1: Obtain relevant permission.

If you are working in a protected area or an ecologically sensitive area, obtain permission from relevant government conservation authorities (i.e., Department of Wildlife Conservation, Forest Department, Coast Conservation Department, etc.). It would be best to submit a proposal of work, indicating objectives of the survey and presenting a work plan, prior to any discussion.

Step 2: Introduce yourself.

Introduce yourself to local administrators (i.e., village administrators, police, etc.), and submit a copy of the letter of approval obtained in Step 1.

Step 3: Familiarise yourself with local communities.

This is important to gain the trust of communities.
- Introduce the assessment team.
- Introduce the assessment and assessment objectives.
- Try to find a suitable local person who is familiar with the survey area, who can assist in field work. This is important as it will allow you to be aware of dangerous locations (for example, conflict and mined areas, areas where trap guns are set for animals).

Step 4: Do not offend communities nor affect the habitats of flora and/or the habitats and behaviour of fauna.

- Ensure that the survey does not disrupt community activities nor offend individuals.
- Ensure privacy when collecting data.
- Ensure that the survey does not contribute to the decline of species, through unnecessary collection of specimens in the field. When surveying animals, identification of species is possible through the use of field guides or good digital photographs that can be used later for identification. When live-trapping methods are used, ensure that traps are visited frequently, so that animals can be identified and released before they become hypo/ hyperthermic or exhausted.

Step 5: Draw a map of the area.

- Use community knowledge to draw a map of the area;
- Add GPS coordinates to the above map;
- Verify the map against published maps.

Step 6: Carry out semi-structured interviews[1] to obtain required biodiversity and ecosystem service information such as:

- Local habitat/ecosystem classifications and their significance based on local knowledge (use local names);
- Dependence of local communities on their surrounding landcapes/ resource use, livelihoods in the area;
- Resource use;
- Services (water purification, waste recycling, etc.) of local ecosystems;
- Direct drivers of biodiversity loss (pollution, invasive alien species, habitat loss and degradation etc.);
- Indirect drivers of biodiversity loss (population, urbanisation, etc.);
- Constraints, issues, pressures related to resource use (for example, legislation, permits, etc.);
- Land ownership/tenure;
- Indigenous knowledge and practices;
- Human wildlife conflicts/pest and disease outbreaks and trends;

Use the worksheet in the following section for all of the above.

Step 7: For at least ten households per village, carry out a questionnaire survey[2] to obtain required economic and livelihood information such as:

- Household size and composition;
- Length of residence in respective village, and place of origin;
- Education level of family members;
- Demography;
- Equipment owned by households (tools, transport, boats, gear, etc.)
- Monthly cash income and seasonal variation;
- Livestock ownership;
- Land area (total, farmed and own/leased);
- Major livelihoods (for example, farming, fisheries, livestock, business, government/ private sector employment);
- Annual production, cost of extraction/and processing, proportion sold and used for subsistence and trends;

Necessary human resources

Experts

- A biodiversity expert with taxonomic and identification knowledge of major faunal and flora groups;
- An environmental economist; and
- A livelihoods expert.

Community

It should be ensured that community participation involves a mixed group of people and should include

- All ethnic groups;
- All religions;
- Women;
- Different age groups;
- Representatives from all sectors (for example, fishermen/carpenters/ farmers/livestock keepers/ NTFP collectors/hunters, etc.)
- Tribal communities/ marginalised groups;
- Representatives from all clubs and societies, etc.;
- Local community members who are knowledgeable about their surrounds;
- Elderly people who know about the history and natural history of the village/ community and how it has changed over time;
- Village religious leaders (who should at least be informed about the activity);
- Village level government officers (who should at least be informed about the activity).

[1] A semi-structured interview is an interview with an individual or individuals that follows a pre-defined set of question parameters, but still allows for a degree of freedom in exploring a range of issues.

[2] A questionnaire survey is a survey where a questionnnaire is filled in.

- Form of product/s marketed (raw material/secondary products/value added or not);
- Marketing mechanism;
- Relative importance different ecosystems for different livelihoods (livelihood value); and
- Monitory value of direct uses (food, fuel wood, timber, etc.) and value of indirect uses (cost of water purification, cost of waste recycling, etc.).
  Use the worksheet in the following section for the above.

Step 7: Find out other relevant information such as:

- Other development organisations and NGOs working in village and their aims and objectives;
- Businesses operating in the village.

Step 8: Carry out a transect walk.

- Using the village map, and in consultation with community participants, define a transect covering all habitat types such as primary forests, fallow land, crop land, slash and burn cultivation, sacred/spirit forests, rivers etc.
- Try to cross the highest possible number of boundaries between such types.
- In order to ensure that you do not return along the same route, define a circular transect.
- The team should walk through the transect, ensuring that measures are taken to make the transect walk safe (for example, from trap guns, land mines, animal attacks etc.).
- Record geo-reference points where necessary (at least at 100m intervals), record habitat/ecosystem/ landscape type (stream, marsh, grassland, forest, pasture etc.) and take photographs referring the recorded geo-reference.
- Record the following while walking: (This is called opportunistic observation.)
  - Plant species (local name/uses/abundance/life form/habitat etc.);
    Animals (local name of the animal, sighted/heard/signs/faeces/foot prints/nests/feathers etc.);
  - Invasive alien species (local name/impact/uses etc.);
  - Pollution (point sources/grey water/noises/smells etc.);
  - Degraded lands, harmful practices to environment etc. This should include oil and chemical storage tanks (both above ground and underground), garbage and sewage disposal/treatment facilities/ underground sewers, areas with unexploded ordinances - i.e., former military training areas and storage facilities.
  - Any other issues/opportunities as listed in the worksheet;
  - Any NTFP collected (part (seed/bark/leaves) season/amount/purpose/history of use and extraction etc.);
  - Communal resources (water/mineral resources/grazing lands etc.);
  - Wildlife related damages (animal/type of damage and gross estimate of damage).
- When it is not possible to identify species, take reference digital photographs with an included scale, for subsequent identification.

Step 9: Carry out focal group discussions.

- Meet representatives of each sector to elicit relevant information (for example, of fish species caught and relative abundance, crops etc.).
- Ask about specific use of habitats, landscapes.
- Ask about specific threats to each of their sectors.

(Adapted from Bambaradeniya, unpublished report).

Necessary equipment

For community-based biodiversity assessments

- Field note book/pen or pencil;
- Map/aerial image of the village if available;
- Compass;
- Transect cord (cut and wrapped to the length of the desired transect);
- Binoculars;
- Hand held GPS;
- Field identification guides for major taxonomic groups;
- Butterfly net for capture and release of species that can not be identified in flight;
- Fish net for capture and release of fish;
- Large clear plastic bottles with wide mouths for capturing fauna to take digital photographs for later identification;
- Digital camera with macro lens; and
- Prepared assessment sheets.

For socioeconomic/ livelihoods assessment

- Bristol boards/flipcharts;
- Beads/pebbles;
- Coloured felt pens; and
- Prepared questionnaire sheets.

Worksheet for integrated assessments

Worksheet for integrated assessments

This can be adapted to suit any habitat. What is shown below is for a wetland.

Name and location:		
Date:	Coordinates:	
Type of ecosystem (habitat)		Description
For example, Lagoon/Estuary/Mangrove/Saltmarsh/Tank/Pond		
Approximate area:		
Management and jurisdiction		
Responsible government institution:		
Is it a protected area?	Yes	No
BIODIVERSITY ASSESSMENT		
Species Diversity (Fauna)		Number
Birds	Number of species	
	Abundance	
	Breeding colonies	Yes/No
Other vertebrate fauna (Define group)	Number of species	
	Abundance	
Fish (Subsistence catch)	Number of species	
	Abundance	
Fish (Commercial catch)	Number of species	
	Abundance	
Macro-invertebrates (crabs, shrimps, molluscs, butterflies, dragonflies)	Number of species	
	Abundance	
Species Diversity (Flora)		Number
Emerging flora or weeds/herbs	Number of species	
	Abundance	
Submerged flora or seedlings/saplings	Number of species	
	Abundance	
Floating flora or Trees/Shrubs	Number of species	
	Abundance	
ECOSYSTEM SERVICE ASSESSMENT		
Service type	Indicator	Details (qualitative/quantitative data)
Provisioning services		
Food	Fruits, vegetables, fish	Types and numbers
Fuelwood		Quantity extracted
Medicines		Types, quantity extracted
Drinking water		Quantity extracted
Other		
Supporting services		
Biodiversity	Species richness from section above	
Nutrient cycling		
Primary production	Green foliage	Quantity of vegetation
Regulating services		
Protection from hazards	Vegetation stands	Extent
Flood control	Wetlands/catchment forests	Extent
Carbon sequestration	Canopy cover	Extent
Pollution control	Tree cover	Extent

Service type	Indicator	Details (qualitative/ quantitative data)
Cultural services		
Recreation/aesthetic value	Extent of tourism	Tourist facilities/number of tourists
Education	Educational facilities	Number/number of students
Traditional knowledge	Traditional practices	Type/number engaged in practice
Other		
ECONOMIC ASSESSMENT		
Type of value	Indicator	Valuation method and data requirements
Direct use value	Economic value of provisioning services harvested (e.g. food, NTFPs, freshwater, wood and fibre, fodder, fuel and medicines)	For products which are traded. *Market Price Method*: Local price X quantity of products harvested over a given time period. For products which are not traded, but consumed within the household or exchanged without cash payments. If the product is traded locally, even if it is not traded by the user himself: *Market price method*: Local price X quantity of products harvested over a given time period. If the product is not traded, but has a close substitute (e.g. kerosene for firewood, purchased foods for wild foods, roofing tiles for thatch): *Substitute Price/Replacement Cost Method:* Equivalent quantity of substitute used over a given time period X local market price of substitute. If the product is not traded, and has no close substitutes which are traded: it may not be possible to get an economic value.
Indirect use value	Economic value of regulating, supporting and cultural services is utilised.	First of all it is necessary to determine what quantity or magnitude of service the ecosystem provides (see ecosystem service assessment findings). *Note: it is always better to use several methods to calculate the value, and present a range of possible values.* If the service contributes clearly towards a specified output or production process as a raw material or input (e.g. year-round water for irrigation, soil nutrients for agriculture, nursery habitat and productivity for fisheries): *Effect on Production Method:* Establish the relationship between changes in a given ecosystem service and changes in production over a given time period, value this contribution to production in terms of market prices of the output.

ECONOMIC ASSESSMENT CONTD.		
Type of value	Indicator	Valuation method and data requirements
Indirect use value contd.	Economic value of regulating, supporting and cultural services is utilised.	If the service can be at least partially provided through artificial means (e.g. through built shoreline protection, sediment trapping, water purification, erosion control measures): *Replacement Cost Method*: Establish the works required to replicate the ecosystem service over a given time period, and calculate the physical costs (capital and recurrent) of building the infrastructure to provide an equivalent type and level of services. If the loss of the service will give rise to effects which would require mitigation[3] or avertive[4] action (e.g. building a reservoir to ensure year round water supplies, purchasing clean water, providing emergency food supplies): *Mitigative[3]/Avertive[4] Cost Method*: Establish the measures required to mitigate or avert the effects of the loss of an ecosystem service for a given area or population over a given time period, and calculate how much these measures would cost to implement. If the loss of the services will give rise to clear damages to infrastructure, production, etc. (e.g. flood damage to roads and bridges, drought damage to agriculture, damages from rising sea level): *Damage Costs Avoided Method*: establish the level of damages and affected area/population resulting from the loss of an ecosystem service over a given time period, and calculate the economic costs or losses associated with these damages. If calculating the recreational value of an ecosystem: *Travel Cost Method*: \collect data from visitors on the costs incurred in visiting and using the site including both direct expenses (such as fuel and fares, food, equipment, accommodation) and time spent on the trip, carry out a statistical regression to test the relationship between visitation rates and other explanatory factors, construct a demand curve relating number of visits to travel cost, model visitation rates at different prices, and calculate visitor consumer surplus. *Note: this is a complex method which requires extensive data collection, detailed data analysis, and a high level of training in environmental economics.*

[3] To act to lessen severity or intensity
[4] An action that avoids the loss of service.

ECONOMIC ASSESSMENT CONTD.		
Type of value	Indicator	Valuation method and data requirements
Option value	Economic value of provisioning, regulating, supporting and cultural services kept for future use.	*Contingent Valuation Method*: How much would people be willing to pay to ensure that the ecosystem is conserved for possible use in the future or how much compensation would people be willing to accept for the loss of the ecosystem and the consequent loss of possible use in the future. *Note: this is a complex method which requires extensive data collection, detailed data analysis, and a high level of training in environmental economics.*
Non use value (Existence and bequest value)	Economic value of provisioning, regulating, supporting and cultural services appreciated for their existence but never intended to be used.	*Contingent Valuation Method*: How much would people be willing to pay to ensure that the ecosystem is conserved or how much compensation would people be willing to accept for the loss of the ecosystem *Note: this is a complex method which requires extensive data collection, detailed data analysis, and a high level of training in environmental economics.*
LIVELIHOODS ASSESSMENT		
Basic materials for life	Indicator	Details (qualitative/quantitative data)
Adequate livelihoods		
	Total income/month/household	Higher than national average/lower than national average/below poverty line
	Total income/month/person	Higher than national average/lower than national average/below poverty line
	Sources of total income	Dependent on natural or other resources.
	Subsistence and non marketed income	From fruit/vegetables/agriculture/fish/livestock/fuelwood/fodder/medicinal plants/nuts (Non-timber forest products, NTFPs)
	Percentage of total income derived from fisheries	
	Percentage of households that are employed in fishing	
	Percentage of households that are employed in coastal tourism and tourism-related activities	
	Total number of households (in a village) directly dependent on fishing for their livelihoods	
	Total number of households (in a village) indirectly dependent on fishing for their livelihoods (net making etc.)	
	Total assets	Cultivable land/other land/cart/boat/plough/thresher/water pump/livestock/poultry
	Percentage of households that own boats	

For detailed descriptions of methods described in this section, please refer to the chapter on economic valuation methodology starting on page 36.

LIVELIHOODS ASSESSMENT CONTD.		
Basic materials for life	Indicator	Details (qualitative/quantitative data)
Sufficient nutritious food/water		
Food per 24hr consumption	Frequency of meals	1/2/3
Balanced diet	Type of food	Protein/starch/fat/minerals
Sources of food	Quantity of monthly household consumption that is derived from fisheries	
	Quantity of daily protein intake that is derived from fisheries	
Water per capita	Access to safe drinking water	Personal piped water/community piped water/spring/personal well/community well/delivered/purchased water/other
	Distance to water source	
	Duration to water source	Days/hours/minutes
	Cost	Weekly spending if bought
Shelter		
Housing	Permanency	Permanent/semi-permanent
	Ownership	Owned/rented/shared/other
	Personal space	Number of people/m^2
Access to housing goods	Percentage of households that use timber/thatch from surrounding ecosystems	
	Frequency of use of timbe/thatch from surrounding ecosystems	
	Quantity of timber/thatch use per house household per year	
Fuel	Type	Gas/wood/other
	Weekly requirement	
	Source	Gas pipeline/gas stove/wood from forest
	Cost	Weekly spending if bought
Access to fuel	Total number of households dependent on fuelwood from the surrounding ecosystem	
	Quantity of fuelwood collected by average household per month	
	Distance and time to collect fuelwood	
Health & Sanitation		
Feeling well	Prevalence of diarrhoea	Number of cases per day/per month.
	Prevalence of infectious hepatitis	Number of cases/day/month
	Prevalence of acute respiratory infections (ARI)	Number of cases/day/month
	Prevalence of chronic respiratory infections (CRI)	Number of cases/day/month
	Maternal mortality rate (to be collected at community level)	Number of deaths/year
	Infant mortality rate (to be collected at community level)	Number of deaths/year
	Under 5 mortality rate (to be collected at community level)	Number of deaths/year
	Access to family health services	Easy/Fair/Difficult

LIVELIHOODS ASSESSMENT CONTD.		
Basic materials for life	Indicator	Details (qualitative/quantitative data)
	Access health clinic services	Easy/Fair/Difficult
	Access to hospital services	Easy/Fair/Difficult
	Type of allopathic health services available	Mobile/clinic/door to door nurse/maternity clinic/midwife/hospital.
	Distance to above services	Hours/days/km etc.
	Type of traditional health services available	Practitioner/clinic/hospital.
	Distance to above services	Hours/days/km etc.
	Proportion acutely malnourished	Proportion of children stunted for age
	Proportion chronically malnourished	Proportion of children underweight for age
	Incidence of diseases in children	Number, water related and others
	Proportion of income spent on health per month	
	Access to sanitation	Exclusive to the HH/shared with other HHs/community toilet/no toilet
	Type of sanitation	Water seal/pit type/temporary covering/ other
Security		
Personal security	See under Hazard assessment	
Resource access	See under Provisioning services	
Security from disasters	See below	
Alternate livelihood strategy in case of disasters		Yes/No
Good social relations		
Social cohesion	Frequency of verbal exchanges	Greetings only/conversation/visits/ attendance at family functions such as marriages.
Mutual respect		
Ability to help others	Existence of a community-based organisation (CBO) to manage ecosystem use	Yes/No
	Membership in the CBO from different income groups	Yes/No
	Frequency of CBO meeting	Weekly/fortnightly/monthly/quarterly
	CBO plan includes disaster risk reduction	Yes/No
Education		
	Years of formal education on average	
	Primary education	
	Secondary education	
	Tertiary education	

ASSESSING DRIVERS OF CHANGE		
Direct drivers of change	*Prevalence*	*Magnitude*
Over-exploitation		
Harmful fishing practices/dynamiting/small mesh nets	Yes/No	High/Moderate/Low
Other (specify)	Yes/No	High/Moderate/Low
Spread of IAS		
IAS flora	Yes/No	High/Moderate/Low
IAS fauna	Yes/No	High/Moderate/Low
Habitat destruction		
Clear felling of habitats	Yes/No	High/Moderate/Low
Filling of wetlands	Yes/No	High/Moderate/Low
Land reclamation	Yes/No	High/Moderate/Low
Development – roads, infrastructure	Yes/No	High/Moderate/Low
Pollution		
Solid waste (garbage)	Yes/No	High/Moderate/Low
Solid waste (sewage treatment facilities/ underground sewers)	Yes/No	High/Moderate/Low
Former military training areas/facilities	Yes/No	High/Moderate/Low
Water pollution	Yes/No	High/Moderate/Low
Diminished water quality	Foul smell	Yes/No
	Foaming	Yes/No
	Silting	Yes/No
Indirect drivers of change		
External drivers	*Prevalence*	*Magnitude*
Prawn farming	Yes/No	High/Moderate/Low
Agricultural fields	Yes/No	High/Moderate/Low
Industrial areas	Yes/No	High/Moderate/Low
Human habitations and population density	Yes/No	High/Moderate/Low
Vulnerability to natural hazards	Yes/No	High/Moderate/Low
Other (specify)		
HAZARD ASSESSMENT INFORMATION		
		Magnitude
Kind of hazard		High/Moderate/Low
Frequency		High/Moderate/Low
Location of hazard		
When does it occur		Rarely/often/very often
Which sector of the community is most affected		
How many deaths?		
How many displacements?		
What used natural resource is affected most?	i.e., fish, fuelwood	

Analysing data

For Biodiversity Assessments:

- Calculate the total number of faunal species seen.
- Calculate the total number of flora species seen.
- For each taxonomic group of fauna, calculate the percentage in relation to the total species seen. For example, if you saw 100 species of fauna, and 20 species of birds, the percentage of birds seen will be 20%.
- Repeat this for abundance.
- The above will reveal which species is most common, which is most abundant, as well as which taxonomic group.
- Bar graphs can be used to display effectively the results obtained.
- Repeat for subsistence and commercial fish catches.
- For flora, calculate the percentage for trees, saplings, seedlings, shrubs, forbs, grasses, for a terrestrial habitat and emergents, submerged plants, floating plants for an aquatic habitat.
- The above will indicate which floral life forms are most dominant.

For Ecosystem Service Assessments:

For all services, rank the service per habitat and total the score as shown in a single example below.
5= very high; 4=high; 3=average; 2= poor; 1=none. An example is given below.

Service component	Habitat			
Provisioning services	Forest	Fallowland	Farmland	River
Fruits	4	-	4	-
Vegetables	3	-	5	1
Fish	-	-	-	5
Fuelwood	5	-	2	-
Medicinal species	5	-	3	1
Drinking water	-	-	5	5
Total				

Assessing drivers of change:

- Identify the most severe threat from the direct drivers listed.
- Identify the most severe threat from the indirect drivers listed.

Ranking assets:

As described in page 14 of Volume 2, rank the ecological assets using three general criteria a) uses and economic value, b) uniqueness, and c) pre-existing threats.

Identify, from the analyses carried out,

1. Which species/ecosystem has the most number of uses;
2. Which species/ecosystem is the most economically valuable;
3. Which species/ecosystem is the most over-exploited;
4. Which is the greatest threat to ecosystem services;
5. Which is the ecosystem service that impacts the most number of people; and
6. Which sector of the community is most affected by the above.

For more detailed biodiversity and ecosystem assessments that require a higher level of technical expertise, please refer to the next section of this volume, which details biodiversity assessment techniques.

Economic Valuation:

This section of the assessment requires a higher technical knowledge than is possible with community participation. For detailed methodology, please refer to the relevant chapter in this volume.

Livelihoods Assessment:

Assessing livelihoods:

- Calculate the percentage of households in the community that have higher/lower than national average and below poverty line incomes.
- Calculate the percentage of persons in the community that have higher/lower than national average and below poverty line incomes.
- Bar graphs can be used to display effectively the results obtained.
- Identify the most common source of income in the community.
- Identify subsistence and non market income in the community.
- Display, using bar graphs, the percentages of households engaged in fisheries, tourism and other natural resource-based livelihoods.
- Display, using bar graphs, the percentages of the community directly and indirectly involved in fisheries.
- Display, using bar graphs, the percentages of the community directly and indirectly involved in tourism.
- Display, using bar graphs, the assets in the community.
- Display, using a pie chart, the percentage of the community owning boats.

Assessing nutrition and water availability:

- Display, using bar graphs, the percentages of the community eating 1/2/3 meals a day.
- Display, using bar graphs, the percentages of the community eating a balanced diet.
- Display, using a pie chart, the per capita use of water: personal piped water/community piped water/spring water/personal well/community well/delivered water/purchased water, etc.
- Calculate the percentages of the community travelling far/average/close distances to collect water.

Assessing shelter:

- Display, using a pie chart, the percentages of the community living in permanent/non-permanent shelter.
- Display, using bar graphs, the percentages of the community living in owned/rented/shared housing.
- Display, using bar graphs, the percentages of the community that use timber, thatch etc. from nearby ecosystems.
- Display, using bar graphs, the frequency of the above use.
- Display, using bar graphs, the quantity of the above use.
- Display, using a pie chart, the types of fuel used in the community and percentage of use.
- Display, using a pie chart, the source of use of the above.
- Display, using a pie chart, the percentage of community dependent on fuelwood from the surrounding ecosystem.
- Calculate, using average household use, and the above, the total fuelwood requirement of the community.
- Calculate the percentages of the community travelling far/average/close distances to collect fuelwood.

Assessing health and sanitation:

- Calculate the percentages of the community that have diarrhoea per month.
- Calculate the percentages of the community that have infectious hepatitis per month.
- Calculate the percentages of the community that have acute respiratory infections per month.
- Calculate the percentages of the community that have chronic respiratory infectious per month.
- Display using bar graphs, the above data against national averages to identify whether the values are higher/on par with/lower than normal.
- Display using bar graphs, maternal mortality, infant and under 5 mortality rates, against national averages to identify whether the values are higher/on par with/ lower than normal.
- Display using bar graphs, proportion of children acutely and chronically malnourished, against national averages to identify whether the values are higher/on par with/lower than normal.
- Calculate the percentages of the community having easy/fair/difficult access to family health services.

- Calculate the percentages of the community having easy/fair/difficult access to health clinic services.
- Calculate the percentages of the community having easy/fair/difficult access to hospital services.
- Display, using a pie chart, the proportion of each type of health service used in the community.
- Display, using a pie chart, the proportion of each type of sanitation used in the community.
- Display, using a pie chart, the proportion of access to sanitation in the community.

These simple analyses will answer clearly the questions posed in page 13 of volume 2.

Initially,
- They will assess household benefits from ecosystem services and identify those services;
- Identify livelihood dependence on provisioning services; and
- Assess the impacts from ecosystem loss on human well-being: i.e., food and water security, health and sanitation, social relations, etc.

Hazard assessment:

The hazard assessment data will show which resource and which sector of the community is affected most by a specific hazard.

Through the data obtained from the integrated assessment, it is possible to build a complete picture of the status of the ecosystem and community, as well as about hazards that affect the given area. When this snapshot of ecosystem and human well-being is taken before a disaster - i.e., during the Prevention phase of disaster management, then it feeds technically sound information for decisions taken during the Mitigation and Preparedness phases, as well as actions taken during post disaster phases.

Biodiversity Assessment Techniques (for coastal ecosystems)[5]

Note that this is a technical annexe that requires advanced knowledge of field biology.

Inventorying and monitoring biodiversity – an overview

Why undertake a biological inventory?
Carrying out a biological inventory, like any other inventory, allows for the assessment of what biological entities are there in a given area. It establishes the composition and structure of the ecosystem, its status and health provides baseline information for informed decision making for disaster management, as well as sustainable development. Biological assessments also allows for the recognition of priority conservation areas. The analyses of data gathered from biological assessments facilitates sustainable harvesting of species. These assessments also serve to provide information for promoting nature-based tourism and increasing awareness about the environment. The ecosystem service assessment focuses on identifying the services being provided by the ecosystem, as well as the expected impacts on the provision of these services from changes in biodiversity composition and structure.

Measuring (Inventorying) versus Monitoring:
There is an important difference between measuring biodiversity and monitoring changes in biodiversity. Measuring/ inventorying biodiversity provides a snapshot of biodiversity (for example, yields a number of plant and animal species) at the time of measurement. It is useful for spatial comparisons of biodiversity. In contrast, monitoring involves measuring trends and changes over time, which would allow the researcher to determine the impacts of anthropogenic or natural factors on biodiversity. Monitoring also assesses whether management interventions are achieving the desired conservation goals and allows for adaptation of management. An inventory provides the necessary baseline data for monitoring the effects of anthropogenic disturbance or natural phenomena such as climate change on the biota.

Given below is a summary of biodiversity assessment techniques:

Rapid assessments:

Rapid field surveys:
These may be carried out by two or more observers, where opportunistic observations on plants and animals may be made through transect walks in and around a particular ecosystem. The morpho-species concept (categorising species according to morphological features) may be adopted for invertebrate groups (for example, crabs, molluscs, dragonflies) that do not have sufficient information for field identification.

Secondary information:
Information on the biodiversity of a particular site can be compiled through the review of secondary information such as published papers and articles, unpublished reports, as well as field notes maintained by protected area managers/rangers. Information on species could also be gathered through interviews with local communities (key informants).

Detailed assessments:

Pure inventory:
This involves a one-off activity to record the presence of plants and animals in a particular area, through systematic assessment techniques for different taxa (see following sections for details on specific sampling techniques for different taxa).

Dynamic inventory:
This involves the repetition of the pure inventory techniques at frequent and uniform intervals (for example, every month, every quarter, and every year) to document temporal changes in biodiversity in a particular area.

[5] Citation: Bambaradeniya, C. N. B (2007). Biodiversity Assessment Techniques (For Coastal Ecosystems) Colombo: Ecosystems and Livelihoods Group, Asia, IUCN. pp viii + 49. Unpublished document.

General methodology for a biodiversity survey:

a. *Selection of suitable personnel:*
- Naturalists, para-taxonomists[6];
- Botanists;
- Ecologists; and
- Suitable members from the local community (for example, NTFP collectors, hunters).

b. *Gathering secondary information*
- Previous work on the particular location/surrounding areas;
- Field guides on fauna and flora; and
- Spatial information (land use/vegetation maps, satellite images, aerial photographs, etc.).

c. *Reconnaissance survey:*
- Familiarising the team with the study area;
- Identifying major habitats and vegetation types;
- Selecting representative sampling sites;
- Verifying the practical application of pre-determined sampling techniques for fauna and flora; and
- Establishing contacts with local authorities/communities.

d. *Design and confirm field sampling techniques for fauna and flora:*
- Selecting taxa to be surveyed and finalise sampling techniques; and
- Designing field data templates for different taxa.

e. *Finalise sampling period and frequency:*
- Number of field visits/days and frequency of field visits to capture temporal changes related to seasonal events.

f. *Field survey:*
- Sampling of habitats, fauna and flora;
- Trying to identify vertebrates in the field itself, using field guides;
- Collecting faunal specimens sparingly (for species that needs to be verified in the laboratory);
- Collecting specimens of plants and preparing herbarium sheets for confirmation of identification;
- Sampling fauna should encompass both diurnal and nocturnal times;
- Identifying specific ecosystem services and dose-response relationships;
- Documenting conservation issues/threats to biodiversity; and
- Obtaining relevant geo-referenced information using a GPS instrument (i.e., boundaries of different habitat types, breeding sites of animal species, sites with specific threats to biodiversity, etc.).

g. *Analyses of data:*
- Using ecological diversity indices, univariate analyses (describing central tendency, dispersion, distribution, and multivariate analysis - for example, MANOVA, PCA, Cluster analysis);
- Evaluating ecosystem services related to biodiversity in the area, and analysing dose-response relationships;
- Identifying critical habitats for the conservation of biodiversity and ecosystem services for human well-being;
- Selecting suitable indicators for monitoring of biodiversity;
- Categorising conservation issues/threats, and identify severity using indicators; and
- Synthesise geo-referenced information for relevant spatial maps.

h. *Data presentation:*
- Presenting key information using visual tools (graphs, tables, charts, etc.);
- Preparing spatial maps with the aid of GIS technology (habitat/vegetation/land-use types);
- Locating threatened/endemic species; critical habitats; threat zones; rank areas according to ecosystem services etc.; and
- Obtaining a compendium of indicators to monitor biodiversity, and threats to conservation.

[6] Parataxonomists: (local assistants trained by professional biologists

Sampling techniques for coastal vegetation:

General methods to record plants:

Method	Life forms
Total counts (to assess density of large plants of low density)	Trees, shrubs
Visual estimates of cover – Braun-Blanquet Scale (% Cover of species)	Trees, shrubs, herbs and grasses, bryophytes, fungi and lichens, algae
Frame quadrats (cover, density, biomass)	Trees, shrubs, herbs and grasses, bryophytes, fungi and lichens, algae
Transects (changes of vegetation along an environmental gradient or through different habitats)	Trees, shrubs, herbs and grasses

Documentation of plant diversity in coastal ecosystems using total counts:

Category	Size	Plot size
Tall trees	Above 10cm dbh[7]	10m x 10m
Treelets, shrubs, palms lianas, herbs, etc.	dbh < 10cm, Height > 2m	5m x 5m
Grasses, herbs, saplings, etc.	Height < 2m	1m x 1m

The following calculations may be made with the information obtained from total counts:

For trees above 10cm dbh:

Radius (r) = Diameter/2; Basal area = πr^2 = Acm^2; 1ha = 10,000m^2

Basal area (m^2ha^{-1}) = A/400

Density (ha^{-1}):

Total individuals of species. A = X (in 20 x 20m)

Density of species A (ha^{-1}) = 25X

Relative Basal Area (%):

Basal area of species A = Z (m^2ha^{-1}); Total basal area of all species = X

Relative basal area of species A = Z/X x 100%

Relative density (%):

Density of species A = Z(ha^{-1}); Total density of all species = X(ha^{-1})

Relative density of species A = Z/X x 100%

Taxonomic richness:

Number of species/genera and families per ha

Important Value Index (IVI):

For woody plant species, the Important Value Index (IVI) can be calculated to indicate the abundance of species. IVI for a particular woody species = %Basal cover + %Density + % Frequency

For others (dbh < 10cm)

Taxonomic richness:

Number of species/genera and families per m^2

Richness of life floral forms

Number of trees/palms/lianas/shrubs/herbs/grasses per m^2

[7] dbh - Diameter at breast height is measured 1.2m above ground level, using a special diameter tape that is used for plant censuses.

The Braun-Blanquet scales for visual estimates of plant cover:

The plot sizes used to document the percentage cover of plants can vary depending on habitat, vegetation types, etc. The scale can be applied to determine the cover of plants in strip quadrats (i.e., 20m x 5m) or in quadrats (i.e., 5m x 5m).

Value	Cover
+	<1% cover
1	1-5% cover
2	6-25% cover
3	26-50% cover
4	51-75% cover
5	76-100% cover

Sampling techniques for coastal fauna:

(A) *Direct methods* – Visual encounter of live or dead animals.
(B) *Indirect methods* – Calls, footprints, faeces, prey hair/bone remains in carnivore scat samples, nests of birds, feeding signs.
(C) *Reliable information from local people* – Pictorial guides and photos of species could be shown to local communities to verify the presence of different faunal taxa.

Fish:

Method	Habitat
Fish catch surveys (commercial/subsistence)	Lagoons, estuaries, ponds.
Bank side counts	Shallow pools, slow-flowing shallow streams.
Snorkelling	Clear shallow pools, slow-flowing shallow streams, coral reefs.
Seine netting	Tanks, reservoirs, slow-flowing rivers, lagoons/estuaries.
Scoop netting	Shallow pools, slow-flowing shallow streams, marshes.
Cast netting	Tanks, reservoirs, slow-flowing rivers, lagoons/estuaries.
Gill netting	Tanks, reservoirs, slow-flowing rivers, lagoons/estuaries.

Herpetofauna (Amphibians and Reptiles):

Method	Habitat
Visual Encounter Surveys (VES) and hand-capturing A) Transect sampling; B) Quadrat sampling	Mangroves, saline marshes, grassland, scrubland.
Pitfall and fence trapping	Mangroves, saline marshes, grassland, scrubland.
Netting	Ponds, tanks.
Nocturnal road cunts	Roads that adjoin/cut across mangroves, coastal scrubland, lagoons and estuaries.

Avifauna:

Method	Habitat
Timed point counts (for example, 15 minute radial point counts)	Estuaries, lagoons, tanks, saline marshes, beach, mangroves.
Line transects	Mangroves, saline marshes, maritime grasslands.
Mist netting	Mangroves.

Mammals:

Method	Habitat
Belt transects	Mangroves, saline marshes, maritime grasslands.
Nocturnal road counts	Roads that adjoin/cut across mangroves, coastal scrubland, lagoons and estuaries.
Cage trapping	Mangroves, saline marshes, maritime grasslands.
Camera trapping	Mangroves, saline marshes, maritime grasslands.

Selected coastal invertebrates:

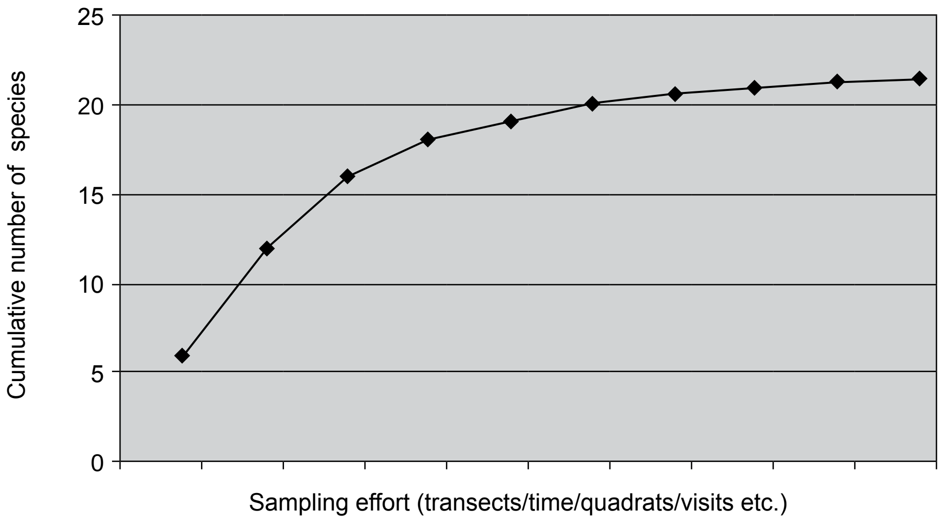
Group	Method	Habitat
Corals	Line transects (50m)	Coral reefs
Butterflies, dragonflies and damselflies	Line transects/sweep netting	Coastal scrubland, mangroves, coastal ponds
Crabs	Bucket traps (1litre)	Ponds, mangroves
Molluscs	Quadrat sampling	Mangroves, lagoons, mudflats

Data analysis:

Species Recruitment Curves:

A graph is plotted using sampling effort and cumulative species recorded. The curve will reach an upper asymptote (plateau), when all species in a given area are documented adequately.

Figure 1: Species recruitment curve



Ecological diversity indices:

Diversity measurement	Index	Equation	Definition of terms
Species richness	Margalef (D_{Mg})	D_{Mg} = (S-1) /ln N	S = Total species N = Total individuals
Species diversity	Shannon (H')	H' = p_i ln p	p_i = Proportion of individuals in *i*th species p_i = n_i/N

Statistical methods:

- Univariate methods (for example, ANOVA)
- Multivariate methods (for example, Cluster Analysis)

Assessment of the threats to coastal biodiversity:

Major threat	Contributory factors	Indicators to assess severity
Habitat deterioration/degradation	Reclamation/transformation	Area reclaimed (ha/acres/km^2).
	Clearing of vegetation (mangrove and scrubland)	Area cleared (ha/acres/km^2).
Pollution	Organic pollution	Levels of DO, BOD5, COD. Oil spills/leakages (amount leaked/ spilled, areas affected, animals (fish, birds, etc.) affected.
	Chemical effluents	NO_3 and PO_4 levels, algal blooms. Levels of heavy metals, biocide residues, indicator biota (i.e., odonates, molluscs, annelids, surface insects, micro-crustaceans etc.).
	Sewage disposal	Coliform bacteria, algal blooms.
Direct loss/Exploitation	Poaching	Information gathered from forest rangers (frequency of incidences). Number of traps observed in the wild. Frequency of gunshots heard at night. Bushmeat available in surrounding areas.
	Removal of vegetation	Number of large trees cut (based on remaining stumps). Information gathered from the Department of Wildlife/Forest Department (frequency of incidences).
	Over-exploitation of live animals and plants for commercial trade/ornamental purposes/medicinal purposes/ consumption	Direct field observations of species collections. Data gathered from collectors (number of individuals collected, weight, etc.) Data gathered from government departments.
Spread of invasive alien species	Introduction and spread of invasive alien flora	Area of invasion (ha/acres/km^2)
	Introduction and spread of invasive alien fauna	Population numbers if IAS fauna. Reduction of native fauna due to predation (area).
Natural hazards	Floods	Number of dead animals.
	Storms/hurricanes	Number of dead animals, vegetation destroyed (area/number of trees).
	Drought	Number of dead animals and trees.

Criteria for selection of critical habitats for conservation:

a. *Ecological attributes:* Areas with high species richness and habitat diversity.

b. *Ecological functions and services:* Areas that provide a large number of provisioning, supporting, regulating and cultural services, as well as areas that are are feeding and breeding sites of threatened species.

c. *Naturalness*: The extent to which the area has been protected from, or has not been subject to, human-induced change.

Evaluation of ecosystem services and dose-response relationships related to coastal ecosystems:

Ecosystem services:

Ecosystem services include provisioning services, supporting services, regulating services and cultural services (see below for examples)

Provisioning services related to coastal ecosystems:

Service component	Coral reefs	Seagrass	Beach scrub	Mangrove
Lime	+	-	-	-
Food fish	+	+	-	+
Ornamental fish	+	+	-	-
Curios/ornaments	+	-	-	-
Fruits/vegetables	-	+	-	+
Timber/fuelwood	-	-	-	+
Medicines	-	-	-	+
Sand	-	-	+	-

Supporting services related to coastal ecosystems:

Service component	Coral reefs	Seagrass	Beach scrub	Mangrove
Biodiversity sustenance	+	+	+	+
Primary production	-	+	-	+
Nutrient cycling	+	+	-	+

Regulating services related to coastal ecosystems:

Service component	Coral reefs	Seagrass	Beach scrub	Mangrove
Carbon sequestration	+	+	-	+
Prevention of coastal erosion	+	+	+	+
Protection from storms and tidal surges	+	-	+	+
Flood control	-	-	-	+
Pollution control/treatment	-	-	-	+

Cultural services related to coastal ecosystems:

Service component	Coral reefs	Seagrass	Beach scrub	Mangrove
Coastal recreation and tourism	+	+	-	+
Education and research	+	+	+	+
Sustenance of traditional knowledge	+	-	-	+

Dose-response relationships related to ecosystem services:

Any changes in ecosystem services can be documented in response to human interventions or effects of natural hazards as a dose-response relationship. These changes can be documented by biodiversity monitoring surveys. These may include changes such as the following:

– Anthropogenic negative impacts on ecosystems (i.e., reclamation of wetlands, forest clearance);
– Anthropogenic positive impacts on ecosystems (i.e., reforestation, dredging of silted mangroves); and
– Natural hazard-related negative impacts (i.e., damage associated with hurricanes, drought, floods, etc.).

The responses related to specific interventions can be identified using suitable biodiversity and socio-economic indicators, as shown in the following examples:

Clearing coastal vegetation for development (negative impact):

Impact on ecological functions and services	Physical impact of change in functions and services
Reduction of timber and fuelwood	Over-exploitation of trees in remaining sites.
Reduction of mangrove fruits	Increase in damage to home garden fruit crops by bats.
Loss of refuge/breeding sites for fish and other animals (i.e., birds)	Decrease in fish catches; decrease in species richness and abundance of birds.
Increase in coastal erosion	Loss of beach area; decrease in turtle nesting.
Decrease in recreational and aesthetic value	Decrease in tourist visitation.

Dredging a mangrove/lagoon to remove excess silt/sand (positive impact):

Impact on ecological functions and services	Physical impact of change in functions and services
Increase in fish production	Increase in fish catches; increase in species richness and abundance of aquatic birds.
Increased efficiency in nutrient recycling and tidal flushing	Increase in the number of seedlings established in mangroves; increase in crustaceans.
Increase in primary productivity	Increase in above ground productivity (stock).
Increased capacity for flood control	Reduction in flashfloods.
Increase in recreational and aesthetic value	Increase in tourist visitation.

Preparation of maps:

High quality remote sensing coverage, combined with Geographic Information System (GIS) technology and ground surveys facilitated with a Global Positioning System (GPS) instrument will lead to the preparation of accurate maps. Such maps make an important contribution to biodiversity monitoring.

Initially, a one inch map on vegetation/land-use types in a given area should be digitised and divided into equal-sized grids (i.e., 1 x 1km^2). The vegetation/land-use types in each grid should be analysed with remote sensed images and/or aerial photographs, and further verified through field visits covering representative areas.

References

Kitching, R. L., Vickerman, G., Laidlaw, M. and K. Hurley (2000). *The Comparative Assessment of Arthropod and Tree Biodiversity in Old-World Forests: The Rainforest CRC/Earthwatch Protocol Manu*al. CRC, Cairns: Cooperative Research Centre for Tropical Rainforest Ecology and Management. Technical Report. Rainforest. 70pp.

Magurran, A (1988). *Ecological Diversity and its Measurement*. Princeton: Princeton University Press. 179 pp.

Noss, R. F. (1990). Indicators for monitoring biodiversity: A hierarchical approach. *Conservation Biology* 4 (4):355-365.

Sutherland, W. J (1996). *Ecological census techniques – A handbook*. Cambridge, UK: Cambridge University press. 448 pp.

UNEP (2006), *Marine and coastal ecosystems and human well-being: a synthesis report on the findings of the millennium ecosystem assessment*. UNEP. 76pp.

Wilson, E. O (1988). *Biodiversity*. Washington DC: National Academic Press. 521pp.

Rapid Environmental Impact Assessments

This annexe is extracted from the Guidelines for Rapid Environmental Impact Assessment developed by Benfield Hazard Research Centre, University College London and CARE International[8] as well as OECS (2003) Technical Manual for Post-disaster Rapid Environmental Assessments, Volume 1 & 2[9].

'A Rapid Environmental Impact Assessment (REA) is a tool to identify, define, and prioritise potential environmental impacts in disaster situations. REAs are simple, consensus-based qualitative assessment process, involving narratives and rating tables, and are used to identify and rank environmental issues and follow-up actions during a disaster. The REA is built around conducting simple analysis of information in the following areas:

- The general context of the disaster;
- Disaster related factors which may have an immediate impact on the environment;
- Possible immediate environmental impacts of disaster agents;
- Unmet basic needs of disaster survivors that could lead to adverse impact on the environment; and
- Potential negative environmental consequences of relief operations' (CARE, 2003).

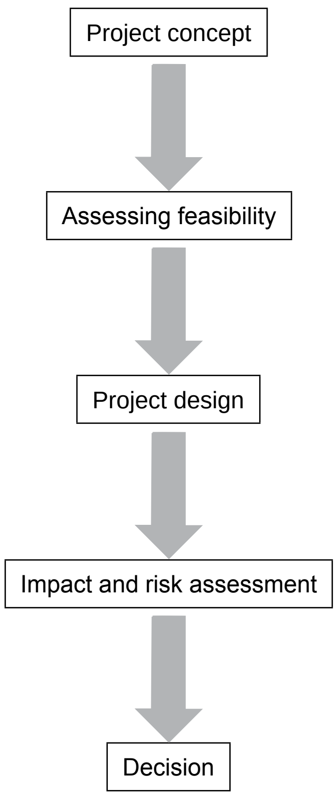
Under non-disaster conditions, a longer, more detailed process of environmental impact assessments is followed.

'An Environmental Impact Assessment (EIA) is an assessment of the possible impact - positive or negative - that a proposed project may have on the natural environment. The purpose of the assessment is to ensure that decision makers consider the ensuing environmental impacts to decide whether to proceed with the project.' (http://en.wikipedia.org/wiki/Environmental_impact_assessment).

The following matrix shows how an EIA aids in the decision making process.

Figure 2: Decision making matrix (Source: D. Weerakoon, personal comm.)

Socio-economic	Environmental
+	+
+	-
-	+
-	-



[8] Rapid Environmental Impact Assessment in Disaster Response. Copyright © 2003 Cooperative for Assistance and Relief Everywhere, Inc. (CARE). Used by Permission, summarised by Devaka Weerakoon, and

[9] OECS (2003). Technical Manual for Post-disaster Rapid Environmental Assessments, Volume 1 & 2 . http://www.caribank.org/titanweb/cdb/webcms.nsf/AllDoc/9E2B73C29C5CB1A1042573D100546360/$File/OECSManualVolume_1_Final.pdf

Listed below are some of the socio-economic queries that arise with respect to a proposed project (D. Weerakoon, personal comm.):

- Is the project likely to have a significant positive impact in the overall economy of the country?
- What are the impacts it will have on socio-economics of the community?
  - Will the project generate new jobs?
  - Will the project improve the marketability of community products?
  - Will the project improve infrastructure - such as health, education, transport?
  - Will the project relocation of people from their traditional homeland?
  - Will the project increase or decrease risk?
  - Will the project increase or decrease the risk of disasters?
  - Will the project have negative impacts on cultural heritage?

Similarly there are environment-related queries that arise with respect to a proposed project:

- What are the impacts on the physical, chemical and biological components of the environment
  - in the immediate impact area?
  - in upstream and downstream impact zones?
- What are the impacts on the main habitats and species?
  - What is the inventory of ecosystems and species?
  - What are the critical ecosystems and species?
- What are the impacts on the chemical and physical environment?
  - Is there contamination of soil, water or air?
  - Is there destabilisation of soil, changes in flow patterns etc.?
- What is the extent of the significance of these impacts - heavy/moderate/low?
  - What is the magnitude of impact, area affected, and the duration of the effect?
  - Do these impacts need mitigation and can they be mitigated?
  - If so which ones and how?

Valution of impacts:

These impacts can be valued economically.

- Some impacts can be valued directly, such as:
  - Loss of income or income generated through the project;
  - Value of products harvested from nature;
  - Value of mitigation activities required.
- Some impacts cannot be valued directly, such as:
  - Services provided by ecosystems;
  - Loss of critical habitats and species.
- There are different valuation techniques available for such valuation (See section on economic valuation methodology).

Mitigation of impacts:

Mitigation is the reduction of adverse impacts of the project. However, all adverse impacts cannot be mitigated, and mitigation of some impacts may not be cost effective. Therefore, there should be a critical analysis in order to identify the impacts that must be mitigated and a mitigation plan developed for each of the identified impacts. The mitigation plan should

  - adopt an adaptive approach;
  - should include a time-bound set of activities;
  - should include costs for each of the activities and the mode of financing; and
  - parties responsible for activities (develop Memoranda of Understanding).

Monitoring mitigation:

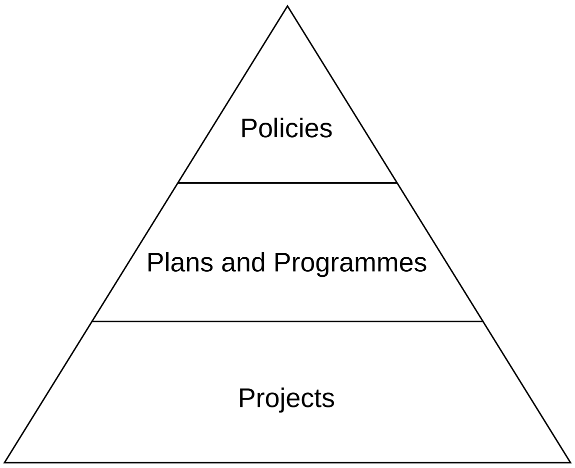
- Monitoring should take place during the construction and implementation phase to ensure that
  - the recommendations of the EIA are carried out;
  - that proposed mitigation measures are carried out as defined;
  - that best practices are followed during project implementation.
- A set of parameters to be monitored should be identified;
- Then, the parties responsible for monitoring, indicators to be monitored, monitoring frequency and method of financing should be defined clearly;
- A committee should be formed to evaluate the results of the monitoring programme and take necessary action.

Data collected from biodiversity and ecosystem service assessments facilitate the EIA process.

Strategic Environmental Impact Assessment

Strategic Environmental Assessment (SEA) is a system of incorporating environmental considerations into policies, plans and programmes. It is sometimes referred to as Strategic Environmental Impact Assessment (http://en.wikipedia.org/wiki/Strategic_Environmental_Assessment). SEAs look at the impacts of many projects at a macro level as shown in the figure below.

Figure 3: Strategic Environmental Assessment (Source: D. Weerakoon personal comm.)



However, in a context of a disaster, EIAs become inappropriate (CARE, 2003) for reasons shown below.

Table 1: Contextual differences between normal and disaster assessments
(Source: UNHCR and CARE International.)

Normal conditions	Disasters
Considerable lead time	Sudden onset
Legal requirement often exists (country and/or donor)	Rarely a legal requirement but some donor may ask for it
Deliberate and pro-active	Reactive
Will take time, be thorough and extensive: comprehensive data collection	May need to be partial in coverage
'No project' option is a possible outcome	'No project' outcome is not an option
Location chosen	Unpredictable location
Duration planned	Uncertain duration
Beneficiary population identifiable and static	Beneficiary population heterogeneous and dynamic
Environmental goals may be made compatible with socio-economic ones	Priority given to 'life saving' activities sometime difficult to reconcile with environmental goals

Rapid Environmental Assessments

Rapid Environmental Assessments are carried out in the period immediately following a disaster to determine the degree of damage to the environment and ecosystem services and the appropriate response (OECS, 2003).

The Rapid Environmental Impact Assessment (REA) process is designed to:

1. Collect information needed to assess environmental impacts;
2. Provide simple steps for analysing this information to identify important issues; and
3. Review procurement decisions to reduce the potential negative environmental impacts of emergency assistance (CARE, 2003).

Rapid Environmental Impact Assessments are designed with the following considerations that

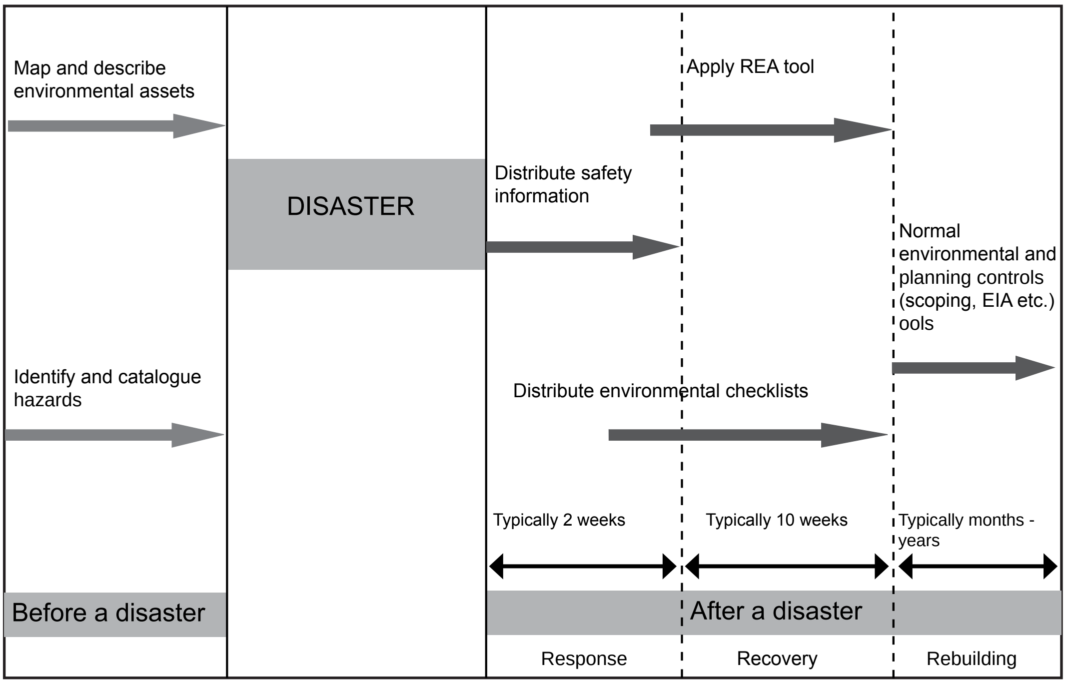
- The environment is considered as an economic asset (as natural capital) that provides various ecosystem services, as described in Volume 1 of this manual.
- The environment also provides welfare through the benefits of non-use values. (See Volume 1.)
- That existing constraints such as:
  – limited availability of time for undertaking the assessment;
  – lack of information on the environment;
  – methodological problems derived from the absence of markets for most of environmental services must be accommodated in the design.

Table 2 below shows the REA process in the context of the disaster management cycle.

Table 2: The REA process in context (adapted from OECS, 2003)

Stage in disaster management cycle	Activities to be undertaken	Outputs
Preparedness	Mapping and describing environmental assets (See Volume 2).	Database of significant environmental assets.
	Hazard mapping and risk assessment (See Volume 2).	Database of hazards and risk.
Disaster		
Response (Damage assesssment: 48hr for an Initial Damage Assessment to several weeks for a Detailed Sector Assessment)	Provide safety information.	Hazard summaries.
	Assess damage to environmental assets.	Systematic categorisation of damage, including financial value.
Response: (typically lasting 2 weeks); Recovery: (typically lasting 10 weeks)	Implement measures to minimise damage to environmental assets.	Environmental control checklists.

Figure 4: Environmental protection in disaster response (adapted from OECS, 2003)



Assessing damage (sourced from OECS, 2003):

Immediately after a disaster, the following needs to be assessed.

- Date and location;
- Nature of incident/threat and cause;
- Impact/potential impact;
- Secondary effects;
- Need for potection of population;

- Evacuation need (if any);
- Life support systems affected/under threat;
- Emergency clean-up/containment measures required;
- Special technical assistance needed (if any).

The damage is then rated according to a) the intensity of the damage and b) the spatial extent of the damage.

Intensity of damage:
This is usually rated as low/medium/high and presented in a matrix as shown below.

Table 3: Rating damage intensity (Sourced directly from OECS, 2003)

Intensity of damage	Definition		
	Individuals	Functioning of asset	Recovery of asset
Minor	Few affected	No effect	Natural
		Limited effect	
Medium	Marked effects on several	No effect	Natural
		Moderate effect	Requires appropriate environmental protection measures
Major	Significant effects on many	Irreversible impairment	Requires appropriate environmental protection measures

Extent of damage:

Extent of damage can be classified simply as
- Less than 10% of the asset affected;
- 10-25% of the asset affected;
- 25-50% of the asset affected; and
- More than 50% of the asset affected.

Based on the intensity and extent of damage, a matrix of damage assessment can be constructed as follows:

Table 4: Overall damage assessment (Sourced directly from OECS, 2003)

Intensity of damage	Area damaged			
	<10%	10-25%	25-50%	50%
Minor	Low	Low	Moderate	High
Medium	Low	Moderate	High	High
Major	Moderate	Moderate	High	Extreme

Mitigation measures:

Mitigation must be assessed on a case-by-case basis, but the following matrix may be used as a guide.

Table 5: Response options (Sourced directly from OECS, 2003)

Degree of damage	Response options	
	Use	Corrective/preventive action
Low	No restriction	Minor actions to address specific issues
Moderate	Some restriction	Minor actions to address specific issues
High	Significant medium-term restriction	Some corrective actions required
Extreme	Long-term restriction	Intensive corrective action

Economic Valuation Methodology

Figure 5: Steps, stages and methods for the valuation of wetlands and descriptions of different valuation techniques, sourced directly but simplified from Emerton and Bos (2004)[10] and Springate-Baginski, et al. (in press)[11].

Note that this is a technical annexe that requires considerable knowledge of environmental economics. Economic valuation follows a series of iterative steps that are complementary, and run parallel, to those carried out in biodiversity and livelihood assessment (Sourced directly from Springate-Baginski, et al., in press).

Figure 5: Steps, stages and methods for the valuation of wetlands

Stage	Step	Activity	Output
STAGE I: Setting the study and the parameters	1. Defining the study goal and management focus	Identifying the management issue to be addressed and questions to be answered by the study	Statement of the study objectives and questions to be answered in the context of a particular management issue
	2. Identifying the scale and boundaries of the study	Defining who and what will be included in the study, at what level of detail	Conceptual demarcations of the socio-economic group(s) and physical location(s) on which the study will focus
STAGE II: Defining wetland values	3. Identifying and categorising wetland values	Categorising values according to TEV and assessing their distribution between stakeholders	Full description of wetland economic costs and benefits
	4. Selecting the costs and benefits to be valued	Prioritising wetland values in terms of study aims and management issue	List of wetland economic costs and benefit/costs that will form the focus of the study
	5. Choosing the appropriate valuation techniques	Matching valuation methods to selected costs and benefits	Relating wetland benefits/ costs to economic valuation techniques
STAGE III Valuing wetland costs and benefits	6. Undertaking the valuation exercise: carrying out data collection	Formulating lists of data and information required, and their sources	List of data requirements and sources for valuing selected wetland benefits and costs
		Implementing methods to collect required data and information	Data that can be used to calculate selected wetland economic values
STAGE IV Analysing and presenting data for decision-making	7. Analysing and expressing the valuation data	Relating values to the management issue or scenario under study	Understanding the economic implications of particular wetland management scenarios, expression for changes as indicators for decision-making support
		Linking wetland status or management options to changes in value	
	8. Presenting management and decision-making conclusions	Relating the findings of the valuation study to ongoing management issues, and targeting this to particular audiences and aims	Communication of the economic status and value of the wetland as it related to management priorities and threats

[10] Emerton, L. and E. Bos (2004) Counting Ecosystems as Water Infrastructure. Gland: IUCN. 88 pp.

[11] Springate-Baginski, O., Darwall, W., Emerton, L., Allison, E., McIvor, A. and C. Bambaradeniya (in press). A Toolkit for Integrated Wetland Assessment. Cambridge: Freshwater Biodiversity Assessment Unit, International Union for Conservation of Nature.

Setting the study scope and parameters (Stage I)

Step 1: Defining the study goal and management focus:

Economic valuation cannot take place in isolation: it must be directed by a particular management or policy issue that needs to be addressed, or a particular decision that needs to be made about the use of funds, land or other resources.

The information that is generated by a valuation study assists in understanding or dealing with this issue, or in making this decision. It is the management or policy issue which determines the scope, objective and parameters of the valuation study — what it will include, what it will exclude, which values will be considered, and to what ends.

The very first step in wetland valuation is, therefore, to define and understand the management context in which the study is taking place, and the management need and issue it addresses. This, in turn, determines the questions which have to be answered by the valuation study, and the information it needs to generate.

It is impossible to define before what these questions will be — obviously the specific management issue that is being addressed by the valuation study will vary in different cases. There are, however certain types of issues which are faced commonly by wetland managers, and for which valuation studies can provide important information to assist in decision-making. For example:

- Justifying or making a case for wetland conservation;
- Identifying wetland financing needs and mechanisms;
- Assessing the impacts of upstream developments on wetland status;
- Choosing between particular wetland management regimes;
- Assessing the profitability of different sustainable use options;
- Looking at needs and niches for local benefit sharing;
- Setting fees for wetland use, or penalties or fines for illegal activities;
- Estimating the relative profitability, or returns, to different investment, land and resource use options in and around wetlands.

Step 2: Identifying the scale and boundaries of the study:

This step involves defining who and what will be included in the study and at what level of detail.

It is rarely necessary, or practical, for a valuation study to consider each and every value, stakeholder or unit of area associated with a given location. In line with the overall objective or management/policy focus, it is necessary to define the boundaries of the valuation study, and to demarcate the area in which it will actually work. The second stage of a valuation study is, therefore, to identify the scale and boundaries within which the study will focus, including the geographic boundary of the site to be studied, its socio-economic boundary (or user/beneficiary population), as well as the time-period to be incorporated in the study.

Defining wetland values (Stage 2)

Step 3: Identifying and categorising wetland values:

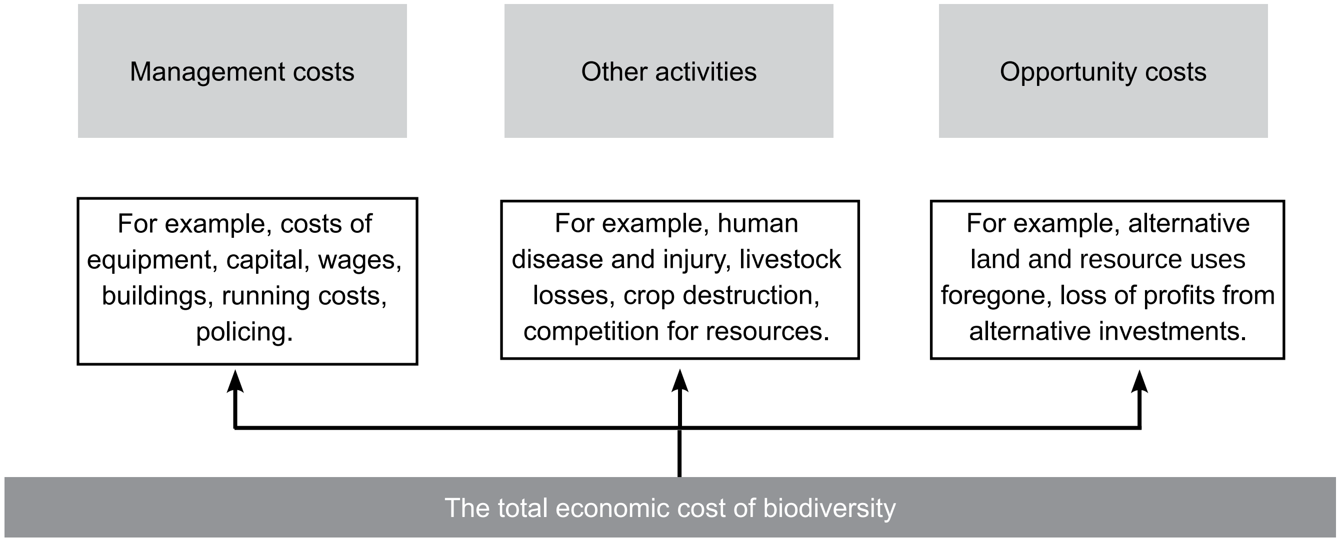
This step involves prioritising wetland benefits and selecting those which will be valued in the study. It should result in a list of wetland economic costs and benefits that will form the focus of the study. Field checklists (#1 and 2) for identifying, listing and selecting wetland costs and benefits to be valued are provided at the end of this chapter.

- Wetlands yield multiple goods and services, and also acquire a range of economic costs. In any valuation study, it is important to define and categorise all the costs and benefits that have relevance to the given wetland. These values should include both direct and indirect values. (See Figure 11, page 36, Volume 1.)

Costs:

There is a tendency, especially in conservation-based assessments, to ignore the fact that wetlands generate a wide variety of costs, which impact on people's livelihoods and economic activities. As in the case for benefits, wetlands costs have tended to be defined narrowly in the past. Valuation must take account of the full range of economic costs associated with wetlands as illustrated in Figure 5 below.

Figure 6: The total economic cost of wetlands (After Emerton and Bos, 2004)



- **Management costs**: management costs are direct physical expenditures on the equipment, infrastructure and human resources required to manage wetlands;
- **Opportunity costs**: opportunity costs are the alternative uses of time, land, money and other resources required for wetlands conservation which could have generated income and profits had they been used differently or allocated elsewhere such as agricultural land uses or unsustainable resource utilisation activities foregone in wetland areas, wetlands polluting industrial technologies and production processes precluded or upstream water developments prevented;
- **Costs to other activities:** costs to other activities are the damage and interference to human and economic activities caused by wetlands resources and species, including human and livestock disease and injury, crop pests and sources of competition over resources.

All of these costs lead to economic losses because they require cash, require expenditures, decrease income or reduce livelihood options. Valuation, in addition to making a monetary estimate of wetlands benefits, attempts to quantify the total economic costs associated with wetlands.

Step 4: Selecting the costs and benefits to be valued

In most cases it is impossible to value each and every economic benefit and costs associated with a particular wetland. For this reason, it is necessary to decide on which benefits and costs the study will value, and how. Once these have been identified, they need to be prioritised in terms of their importance to the overall goal and objectives of the study (which, in turn, is determined by its management focus).

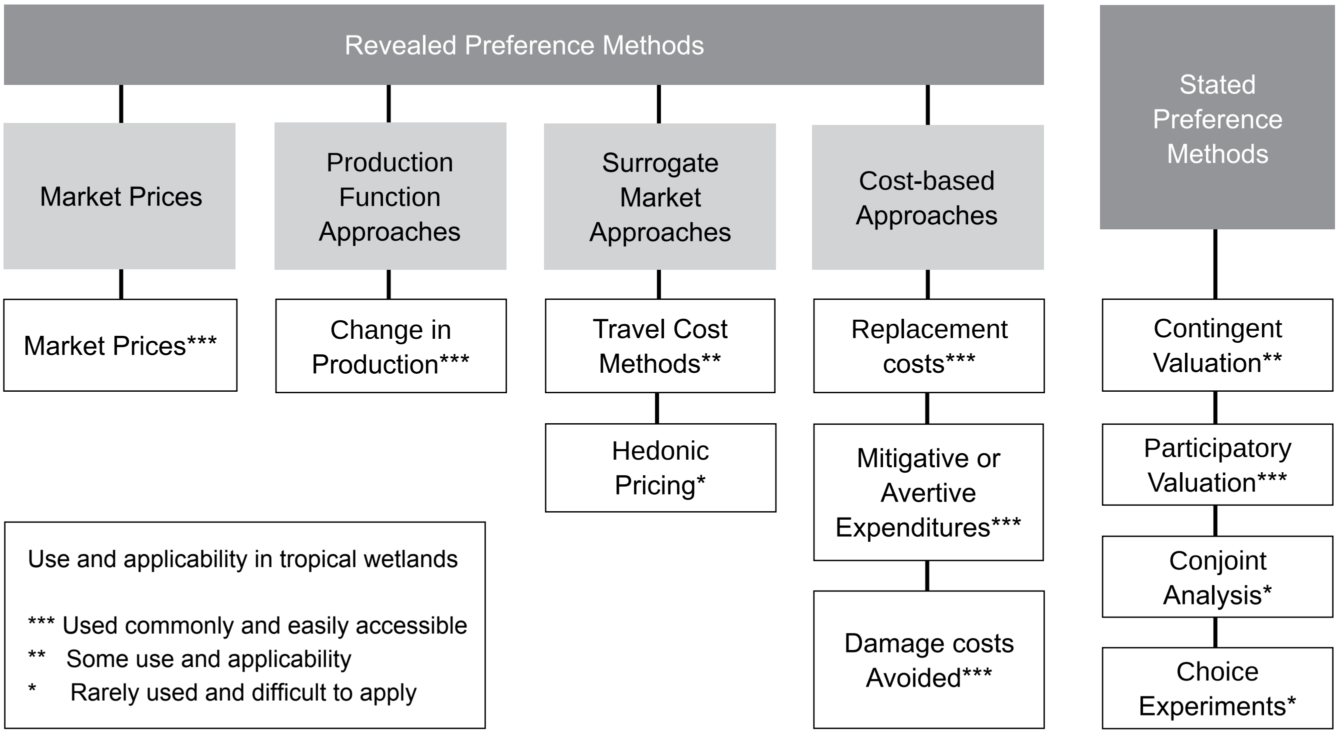
Step 5: Choosing the appropriate wetland valuation techniques

This step involves examining the economic methods and techniques that will be used to value selected wetland benefits/costs. It should result in a list relating wetland benefits/costs to economic valuation techniques. A field checklist (#3) for choosing wetland valuation techniques is provided at the end of this annexe.

A wide variety of methods are now available with which to quantify wetland values. Each method has different requirements, is more or less applicable to different types of wetland costs and benefits, and has varying suitability in different situations. For this reason, having defined and prioritised which costs and benefits the valuation study will focus on, it is necessary to decide on which method(s) will be used to determine the value of each.

After identifying the values and the costs and ranking them, the values and the costs need to be assigned a monetary value. There are a number of techniques that are used to do this, which can be categorised in a number of ways. One way of classifying wetland valuation methods is to distinguish between revealed preference methods (those which rely on observing people's behaviour to ascertain the value of wetland goods and services) and stated preference methods (those which directly ask people the value they place on wetlands). These are illustrated in Figure 6, and described below.

Figure 7: Methods for wetland valuation (From Emerton and Bos, 2004)



- **Market prices**: This approach looks at the market price of ecosystem goods and services as they are bought or sold in the market.
- **Production function approaches**: These approaches, including effect on production, attempt to relate changes in the output of a marketed good or service to a measurable change in the quality of quantity of ecosystem goods and services by establishing a biophysical or dose-response relationship between ecosystem quality, the provision of particular services, and related production.
- **Surrogate market approaches:** These approaches, including travel costs and hedonic pricing, look at the ways in which the value of ecosystem goods and services are reflected indirectly in people's expenditures, or in the prices of other market goods and services.
- **Cost-based approaches**: These approaches, including replacement costs, mitigative or avertive expenditures and damage costs avoided, look at the market trade-offs or costs avoided of maintaining ecosystems for their goods and services.
- **Stated preference approaches:** Rather than looking at the way in which people reveal their preferences for ecosystem goods and services through market production and consumption, these approaches ask consumers to state their preference directly. The most well-known technique is contingent valuation, participatory valuation is gaining currency particularly in situations where wetland use is primarily for subsistence purposes, while less commonly-used stated preference valuation methods include conjoint analysis and choice experiments.

All of these methods are elaborated in detailed in the next few pages. Different categories of method are more or less suitable for different kinds of wetland costs and benefits. Market price and surrogate market price techniques are most suitable for wetland direct values, while wetland indirect values are commonly measured using cost-based and production function approaches. Stated preference methods are, in principle, applicable to any category of wetland benefit, and provide some of the few available methods which can be used to estimate option and existence values.

Valuing wetland costs and benefits (Stage 3)

Step 6: Undertaking the valuation exercise: carrying out data collection:

This step involves formulating a list of the data that must be collected to allow the economic valuation of wetland benefits. It should result in a list of data requirements for valuing selected wetland benefits and costs. A field checklist (#4) for identifying data needs and sources for the valuation exercise is provided at the end of this annexe.

Having prioritised the wetland costs and benefits to be valued, and selected the most appropriate methods by which to do this, it is necessary to determine what data will be required to apply the chosen valuation methods and to identify how these data will be collected. It should be underlined that before starting valuation fieldwork, it is important to have thought through what data will be required, and how they will be obtained. Typically, a valuation study will use various data collection techniques and information sources, including both primary and secondary data collection:

- **Literature review**: including a review of similar valuation studies carried out in other areas or countries, as well as of documents and reports that contain information on the wetland under study such as project eports, government statistics and records, scientific articles and publications.
- **Expert consultation**: including with technical experts (for example, sociologists, hydrologists, biologists and ecologists, civil engineers) as well as with the various stakeholders who are involved in managing and using the wetland (for example, government officials, NGOs, community leaders, local households, wetland user groups).
- ‘**Traditional’ socio-economic information gathering techniques**: such as questionnaires, interviews and statistical analysis.
- **Participatory techniques**: such as focus group interviews, Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) techniques.

Having identified the data sources and collection techniques, the next thing to do is to actually apply the selected valuation methods. A detailed description of each of the main valuation techniques is given below, which is primarily drawn from IUCN’s toolkit for valuing water-based ecosystem services (Emerton and Bos 2004).

Applying wetland valuation techniques (Stage 3)

Market price techniques:

Overview of the method:
The simplest, most straightforward and commonly-used method for valuing any good or service is to look at its market price: how much it costs to buy, or what it is worth to sell. In a well-operating and competitive[12] market these prices are determined by the relative demand for and supply of the good or service in question, reflect its true scarcity, and equate to its marginal value[13].

In theory, market price techniques can be applied to any ecosystem good or service that can be freely bought or sold. They are particularly useful for valuing the resources and products that are harvested from water-dependent ecosystems, for example, timber, fuelwood, fish, or non-timber forest products.

Data collection and analysis requirements:
There are three main steps involved in collecting and analysing the data required to use market price techniques to value ecosystem goods and services:
- Find out the quantity of the good used, produced or exchanged;
- Collect data on its market price;
- Multiply price by quantity to determine its value.

[12] A market is said to be competitive when there are a large number of buyers and sellers, there are no restrictions on market entry, buyers and sellers have no advantage over each other and everyone is generally informed about the price of goods.
[13] Marginal value is the change in value resulting from one more unit produced or consumed

These data are generally easy to collect and analyse. Market information, including historical trends, can usually be obtained from a wide variety of sources such as government statistics, income and expenditure surveys, or market research studies. In most cases it will be necessary to supplement these secondary sources with original data, for example through performing market checks or conducting some form of socio-economic survey.

When applying this technique it is important to ensure that the data collected cover an adequate period of time and sample of consumers and/or producers. Factors to bear in mind include the possibility that prices, consumption and production may vary between seasons, for different socio-economic groups, at different stages of the marketing or value-added chain, and in different locations.

Applicability, strengths and weaknesses:
The greatest advantage of this technique is that it is relatively easy to use, as it relies on observing actual market behaviour. Few assumptions, little detailed modelling, and only simple statistical analysis are required to apply it.

A major disadvantage is the fact that many ecosystem goods and services do not have markets or are subject to markets which are highly distorted or irregular. In such cases, it is not appropriate to use market price techniques.

- Ecosystem services such as catchment protection or nutrient retention are rarely available for purchase or ale. Because they have many of the characteristics of public goods[14], it is in fact questionable whether the market can ever accurately allocate or price them.
- Many ecosystem goods and natural products are used at the subsistence level. They are not traded in formal markets, and are consumed only within the household.
- There exist a wide variety of subsidies and market interventions which distort the price of natural products or ecosystem-dependent goods. Examples include subsidies to water and electricity, centrally-set royalties and fees for products such as timber, and state controlled prices for basic food and consumer items.
- Because markets for most ecosystem goods and services are not well-developed, they tend not to be competitive, and prices are a poor indicator of true social and economic values. This may be the case where there is an additional social or environmental premium attached to natural goods and services, where there are only a small number of buyers and sellers, or where there is imperfect market information.
- In many cases, even where an ecosystem good has a market and a price, it is impossible to measure the quantities produced or consumed. Especially at the subsistence level, natural resource consumption and sale is often highly seasonal or irregular. For example, particular products are only available at particular times of the year, are used under special conditions, or are collected and used on an opportunistic basis. Ecosystem goods are also often collected and consumed as part of a bundle of items or have high levels of substitution[15] or complementarity[16] with other goods. For example, they are used only when other products are unavailable or unaffordable, or they form occasional inputs into the production of other goods.
- Even where an ecosystem good or service has a market, and quantities bought or sold can be measured, prices do not tell us how important this good or service is to society, nor how much some buyers would actually be willing to pay.

In such cases it is usually necessary to use alternative valuation techniques, such as those described below.

Effect on production techniques:

Overview of the method:
Even when ecosystem goods and services do not themselves have a market price, other marketed products often rely on them as basic inputs. For example, downstream hydropower and irrigation depend on upper catchment protection services, fisheries depend on clean water supplies, and many sources of industrial production use natural products as raw materials. In these cases, it is possible to assess the value of ecosystem goods and services by looking at their contribution to other sources of production, and to assess the effects of a change in the quality or quantity of ecosystem goods and services on these broader outputs and profits.

[14] A public good is characterised by the non-excludability of its benefits – each unit can be consumed by everyone, and does not reduce the amount left for others. Many ecosystem services are pure or partial public goods – for example, scenic beauty (a pure public good), or water quality (which has many of the characteristics of a public good). In contrast a private good is one from which others can be excluded, where each unit is consumed by only one individual. Most natural resources are private goods.

[15] A substitute good or service is one which is used in place of another – for example, kerosene instead of firewood, or bottled water instead of tap water.

[16] A complementary good is one which is used in conjunction with another – for example, between other products and fishing activities such as the collection of reeds for fishing baskets or firewood for fish smoking.

Effect on production techniques can thus be used to value ecosystem goods and services that clearly form a part of other, marketed, sources of production - for example, watershed protection and water quality services, or natural resources that are used as raw materials.

Data collection and analysis requirements:
There are three main steps to collect and analyse the data required for effect on production techniques to value ecosystem goods and services:

- Determine the contribution of ecosystem goods and services to the related source of production, and specify the relationship between changes in the quality or quantity of a particular ecosystem good or service and output;
- Relate a specified change in the provision of the ecosystem good or service to a physical change in the output or availability of the related product;
- Estimate the market value of the change in production.

Effect on production techniques rely on a simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem-dependent products (see above, market price techniques).

The most difficult aspect of this method is determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem goods and services with other sources of production. For example, detailed data are required to relate catchment deforestation to a particular rate of soil erosion, consequent siltation of a hydropower dam and reduced power outputs, or to assess exactly the impacts of the loss of wetland habitat and water purification services on local fisheries production. To be able to specify these kinds of relationships with confidence usually involves wide consultation with other experts, and may require situation-specific laboratory or field research, controlled experiments, detailed modelling and statistical regression.

Applicability, strengths and weaknesses:
Effect on production techniques are used commonly, and have applicability to a wide range of ecosystem goods and services. Their weakness relates to the difficulties that are often involved in collecting sufficient data to be able to accurately predict the biophysical or dose-response relationships upon which the technique is based. Such relationships are often unclear, unproven, or hard to demonstrate in quantified terms. Simplifying assumptions are often needed to apply the production function approach.

An additional concern is the large number of possible influences on product markets and prices. Some of these should be excluded when using effect on production techniques. In some cases changes in the provision of an ecosystem good or service may lead not just to a change in related production, but also to a change in the price of its outputs. That product may become scarcer, or more costly to produce. In other cases consumers and producers may switch to other products or technologies in response to ecosystem change or to a scarcity of ecosystem goods and services. Furthermore, general trends and external factors unrelated to ecosystem goods and services may influence the market price of related production and consumption items. They must be isolated and eliminated from analysis.

Travel cost techniques:

Overview of the method:
Ecosystems often hold a high value as recreational resources or leisure destinations. Even when there is no direct charge made to enjoy these benefits, people still spend time and money to visit ecosystems. These travel costs can be taken as an expression of the recreational value of ecosystems. We can use this technique at the whole ecosystem level, taking into account all of its attributes and components in combination, or for specific goods or services such as rare wildlife, opportunities for extractive utilisation of products such as fishing or resource collection, or for activities such as hiking or boating that are related to its services. In the example given below, improved freshwater ecosystem quality was estimated through looking at visitor travel costs.

Data collection and analysis requirements:
There are six main steps involved in collecting and analysing the data required to use travel cost techniques to value ecosystem goods and services as listed in the following page.

- Discover the total area from which recreational visitors come to visit an ecosystem, and dividing this into zones within which travel costs are approximately equal;
- Within each zone, sample visitors to collect information about the costs incurred in visiting the ecosystem, motives for the trip, frequency of visits, site attributes and socio-economic variables such as the visitor's place of origin, income, age, education and so on;
- Obtain the visitation rates for each zone, and use this information to estimate the total number of visitor days per head of the local population;
- Estimate travel costs, including both direct expenses (such as fuel and fares, food, equipment, accommodation) and time spent on the trip;
- Carry out a statistical regression to test the relationship between visitation rates and other explanatory factors such as travel cost and socio-economic variables;
- Construct a demand curve relating number of visits to travel cost, model visitation rates at different prices, and calculate visitor consumer surplus[17].

Travel cost techniques depend on a relatively large data set. Quite complex statistical analysis and modelling are required in order to construct visitor demand curves. Basic data are usually collected via visitor interviews and questionnaires, which make special efforts to cover different seasons or times of the year, and to ensure that various types of visitors from different locations are represented.

Applicability, strengths and weaknesses:
The travel cost method is limited mainly to calculating recreational values, although it has in some cases been applied to the consumptive use of ecosystem goods.

Its main weakness is its dependence on large and detailed data sets, and relatively complex analytical techniques. Travel cost surveys are typically expensive and time consuming to carry out. An additional source of complication is that several factors make it difficult to isolate the value of a particular ecosystem in relation to travel costs, and these must be taken into account in order to avoid over-estimating ecosystem values. Visitors frequently have several motives or destinations on a single trip, some of which are unrelated to the ecosystem being studied. They also usually enjoy multiple aspects and attributes of a single ecosystem. In some cases travel, not the destination *per se*, may be an end in itself.

Hedonic pricing techniques:

Overview of the method:
Even if they do not have a market price themselves, the presence, absence or quality of ecosystem goods and services influences the price that people pay for, or accept for providing, other goods and services. Hedonic pricing techniques look at the difference in prices that can be assigned to the existence or level of ecosystem goods and services. Most commonly this method examines differences in property prices and wage rates between two locations, which have different environmental qualities or landscape values. In the example given below, the value of urban wetlands was estimated through looking at impacts on property prices.

Data collection and analysis requirements:
There are five main steps involved in collecting and analysing the data required to use hedonic pricing techniques to value ecosystem goods and services:

- Decide on the indicator to be used to measure the quality or quantity of an ecosystem good or service associated with a particular job or property.
- Specify the functional relationship between wages or property prices and all of the relevant attributes that are associated with them, including ecosystem goods and services.
- Collect data on wages or property prices in different situations and areas which have varying quality and quantity of ecosystem goods and services.
- Use multiple regression analysis to obtain a correlation between wages or property prices and the ecosystem good or service.
- Derive a demand curve for the ecosystem good or service.

[17] Consumer surplus is the difference between the value of a good and its price, in other words the benefit over and above what is paid that is obtained by a consumer who is willing to pay more for a good or service than is actually charged. When a benefit is obtained free, all of its value is consumer surplus.

Hedonic pricing techniques require the collection of a large amount of data, which must be subject to detailed and complex analysis. Data are usually gathered through market observation, questionnaires and interviews, which aim to represent a wide variety of situations and time periods.

Applicability, strengths and weaknesses:
Although hedonic pricing techniques can, in theory, be applied to any good or service they are most commonly used within the context of wage and property markets.

In practice, there remain very few examples of the application of hedonic pricing techniques to water-related ecosystem goods and services. One reason for this, and a weakness in this technique, is the very large data sets and detailed information that must be collected, covering all of the principal features affecting prices. It is often difficult to isolate specific ecosystem effects from other determinants of wages and property prices.

Another potential problem arises from the fact that this technique relies on the underlying assumption that wages and property prices are sensitive to the quality and supply of ecosystem goods and services. In many cases markets for property and employment are not perfectly competitive, and ecosystem quality is not a defining characteristic of where people buy property or engage in employment.

Replacement cost techniques:

Overview of the method:
It is sometimes possible to replace or replicate a particular ecosystem good or service with artificial or man-made products, infrastructure or technologies. For example, constructed reservoirs can replace natural lakes, sewage treatment plants can replace wetland wastewater treatment services, and many natural products have artificial alternatives. The cost of replacing an ecosystem good or service with such an alternative or substitute can be taken as an indicator of its value in terms of expenditures saved. In the example below, the value of wetland water quality services was estimated through looking at the costs of replacing these services by artificial means.

Data collection and analysis requirements:
There are three main steps involved in collecting and analysing the data required to use replacement cost techniques to value ecosystem goods and services:

- Ascertain the benefits that are associated with a given ecosystem good or service, how it is used and by whom, and the magnitude and extent of these benefits;
- Identify the most likely alternative source of product, infrastructure or technology that would provide an equivalent level of benefits to an equivalent population;
- Calculate the costs of introducing and distributing, or installing and running, the replacement to the ecosystem good or service.

Data collection is relatively straightforward, and usually relies on secondary information about the benefits associated with a particular ecosystem good or service and alternatives that are available to replace it. In most cases this can be ascertained through expert consultation and professional estimates, supplemented with direct observation.

Applicability, strengths and weaknesses:
Replacement cost techniques are particularly useful for valuing ecosystem services, and have the great advantage that they are simple to apply and analyse. They are particularly useful where only limited time or financial resources are available for a valuation study, or where it is not possible to carry out detailed surveys and fieldwork.

The main weakness of this technique is that it is often difficult to find perfect replacements or substitutes for ecosystem goods and services that would provide an equivalent level of benefits to the same population. In some cases this results in ecosystem under-valuation, as artificial alternatives generate a lower quantity or quality of goods and services. Yet this technique may also lead to the over-valuation of ecosystem benefits, as in some instances the replacement product, infrastructure or technology may be associated with secondary benefits or additional positive impacts. The reality of the replacement cost technique is also sometimes questionable: we may question whether, in the absence of a well-functioning ecosystem, such expenditures would actually be made or considered worthwhile.

Mitigative or avertive expenditure techniques:

Overview of the method:
When an economically valuable ecosystem good or service is lost, or there is a decline in its quantity or quality, this almost always has negative effects. It may become necessary to take steps to mitigate or avert these negative effects so as to avoid economic losses. For example, the loss of upstream catchment protection can make it necessary to desilt reservoirs and dams, the loss of wetland treatment services may require upgrading water purification facilities, and the loss of ecosystem flood control may require the construction of flood control barriers. These mitigative or avertive expenditures can be taken as indicators of the value of maintaining ecosystem goods and services in terms of costs avoided.

Data collection and analysis requirements:
There are four main steps involved in collecting and analysing the data required to use mitigative or avertive expenditure techniques to value ecosystem goods and services:

- Identify the negative effects or hazards that would arise from the loss of a particular ecosystem good or service.
- Locate the area and population who would be affected by the loss of the ecosystem good and service, and determine a cut-off point beyond which the effect will not be analysed.
- Obtain information on people's responses, and measures taken to mitigate or avert the negative effects of the loss of the ecosystem good or service.
- Cost the mitigative or avertive expenditures.

Data collection and analysis is relatively straightforward, and usually relies on a combination of interviews, surveys, direct observation and expert consultation.

Applicability, strengths and weaknesses:
Mitigative or avertive expenditure techniques are particularly useful for valuing ecosystem services. In common with other cost-based valuation methods, a major strength is their ease of implementation and analysis, and their relatively small data requirements.

As is the case with the replacement cost technique, the mitigative or avertive measures that are employed in response to the loss of ecosystem goods and services do not always provide an equivalent level of benefits. In some cases it is also questionable whether in fact such expenditures would be made or would be seen as being worth making. An additional important factor to bear in mind when applying this technique is that people's perceptions of what would be the effects of ecosystem loss, and what would be required to mitigate or avert these effects, may not always match those of 'expert' opinion.

Damage cost avoided techniques

Overview of the method:
Ecosystem services frequently protect other economically valuable assets. For example, the loss of catchment protection services may result in increased downstream siltation and flooding, which leads to the destruction of infrastructure, settlements and agriculture. Such damage costs can be taken to represent the economic value of ecosystems in terms of expenditures avoided.

Data collection and analysis requirements:
There are four main steps involved in collecting and analysing the data required to use damage cost avoided techniques to value ecosystem goods and services:

- Identify the protective services of the ecosystem, in terms of the degree of protection afforded and the on and off-site damages that would occur as a result of loss of this protection;
- For the specific change in ecosystem service provision that is being considered, locate the infrastructure, output or human population that would be affected by this damage, and determine a cut-off point beyond which effects will not be analysed;
- Obtain information on the likelihood and frequency of damaging events occurring under different scenarios of ecosystem loss, the spread of their impacts and the magnitude of damage caused;
- Cost these damages, and ascribing the contribution of the ecosystem service towards minimising or avoiding them.

Data collection is for the most part straightforward, usually relying on a combination of analysis of historical records, direct observation, interviews and professional estimates. Predicting and quantifying the likelihood and impacts of damage events under different ecosystem scenarios is however usually a more complex exercise, and may require detailed data and modelling.

Strengths and weaknesses of the method:
Damage cost avoided techniques are particularly useful for valuing ecosystem services. There is often confusion between the application of damage costs avoided and production function approaches to valuation. Here it is important to underline that whereas this technique deals with damage avoided such as from pollution and natural hazards (which are typically external effects), change in production techniques usually relate to changes in some input such as water (typically internalised).

A potential weakness is that in most cases estimates of damages avoided remain hypothetical. They are based on predicting what might occur under a situation where ecosystem services decline or are lost. Even when valuation is based on real data from situations where such events and damages have occurred, it is often difficult to relate these damages to changes in ecosystem status, or to be sure that identical impacts would occur if particular ecosystem services declined.

Contingent valuation techniques:

Overview of the method:
Absence of prices or markets for ecosystem goods and services, of close replacements or substitutes, or of links to other production or consumption processes, does not mean that they have no value to people. Contingent valuation techniques infer the value that people place on ecosystem goods and services by asking them directly what is their willingness to pay (WTP) for them or their willingness to accept compensation (WTA) for their loss, under the hypothetical situation that they could be available for purchase.

Contingent valuation methods might, for example, ask how much people would be willing to see their water bills increase in order to uphold quality standards, what they would pay as a voluntary fee to manage an upstream catchment in order to maintain water supplies, how much they would contribute to a fund for the conservation of a beautiful landscape or rare species, or the extent to which they would be willing to share in the costs of maintaining important ecosystem water services.

Data collection and analysis requirements:
There are five main steps involved in collecting and analysing the data required to use contingent valuation techniques to value ecosystem goods and services:

- Ask respondents their WTP or WTA for a particular ecosystem good or service.
- Draw up a frequency distribution relating the size of different WTP/WTA statements to the number of people making them.
- Cross-tabulate WTP/WTA responses with respondents' socio-economic characteristics and other relevant factors.
- Use multivariate statistical techniques to correlate responses with respondent's socio-economic attributes.
- Gross up sample results to obtain the value likely to be placed on the ecosystem good or service by the whole population, or the entire group of users.

This valuation technique requires complex data collection and sophisticated statistical analysis and modelling, which are described in detail elsewhere. (See Carson and Mitchell 1989.)

Most contingent valuation studies are conducted via interviews or postal surveys with individuals, but sometimes interviews are conducted with groups. A variety of methods are used in order to elicit people's statement or bids of their WTP/WTA for particular ecosystem goods or services in relation to specified changes in their quantity or quality. The two main variants of contingent valuation are: dichotomous choice surveys, which present an upper and lower estimate between which respondents have to choose; and open-ended surveys, which let respondents determine their own bids. More sophisticated techniques are also sometimes used, such as engaging in trade-off games or using take-it-or-leave it experiments. The Delphi technique uses expert opinion rather than approaching consumers directly.

Applicability, strengths and weaknesses:
A major strength of contingent valuation techniques is that, because they do not rely on actual markets or observed behaviour, they can in theory be applied to any situation, good or service. They remain one of the only methods that can be applied to option and existence values, and are widely used to determine the value of ecosystem services. Contingent valuation techniques are often used in combination with other valuation methods, in order to supplement or cross-check their results.

One of the biggest disadvantages of contingent valuation is the large and costly surveys, complex data sets, and sophisticated analysis techniques that it requires. Another constraint arises from the fact that they rely on a hypothetical scenario which may not reflect reality or be convincing to respondents.

Contingent valuation techniques require people to state their preferences for ecosystem goods and services. They are therefore open to various sources of bias, which may influence their results. The most common forms of bias are strategic, design, instrument and starting point bias. Strategic bias occurs when respondents believe that they can influence a real course of events by how they answer WTP/WTA questions. Respondents may for instance think that a survey's hypothetical scenario of the imposition of a water charge or ecosystem fee is actually in preparation. Design bias relates to the way in which information is put across in the survey instrument. For example, a survey may provide inadequate information about the hypothetical scenario or respondents are misled by its description. Instrument bias arises when respondents react strongly against the proposed payment methods. Respondents may for instance resent new taxes or increased bills. Starting point bias occurs when the starting point for eliciting bids skews the possible range of answers, because it is too high, too low, or varies significantly from respondents' WTP/WTA. With careful survey design, most of these sources of bias can however be reduced or eliminated.

Participatory valuation techniques:

Overview of the method:
It is often difficult to use conventional environmental valuation techniques within largely subsistence-based economies, or to generate realistic estimates of local wetland use. Participatory valuation responds to some of the constraints and problems associated with using conventional valuation techniques, including:

- Many wetland goods have no substitute or market price, or it is unrealistic to use these as a proxy for their value in situations where the majority of the population do not have access to markets or substitutes.
- Cash measures and market prices may have little relevance in a subsistence economy where cash is not the main medium of exchange or indicator of local value.
- People frequently become suspicious when faced with a scenario where they must state a monetary willingness to pay/accept compensation for a natural product, if they suspect that they will be actually subjected to some kind of payment, tax or compensation. They will often under-quote the amount of money they would be willing to pay for wetlands goods if they fear that such charges may actually be made in the future, and over-quote the compensation they require if they think there may be a possibility of actually receiving payments.
- Most wetland uses are illegal in protected areas. People are reluctant to speak openly about their wetland use activities because they fear arrest. Some activities also have ritual or cultural significance, and knowledge is considered the preserve of specialist groups. Whereas households are reticent in the face of direct questioning, indirect techniques are a good means of stimulating discussion and gathering information.

Participatory valuation aims to find a bridge between local economic systems and cash values, and elicit information about wetland use and values at the subsistence, non-market level. It allows people to define wetland values within the context of their own perceptions, needs and priorities rather than according to externally-imposed categories or market prices. It is particularly suitable for valuing occasional, subsistence-based or illegal wetland uses, and for relating wetland values to broader household livelihoods.

Data collection and analysis requirements:
There are seven main steps to collect and analyse the data required for participatory valuation techniques to value ecosystem goods and services:
- Establishing the categories of wetland product, and types of activities, that are carried out in a particular locality;

- Defining a numeraire, or yardstick for valuation which is not cash. This is usually a commodity that forms an important part of the local socio-economy, has wide significance as an item of local value and exchange, and can easily be translated into a cash amount;
- Using picture cards to refer to each wetland product or activity that is used, and to the selected numeraire;
- Performing a ranking exercise on the picture cards, to ascertain the relative importance of different products;
- Establishing values by distributing a set number of counters between different picture cards, including the numeraire;
- Using the number of counters allocated to each card, translating wetland products into numeraire equivalents and converting this to cash amounts based on the price/market value of the numeraire;
- Discounting the resulting figures to give annual wetland use values.

Applicability, strengths and weaknesses:
Participatory valuation techniques have most applicability to subsistence economies, particularly those which are relatively remote and where the majority of the population have a high livelihood dependence on wetland products. They are particularly useful in situations where wetland goods are used for subsistence purposes only, where wetland use is illegal, or otherwise a sensitive topic. One factor to bear in mind is that even where markets for wetland products exist, participatory valuation rarely yields the same value estimates as market prices. This is because it is based on local perceptions of value, which may well not coincide with market-driven prices. Different people will value products differently, as values will reflect their relative importance to them in their daily lives, according to their personal preferences and responsibilities. Participatory valuation often yields far higher estimates of wetland value than other methods, because it incorporates a wide range of perceptions of value and is not confined to market prices alone.

Selection of the numeraire must be undertaken carefully, and a single measure used consistently across the community being studied. It is often challenging to identify a measure which has relevance and value for all concerned, and can be accurately reflected via a monetary value. It should be emphasised that the results of participatory valuation *must* be converted to an equivalent annual amount (or whatever time period that wetland values are being calculated for). This depends on the effective lifespan of the numeraire that has been selected.

Other stated preference techniques: conjoint analysis and choice experiments:

Other stated preference valuation methods include conjoint analysis and choice experiments. Due to their complexity in terms of data needs and analysis, and because there exist very few examples of their application to ecosystem water services (see, for example, DGA & UAC 2000, Griner and Farbver 1996, Kuriyama 2002, Morrison et al 1998), these methods are not described in detail here.

Conjoint analysis was developed originally in the fields of marketing and psychology, in order to measure individuals' preferences for different characteristics or attributes of a multi-choice attribute problem. In contrast to contingent valuation, conjoint analysis does not explicitly require individuals to state their willingness to pay for environmental quality. Rather, conjoint asks individuals to consider status quo and alternative states of the world. It describes a specific hypothetical scenario and various environmental goods and services between which they have to make a choice. The method elicits information from the respondent on preferences between various alternatives of environmental goods and services, at different price or cost to the individual.

Choice experiments techniques present a series of alternative resource or ecosystem use options, each of which are defined by various attributes including price. Choice of the preferred option from each set of options indicates the value placed on ecosystem attributes. As is the case for contingent valuation, data collection and analysis for choice experiments is relatively complex. Usually conducted by means of questionnaires and interviews, choice experiments ask respondents to evaluate a series of 'sets', each containing different bundles of ecosystem goods and services. Usually, each alternative is defined by a number of attributes. For example, for a specific ecosystem this might include attributes such as species mix, ecosystem status, landscape, size of area, price or cost. These attributes are varied across the different alternatives, and respondents are asked to choose their most preferred alternative. Aggregate choice frequencies are modelled to infer the relative impact of each attribute on choice, and the marginal value of each attribute for a given option is calculated using statistical methods.

Analysing and presenting the data for decision-making (Stage 4)

Calculating the economic value of wetlands is not an end in itself. Rather, it is a means of providing information which can be used to make better and more informed choices about how resources are managed, used and allocated. In order for the results of the valuation study to influence real-world policy and practice, it is of critical importance that time and thought is given to analysing the data that has been gathered, and presenting it in a form that captures the attention of decision-makers, and is convincing to them.

Step 7: Analysing and expressing the valuation data.

This step involves relating values to the management issue or scenario under study and expressing changes in wetland status as indicators for decision-making support. It should result in quantified estimates of wetland benefits and costs, understanding of the economic implications of particular wetland management scenarios, and expression of changes in wetland status as indicators for decision-making support.

Decision-makers, whether in conservation or development sectors, are concerned primarily with choosing between different uses of land, funds and other resources - for example, whether to manage a wetland under strict protection or to allow for some form of sustainable use, whether or not to build a dam, irrigation scheme or housing estate, which infrastructure design option to invest in, or whether to zone a wetland for conservation or to convert it to settlement or agriculture (assessing damage to a wetland). To analyse the results of a valuation study thus we need to be able to express ecosystem values as measures that make sense to decision-makers when they weigh up the different funding, land and resource management choices that wetland decisions involve.

Conducting a valuation study provides us with data about the economic value of particular wetland goods and services. However, what is important for decision-making is to be able to understand and express how making choices between alternative uses of land, water, resources or investment funds will influence these values. For example, how much additional flood-related costs would be incurred if a wetland were degraded, and what downstream production losses would arise from additional silt loads? Or what additional investments in water treatment and purification would be required if a particular wetland were reclaimed? Or what potential actually exists for raising revenues from urban dwellers to maintain water quality in a particular river or lake?

In order to answer these questions, and to integrate wetlands values into these decision-making processes, it is necessary to be able to analyse data so as to trace the economic implications of changes in the stock of wetland resources, flows of wetland services, or attributes of wetland systems that result from following a particular course of action, and factor them into measures of its economic desirability. In other words, we need to know what the economic impacts of particular decisions will be in terms of wetland costs and benefits.

Building up a bio-economic model:

Various studies have demonstrated the utility of applying a simple bio-economic model in order to generate information for wetland decision-making (Colavito 2002, Creemers and van den Bergh 1998, Bennett and Whitten 2002). This type of model presents a useful tool for relating wetland values to decision-making, and involves a number of steps which translate baseline data on ecosystem values into information that can be used to assess the economic impacts of decisions on wetlands:

- Establish ecological and socio-economic background and parameters: This involves identifying, defining and understanding the status of the wetland and its links to hydrological goods and services, their benefits and beneficiaries, and the way in which various social, institutional and management aspects affect it.
- Calculate baseline economic values from which to measure ecosystem changes: This involves carrying out the partial or total valuation study.
- Link physical changes in ecosystem status and integrity to changes in these economic values: This involves tracing the effects of different decisions on the provision of wetland goods and services, and determining the impacts of these changes on economic values.
- Express the results as indicators or measures that can be integrated into broader economic appraisal or analysis processes: This involves expressing the results of value changes as quantitative indicators or measures that can be integrated into wider decision-support frameworks. The next two sections look at

two of the most commonly used techniques for expressing wetland values in decision-making: cost-benefit analysis and multi-criteria analysis.

Cost Benefit Analysis:

Cost-Benefit Analysis (CBA) remains the most commonly used decision-making framework for using the results of a wetland valuation study in order to assess and compare economic and financial trade-offs. It is the standard tool for appraising and evaluating programmes, projects and policies and one that is a required part of many government and donor decision-making procedures. CBA is a decision tool that judges alternative courses of action by comparing their costs and benefits. It assesses profitability or desirability according to net present benefits - the total annual benefits minus total annual costs for each year of analysis or project lifetime, expressed as a single measure of value in today's terms.

In order to bring a project's benefits and costs over time to their present value, each is discounted. Discounting is essentially the inverse of applying a compound interest rate, and gives values relatively less weight the further into the future they accrue. It accounts for the fact that people generally prefer to enjoy benefits now and costs later, and that any funds tied up in a project could be used productively to generate returns or profits elsewhere. In most cases, the discount rate is therefore based on the opportunity cost of capital - the prevailing rate of return on investments elsewhere in the economy.

ICBA presents three basic measures of worth, which allow different projects, programmes or policies to be assessed and compared with each other:

- **Net Present Value (NPV)** is the sum of discounted net benefits (i.e., benefits minus costs), and shows whether a project generates more benefits than it incurs costs.
- **Benefit Cost Ratio (BCR)** is the ratio between discounted total benefits and costs, and shows the extent to which project benefits exceed costs.
- **Internal Rate of Return (IRR)** is the discount rate at which a project's NPV becomes zero.

In general, a project can be considered to be worthwhile if its NPV is positive and its BCR is greater than one and if its IRR exceeds the discount rate. A positive NPV and a BCR greater than one means the project generates benefits that are greater than its costs. An IRR above the discount rate means that the project generates returns in excess of those which could be expected from alternative investments.

There are basically two types of Cost-Benefit Analyses: financial and economic. Financial CBAs look only at the private returns accruing to a particular individual or group. They calculate costs and benefits at market prices, reflecting the actual cash profits and expenditures that people face. A financial CBA might for example measure and compare the relative profitability of different dam design options for a hydropower company, the returns to improved water and sanitation facilities for urban consumers, or the highest earning mix of irrigated crops for a farmer. Here, wetland values will primarily be incorporated into CBA calculations as they influence private costs and benefits, affect investments and are expressed through market prices.

In contrast, economic CBAs examine the effects of projects, programmes and policies on society as a whole. They consider all costs and benefits, for all affected groups. Sometimes weights are assigned to prioritise particular groups, benefits or costs that are considered to be of particular importance in economic terms. As such, economic CBAs are mainly carried out by public sector and donor agencies, who are concerned with broad development impacts. For example, an economic CBA would consider the total costs and benefits of different hydropower design options, such as relocation costs and loss of production incurred by reservoir flooding, income from increased employment in the power sector and benefits associated with improved earning opportunities arising from electrification. An economic CBA of different irrigated crop mixes might include consideration of the premium attached to foreign exchange earnings from export crops, improved food security benefits, and revenues in agro-processing and value-added industries.

Because economic CBAs assess the desirability of a given course of action from the perspective of society as a whole, they usually adjust financial costs and benefits to account for the various imperfections and distortions in the market. It recognises that market prices are not a good indicator of the true social and economic value of goods and services. This means that wetland values should form an integral component of economic CBAs.

Other economic decision-support tools:

CBA remains the most widely used tool for the financial and economic appraisal of projects, programmes and policies. Other, less commonly-used, value-based measures of profitability or economic/financial desirability include:

- *Cost-effectiveness analysis*: This decision-support tool judges the minimum cost way of attaining a particular objective. Is useful where a project has no measurable benefits, or where a particular goal has already been set (for example, maintaining a certain water quality level). It involves calculating all the costs of attaining the given objective, discounting them, and pointing to the option with the lowest NPV.
- *Risk-benefit analysis:* This decision-support tool focuses on the prevention of events carrying serious risks (for example, investing in flood prevention). It assesses the costs of inaction as the likelihood of the specified risk occurring. The benefit of inaction is the saving in the cost of preventive measures. Is useful where risk is a major consideration in projects, and can be captured via monetary values.
- *Decision analysis:* This decision-support tool weights the expected values of a given course of action (in other words, the sum of possible values weighted by their probability of occurring) by attitudes to risk, to give expected utilities. It draws up and assesses decision makers' preferences, judgements and trade-offs in order to obtain weights that are attached to outcomes carrying different levels of risk.
- *Multi-criteria analysis:* Multi-criteria analysis provides one of the most useful and increasingly common tools for integrating different types of monetary and non-monetary decision criteria. It has been developed to deal with situations where decisions must be made taking into account multiple objectives, which cannot be reduced to a single dimension. Multi-criteria analysis is usually clustered into three dimensions: the ecological, the economic and the social. Within each of these dimensions certain criteria are set, so that decision-makers can weigh the importance of one element in association with the others. Here, monetary values and CBA measures can be incorporated as one of the criteria to be considered, and weighed against the others in decision-making.

Step 8: Presenting management and decision-making conclusions.

This step involves relating the findings of the valuation study to on-going management issues, and targeting this to particular audiences and aims. It should result in a convincing report on the economic status and value of the wetland as it relates to management priorities and threats.

However good the results of a valuation study are, they will have little impact on decision-making if nobody sees, reads or is persuaded by them. There is an art to presenting information, and communicating it effectively. In many cases, the technical experts who carry out the valuation study itself may not be the best placed to do this – there is often a need for professional communicators and a properly-designed communications strategy.

Information about wetland values will be easiest to communicate when decision-makers find it useful, and it is helps them to address or better understand a particular situation or problem. Many people are involved in shaping decision-making, and communication of the results of valuation studies must usually take place at many levels of scale. Making the results of valuation convincing to these different groups requires different types of communications strategies, different messages and different ways of presenting information.

In a perfect world where all decisions were made for the good of society, merely making valuation information available might be enough to ensure that water decisions took fair account of ecosystems. Unfortunately this is not usually the case. There exist multiple, and often competing, interests in wetlands. Fostering cooperation and balancing these competing interests is critical when the results and recommendations of wetland valuation studies are presented. Here, it is important to be tactical and work with the different constituencies who actually have the political will, and power, to influence wetlands. Just as wetland valuation aims to articulate particular costs and benefits that have traditionally been ignored in decision-making, it also represents the interests of many of the groups who have often been excluded from these decisions.

Table 6: Valuation checklist #1: identifying and listing wetland values

Category of value	Values found in study wetland	Beneficiary or cost-bearing group
Direct values		
Indirect values		
Option values		
Existence values		
Direct costs		
Opportunity costs		
Costs to other activities		

Table 7: Valuation checklist #2: selecting wetland costs and benefits to be valued

Benefit/Cost	Values found in study wetland	Beneficiary or cost-bearing group

Values found in study wetland	Beneficiary or cost-bearing group	Include	Exclude

Values found in study wetland	Beneficiary or cost-bearing group	Include	Exclude

Table 8: Valuation checklist #3: choosing wetland valuation techniques

Values found in study wetland	Beneficiary or cost-bearing group	Include ☐	Exclude ☐

Values included in study	List of possible valuation techniques	Technique to be used ☐	Technique not to be used ☐

Values included in study	List of possible valuation techniques	Technique to be used ☐	Technique not to be used ☐

Table 9: Valuation checklist #4: identifying data needs and sources

Values included in study	List of possible valuation techniques	Technique to be used ☐	Technique not to be used ☐

Values included in study	Selected valuation technique	Data required	Source of data

Values included in study	Selected valuation technique	Data required	Source of data

References

Barbier, E (1994). Valuing environmental functions: tropical wetlands. *Land Economics* **70**(2): 155-73.

Barbier, E., Acreman, M., and D. Knowler (1997). *Economic Valuation of Wetlands: A Guide for Policy Makers and Planners*. Gland: Ramsar Convention Bureau. 128 pp.

DGA & UAC (2000). Catastro y localizacíon de usos publicos no extractivos o usos in situ del agua, Gobierno de Chile Ministerio de Obras Públicas, Direccion General de Aguas y Universiad Austral de Chile Facultad de Ciencias Forestales, Santiago

Emerton, L (2005). *Valuing Domestic Forest Use: Communities and Conservation in Kenya*. Nairobi: Centre for Biodiversity, National Museums of Kenya. 45 pp. + appendices.

Emerton, L (1999). *Economic Tools for Valuing Wetlands in Eastern Africa*. Nairobi: IUCN — The World Conservation Union, Eastern Africa Regional Office. 31 pp.

Emerton, L (ed.) (2005). Values and Rewards: Counting and Capturing Ecosystem Water Services for Sustainable Development. *IUCN Water, Nature and Economics Technical Paper No. 1*, Colombo: IUCN — The World Conservation Union, Ecosystems and Livelihoods Group Asia. 93 pp.

Emerton, L. and E. Bos (2004). *VALUE: Counting Ecosystems as Water Infrastructure*. Gland: IUCN — The World Conservation Union. 88 pp.

Emerton, L. and B. Kekulandala, (2002). *Assessment of the Economic Value of Muthurajawela Wetland*. Colombo: IUCN — The World Conservation Union, Sri Lanka Country Office and Regional Environmental Economics Programme Asia. iv + 28pp.

Emerton, L., Iyango, L., Luwum, P., and A. Malinga (1999). *The Economic Value of Nakivubo Urban Wetland, Uganda*. Nairobi: IUCN - The World Conservation Union, Eastern Africa Regional Office. Nairobi and National Wetlands Programme, Wetlands Inspectorate Division, Ministry of Water, Land and Enviornment, Kampala. 30 pp.

Feather, P., Hellerstein, D. and H. LeRoy (1999). *Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP. Resource Economics Division, Economic Research Service*. Washington DC.: U.S. Department of Agriculture. Agricultural Economic Report No. 778. 64 pp.

Griner, B. P. and S. C. Farber (1996). *A conjoint analysis of water quality enhancements and degradations in a western Pennsylvania watershed*. Washington DC: United States Environmental Protection Agency.

James, R. F (1991). Wetland Valuation: Guidelines and Techniques, *PHPA/AWB Sumatra Wetland Project Report No 31*. Bogor, Indonesia: Asian Wetland Bureau.

Kramer, R. A., Richter, D. D., Pattanayak, S. and N. Sharma (1997). Ecological and Economic Analysis of Watershed Protection in Eastern Madagascar. *Journal of Environmental Management* **49**: 277–295.

Kuriyama, K (2002). Measuring the value of the ecosystem in the Kushiro wetland: an empirical study of choice experiments. *Forest Economics and Policy working paper #9802.* Japan: Hokkaido University, Department of Forest Science. 16 pp.

Mahan, B. L (1997). Valuing Urban Wetlands: A Property Pricing Approach. *US Army Corps of Engineers Institute for Water Resources, Evaluation of Environmental IWR Report 97-R-1*, Washington DC.

Mitchell, R. and R. Carson (1989). *Using Surveys to Value Public Goods: the Contingent Valuation Method, Resources for the Future.* Washington DC:resources for the Future. 488 pp.

Morrison, M. D., Bennett, J. W. and R. K. Blamey (1998). Valuing Improved Wetland Quality Using Choice Modelling. *Research Report No. 6, Choice Modelling Research Reports*. Canberra: School of Economics, and Management, Unversity College, The University of New South Wales,

Pyo, H (2002). *The Measurement of the Conservation Value for Korean Wetlands Using the Contingent Valuation Method and Cost-Benefit Analysis*. Seoul: Korea Maritime Institute.

Seyam, I. M., Hoekstra, A. Y., Ngabirano, G. S. and H. H. G. Savenije (2001). T*he Value of Freshwater Wetlands in the Zambezi Basin*. Paper presented at Conference on Globalization and Water Resources Management: the Changing Value of Water, AWRA/IWLRI-University of Dundee.

Turpie, J., Smith, B., Emerton, L. and J. Barnes (1999). *Economic Valuation of the Zambezi Basin Wetlands*. Harare: IUCN - - The World Conservation Union Regional Office for Southern Africa.

Steps, stages and methods for the assessment of livelihoods in a village (extracted from CARE 2008)[18]

Note that this is a technical annexe that requires knowledge of sociology and Participatory Rapid Appraisal (PRA) techniques.

Objectives of socio-economic profiles

The objectives of household livelihoods (HLS) assessment are to:

- Assess livelihood security and the underlying causes of poverty amongst selected target groups at [focal site].
- Analyse the underlying causes of poverty in [focal site] in order to promote appropriate livelihood security programming options.
- Identify the most appropriate interventions likely to have the largest sustainable impact related to targeted outcomes, i.e., social positions, human conditions, and enabling environment.
- Train staff on how to develop and conduct an HLS assessment: and
- Train staff on a procedure for using the results of an HLS analysis to design a programme or project.

This assessment uses a variety of exercises that employ Participatory Rapid Appraisal (PRA) techniques, as described below.

A combination of data collection procedures is used, including:

- Qualitative community profiles of different villages representing different combinations of livelihood systems and potential target groups. Participatory analysis tools used for this assessment include:
  - Key informant interviews;
  - Focus group discussions with separate community groups of men and women;
  - Wealth ranking exercise aimed at understanding community-perceived social differentiation;
  - Venn diagramming exercise to understand social and institutional positions of key community institutions;
  - Household opportunity analysis to identify 'positive deviant' households representing success stories in managing risks; and
  - CBO case studies to understand the power dynamics between the organisation or institution being studied and other entities in or around the community.
- Household survey of a specified number of households from specified villages.

The qualitative assessment aims at enhancing our understanding about local livelihood systems – the economic, socio-cultural and political context, including human conditions, social positions, and the enabling environment. The teams used a variety of tools to analyse the constraints to food and livelihood insecurity, vulnerabilities, marginalisation, and risks of poor families living within this context. The major objective is to gain maximum in-depth knowledge regarding the underlying causes of poverty among vulnerable populations.

The assessment team can be subdivided into teams of facilitators each with a supervisor, who visit villages, spending two days in each village, facilitating male and female focus group discussions, key informant interviews, household survey questionnaires, CBO case studies, venn diagrams, case studies of relatively resilient households, and wealth ranking exercises. All of the team members can then spend evenings and a full day entering a substantial amount of qualitative data into matrices used for analysis. Table 1 on the following page outlines the three day process for each of two cycles – four villages in each cycle.

[18] Extracted from Care (2008) Household livelihoods assessment in Jaffna, Sri Lanka. Volume 1: Report of the findings. Prepared by Tango International.

Table 10: Three-day data collection and analysis process

Day 1		
Activity	Number	Tools and targeted group
Transect walk and large group		Introduction to the village, recruitment of participants, introduction of the team to the village, purpose and process of 2-day community exercise.
Focus group interviews	2	Topical outline – Focus group with men and women of different livelihood strategies.
Wealth ranking exercise	1	Wealth ranking matrix, flip charts; group of poor residents; results used to establish household survey participants to be visited later.
Venn diagram exercise	2	Flip charts; men and women groups.
Key informant interviews	1-3	KI format; meet with 1-3 individuals.
Household interviews	5 HH	HH survey questionnaire; meet with man and woman of the household together.
Day 2		
Activity	Number	Tools and targeted group
Focus group interviews	2	Topical outline – focus group with men and women of different livelihood strategies.
Resilient HH case studies	4	Topical outline – Households identified during focus group discussion.
CBO case study	At least 1	Topical outline, problem ranking.
Household interviews	5 HH	HH survey questionnaire.
Day 3		
Objective: To process the information obtained in the previous two days to draw conclusions to be entered in the matrices and assessment summary formats.		
Activity	Tools	
Data entry into focus group matrices and compilation of summary information	Matrices for focus groups, wealth ranking, CBO and resilient HH case studies, venn diagrams, summary formats, notes on various tools used, visual displays.	
Quantification of HH surveys	Tables quantifying 80 household surveys.	

1. Qualitative community profiles

A. Key Informant Interviews

Assessment team members meet with key informants in each of the eight communities selected in order to obtain a ‘snapshot’ of community issues and a community profile. The key informant interview topical outline sought information about:

- Demographic trends;
- Settlement history;
- The economic base and village resources of the community;
- Community infrastructure, including water, schools, health facilities, extension service facilities, markets, and roads; and
- Decision-making and power relations within the community.

The key informant village profile format is presented on the following page.

Village profile

1. Identification:

	Particulars	Name
A. Name of KI	___ division	
B. Age in years	___ division	
c. Status/Occupation	Village	

- How was the village formed?
- What changes have occurred in the village over the last 20 years?
- In the last 20 years, what have been the major events affecting the village?
- What are the strengths and weaknesses of the village?

2. Demographic features:

Type of household (Including ethnic or IDP)	Number of HH	Headed by		Total population		Remarks
		Male	Female	Male	Female	
Total						

Number of disabled people in the village: ____________ men ____________ women.

3. Major livelihoods:

- What are the major sources of livelihoods for people residing in the village?
- For those people living in the village who are extremely poor, what are their major sources of food and income?
- For those people living in the village who are poor, what are their major sources of food and income?

4. Natural resources:

- What are the major types of land in the village?
- What are the major crops grown?
- What are the major tree crops that are grown?
- What are the major water resources available to the village (irrigation systems, tanks, rivers, ocean)?
- What kinds of livestock and poultry are produced in the village, on what scale?
- Do people in the village have access to wild animal, fish or bird resources?

Common property natural resources for the community:

- What common resources are available in the village? How are these resources used? Who makes decisions about their use?
- Who has access to the common resources? Which types of livelihoods groups use these common resources? Which groups are not allowed to use the resources? Why?
- What role does the government or other institution(s) play to ensure access to the common resources?

Environmental quality:

- What changes have occurred environmentally over the last 20 years?
- What major environmental problems does the village face and how do these affect the village?

5. Basic services

i) Infrastructure

Is electricity available in the village? Yes No

If Yes, how many households have access? ________________________________
If no, what is the coping strategy? ____

ii) Transport services

Types of transport services	Quality of services

iii) Potable water and sanitation

Sources of drinking water in the village (indicate number of sources):

Piped water:___________Open well:____________Tube well/bore well: _____________
Other (specify): __________________________
Latrines in the village:

Status	Number		
	Latrine	House	Well
Permanent			
Semi-permanent			
Common			
No fixed place			

- Where do people get water for other uses?
- How would you describe the quality of the water? (For example, is there arsenic, iron, other?)
- How do the sources of water change over the seasons?
- Who owns the water sources or if they are common sources, who makes decisions about accessing the water?
- Which people in the village do not have access to clean water? Why do they not have access?
- How much does water cost?

iv) Education

Educational facilities in the village:

Type of school	Distance from village	Number of children attending	Number of girls attending
Primary school			
High school/college			
Technical institution/university			
Non-formal education (NGO)			
Others (specify)			

- What is the literacy rate in the community?______________________________
- How does this differ between men and women? Men_______Women_________

v) Health services/Medical facilities

SL #	Type of medical facility	Fees/cost (in relevant currency)	Distance(in km)
1	Teaching hospital		
2	Base hospital		
3	District hospital		
4	Divisional hospital		
5	Dispensary		
6	Mobile clinic		
7	Private clinic		
8	Indigenous medical practice		
9	Other (specify)		

How often does the public health inspector visit the community? ___________________
How often does a midwife visit the community? ________________________________

6. Decision-making and power

i) Social decision-making

Official	Distance	Time (in hours)	Quality of service
District secretariat			
Divisional secretariat			
Provincial council / Municipal council			
Lower division			
Civil affairs			

- Who represents the community with local authorities, including government?
- Does this person live in the village? If not, how often does he or she come to the village?
- If the village has a problem with a neighbouring village, how does that problem get solved?
- If two households or two groups of households in the village have a problem with each other, how does that problem get solved? Give an example.
- How have these social problem-solving mechanisms changed over the last 20 years?

ii) Social groups

a. Number of RDS members from the village: __________________
b. Number of WRDS members in the village: __________________
c. Are there any CBOs?: Yes__________No_______________
If Yes,

Name	Activity	# of M/W members	Active/Inactive	Representative at district / division levels?

How have these groups changed over the last 20 years?

Are there any local or international NGOs implementing activities in the village? Yes ____ No ___

Name of NGO	Activities	Current or past?	If NGO stopped implementing activities, why?

iii) Access to government extension services

Extension service	How often do they visit the village?	If not, why not?	Type of service provided
Agriculture			
Livestock			
Fisheries			
Health			

iv) Access to capital

- If someone in the village needs to money because of an emergency, what do they do?
- Which kinds of people can do this and which cannot?
- Under what terms are they able to get access to money for an emergency?
- What about accessing money for income-generating activities?
- What do different kinds of people in the village do?
- How have the sources of money changed over the last 20 years?

Sources of capital:

SL#	Financial institution	Distance (in km)	Types of loans	Terms and conditions of loan
1	Name of state bank			
	Name of private bank			
2	Cooperative society/rural bank			
3	Government schemes in village			
4	NGO			
5.	Other (specify)			
6	Other (specify)			

B. Focus Group Discussions

The assessment team can facilitate focus group discussions, including at least one all-female focus group, and other focus groups by livelihood strategy, such as farming households with land and farm labourers without land, or wealth group, in each of the eight villages. Facilitated focus group discussions can follow the topical outline but should be allowed to develop naturally with greater attention paid to topics the participants felt are the most important. Gathering information from different focus groups proves useful in comparing perceptions and priorities. The focus group discussions should include:

- Community profiles;
- Community perceptions of access to and quality of services, resources, and infrastructure, including transport, schools, markets, and health facilities;
- Area features, including forests, water, climate, and erosion;
- Social capital, political capital, and human rights within the community;
- Livelihood strategies, including agriculture, animal husbandry, horticulture, fishing, wage labour, and other income generating activities (IGAs); and
- Summaries of community problems and priorities.

The focus group topical outline is presented below.

Topical outlines for data collection

Focus Group Discussions

Village____
Division___________________________ Division___________________________
Facilitator ____________________________ Recorder______________________
Focus group gender _____________________
Number of people in group discussion: _______ Date______________________

Collect qualitative information in each of the selected villages. Use four Focus Group (FG) discussions in each qualitative sample village: male and two female groups, with approximately six to ten members each. Select the four male and female focus groups according to wealth or livelihood categories. Interview the men's and women's groups separately.

Two survey team members should conduct each group discussion: one facilitator and one note-taker or recorder. It is important that a female member of the team facilitates the women's group and a male member of the team facilitates the men's group.

Begin by meeting a large community group in order to introduce yourselves and the purpose of the household livelihoods assessment to the focus groups. Use the large community group to identify the different focus groups, based on wealth categories, livelihood categories, and gender. Explain that the discussion will take at least two to three hours. Another hour will be needed for the wealth ranking exercise.

What follows is not a list of formal interview questions, but an outline to guide small group discussions. This is a guideline to help guide the discussion, not a list of questions to be filled in. Keep the conversation flowing and encourage discussion within the group.

I. *Village information:*

Village history:

- Settlement pattern: How long have people lived here? From where? Reasons for moving?
- What changes have occurred in the village in the last 5-10 years? Good changes; bad changes. Why?
- What are the major strengths and weaknesses of the community? Why?

a. Household demographics:
   - Is there seasonal migration? Who migrates? Why do people migrate?
   - Where do people migrate?
   - How long is the migration period?
   - What are the major challenges people face when they migrate? Why?
   - Do men and women both migrate? What do women do when men migrate? Which people are more vulnerable? Why?

b. Infrastructure: perceptions about access/quality:
   - Transport (road type, seasonal accessibility, transport service)
   - Schools (all levels):
     - What types of schools? (Primary, secondary, other schools)
     - Accessibility (time/distance, fees);
     - Where are the nearest schools?
     - Quality of school (desks/latrine/books, teachers);
     - Valued by community? for both boys and girls?
     - Drop outs and reasons: Why do children drop out?
     - Any difference for boys/girls? Why?
     - General problems and participation in school management;
     - How has quality of schools changed over the past three years?

- Common markets
  - Describe the most commonly used common market.
  - Accessibility: time/distance/transport available, costs, if accessible all seasons;
  - Availability of different items in the market;
  - Type/frequency: (Village, regional);
  - Why do you go to market? (primary and secondary uses);
  - Do you get fair prices? How do you know the fair prices (for sale/purchase)?
  - Have prices or availability changed over the past three years? How?
- Other community structures (including community centres, CBO centres)

c. Health facilities
   1. Health services and quality:
      - Accessibility: (time/distance/cost);
      - What kinds of health facilities are available?
      - Are the different health facilities accessible and used? Why/why not?
      - Describe the quality of service of the health facilities.
      - Do you consult traditional health providers?
      - For what types of health issues or diseases?
      - Why do you use traditional health providers instead of government health facilities?
      - What types of traditional health providers are commonly used?
      - Where do you seek antenatal care?
      - Where do you go for birth/delivery?
      - Describe the quality of maternal child care? Why?
      - Common childhood diseases? Causes of child death?
      - Any knowledge of HIV/AIDS? Is HIV/AIDS found in the community? How has HIV/AIDS affected the community?

d. Area features
   1. Water (drinking/irrigation/non-drinking)
      - Sources – seasonal availability, distance, reliability;
      - Time to collect;
      - Quality of water;
      - Control of access to water (community/government/private – cost?);
      - Methods of storage of water, water treatment procedure, Costs of water and use pattern;
      - Trends in access to water over the past five years? Any changes? Describe the changes.
   2. Natural disasters
      - Have there been erratic rains over last decade, flash floods, major floods, cyclones?
      - How was the village affected by the tsunami?
      - How does the village cope with disasters?
      - Any activities to protect village and households from disasters? Describe protection activities.
      - Trends/changes over the past five to ten years?
      - Any major environmental problems? Please describe.
      - Any major climate changes over the past five to ten years? Please describe.

II. Livelihood strategies (All major livelihood activities):

a. Agriculture: Crop production
   1. Major crops grown in order of importance (food crops for domestic consumption/for sale as cash crops) by land type/quality;
   2. Access to agriculture inputs:
      - Sources and availability of seeds (local seeds/hybrid seeds);
      - Fertiliser use: sources and extent of use (manure, compost, chemical)?
      - When and which crops use fertiliser?
      - Pest control: cultural, mechanical, biological, chemical?
      - Animal traction: use, own or rent, cost, availability?
      - Irrigation: regular or irregular, source of irrigation, methods of irrigation;

- Which crops are irrigated?
- Who has access to inputs; who has no access?

3. Access to government or NGO services
   - Types of services: credit, extension?
   - Agricultural extension: access and quality;
   - Access to credit facilities (formal/informal, terms of repayment, specify NGO, Government, moneylender;
   - Type of credit, quality, usefulness, frequency of use.
4. Crop/Food storage
   - Types, length of storage, amount of losses, reasons for losses;
   - Measures taken to prevent or control losses.
5. Marketing of agricultural produce – farmgate marketing
   - Where is the farmgate market?
   - Which products do you market and when?
   - Are the prices you receive fair? Why or why not?
   - Major problems or constraints associated with marketing (Rank).
   - How has marketing changed in the past five years? Why are there changes?
6. Problems associated with production
   (Ranking exercise)
   - Potential solutions to the problems listed above.
   - Has production been increasing or decreasing? Why?
7. How has the war affected agricultural production?
8. Land tenure systems – ownership/access patterns
   - Who owns land? What is the average landholding?
   - Is landlessness a problem? Why?
   - Is there sharecropping (terms, conditions and trends)? Why?
   - What are the sharecropping arrangements? (lease, mortgage, etc.)
   - Is there any conflict over land? Describe.
   - Trends in access to land.

b. Horticulture
   1. What kinds of horticultural activities are practiced?
      - Homestead gardening?
   2. What is normally grown?
   3. Who participates in this activity?
   4. What are the seasons?
   5. Is the production for sale or for consumption (for each crop)?
   6. Do most households have gardens or arable land nearby? How far away normally?

c. Animal Husbandry
   1. Types of animals raised, in order of importance
      - Uses of livestock (production, animal traction, slaughter, consumption, sale)
      - Rearing practices and patterns (hybrid and indigenous livestock types)
      - When are livestock sold and for what reasons?
   2. Availability of pasture: is there any conflict over pasture land, fodder (availability, changes in accessibility).
   3. Major animal diseases, availability of veterinary services.
   4. Poultry types:
      - What are your perceptions and knowledge of avian flu?
   5. How has the war affected animal husbandry? What types of livestock were most affected? Why?
   6. Changing trends in animal husbandry over the past five to ten years.
   7. Major constraints and potential solutions.

d. Fishing
   1. Types of fishing;
   2. Fishing gear owned or funded, boat, nets, costs;

3. What is the moneylending and renting system, credit access for fishing and availability
   - Extension service availability and quality;
4. Fishing production/harvest amounts;
5. Extent of dry fish making;
6. Marketing arrangements, price and seasonal variations;
7. Changes in availability/scarcity?
8. Describe the quality/availability/access to fishing inputs (boats, nets, etc.), markets, and storage facilities;
9. Problems or constraints to production? How to solve these problems?
10. Access to water bodies: What water bodies can households access?
    - What water bodies do you do not have access to? Why?
    - Purposes of use of water bodies.

e. Other Income Generating Activities (IGAs)
   1. Type of activity, extent of practice, and number of activities practiced:
      - Artisan production;
      - Agricultural enterprise;
      - Weaving;
      - Petty vending and trading;
      - Small shops/boutiques;
      - Service;
      - Other IGA;
   2. When do you do each of these activities? (Year-round, annually?)
   3. How much do you earn from each IGA?
   4. Demand and use of credit: is credit available?
      - Source of credit for IGAs (moneylenders, government, NGOs);
      - Terms of credit (interest rates, loan terms, mortgages);
   5. Any support service provided by government? By NGOs?
      - Any technical skills training? Extension services? Who provides?
   6. Availability of wage labour: How many days/month do you participate?
      - Months/year;
   7. Migration for work: where to, why, who goes, when, for how long?
   8. Remittances: from where, when?
   9. Any constraints in earning enough from this activity?
   10. Trends over the past 5-10 years.

f. Wage labour
   1. What kinds of daily labour activities do households undertake?
   2. Who is involved from the household?
   3. How often and when do these activities occur?
   4. What kind of compensation do men and women receive?
      - Differences between men and women's compensation?
   5. What are the major constraints or problems to wage labour activities? Why?
   6. What opportunities exist to increase income from wage labour activities?
   7. Why are households not pursuing these opportunities?
   8. Describe trends and changes in these activities in the last five to ten years.

g. Changes in livelihood strategies in the past several years?
   - Which households are more successful at making these changes?
   - What do these households do?
   - Identify households for the PD case study.

III. Social capital

a. Borrowing or lending relationships:
   1. If a household in this livelihoods group faces a crisis or shock, from whom can they go to borrow money or food? Do you borrow from someone in a different or same social class or social caste? Why?
   2. What is owed back after borrowing money or food? What is expected?

3. How strong are relationships between social classes or social castes? Please describe the differences.
4. What are major constraints to different groups working with each other?
5. How have social relationships changed in the past five to ten years? Describe.

b. Human Rights
   1. Are there any rights that people feel are not being respected?
      - What kinds of rights are not respected? Why?
   2. Are there any groups in the village who are denied equal rights?
      - Who are these groups?
      - Why are they denied equal rights?
      - Who denies them their rights?
   3. How have human rights changed in the past five to ten years?
   4. What should be done to change this situation?
   5. What has the community already accomplished?

IV. Political capital

a. Power relationships:
   1. How are decisions made in this community?
   2. Please describe how decision-making occurs in this community.
      - Is decision-making fair and transparent? Why or why not?
      - Who makes the decisions?
   3. Do all households have equal participation in decision-making?
      - Why or why not?
   4. How have power relationships changed in the past five to ten years?

b. Political parties or groups:
   1. Do some groups have more power than others in this community?
      - Why or why not?
   2. Do any groups control the assets or resources?
   3. Have any groups' assets been lost to another group? Please explain.
   4. Please describe any changes in the past five to ten years.

V. Community constraints and solutions:

Rank in order of importance, and address strategies/trends for each.

a. Major problems: Thinking about the issues discussed above and others not discussed, what are the major problems facing the community?
   - What are the major causes of these problems? Prioritise – ranking exercise.

b. Trends :Are these problems getting worse or better over the last three to five years?
   - Why is it worse or better?

c. Interviewer summarises key problems discussed, asks if anything was left out.

d. What can the community do?/Is the community doing to solve these problems?
   - List and rank the most important initiatives.

e. Prosperity
   If we had the power to change one thing to improve the quality of life in the village, what would we do?
   - Why?
   - Who would be positively affected by the change?
   - Who would be negatively affected?
   - What is the fundamental cause of this particular problem?
   - What is the village currently doing at address this particular problem?

C. Wealth Ranking Exercise

Select residents comprising men and women from the community were asked to participate in an exercise to determine:

- Perceptions of poverty and vulnerability;
- Wealth groupings by community-defined attributes;
- Proportions of community residents belonging to the identified wealth categories; and
- Specific household identification for participation in the household questionnaire survey, based on proportionality of wealth groups.

Community residents define three or four wealth categories, ranging from 'very poor' to 'poor' to 'middle' or 'middle poor' to 'better-off' to 'rich'. The wealth ranking exercise provided the assessment team with key indicators of poverty and vulnerability by wealth category, including (amongst other variables):

- Food consumption patterns;
- Access to land, livestock, and assets;
- Income sources;
- House types; and
- Social capital within the community.

The wealth-ranking format is presented below.
Village____
Division____________________________ Division________________________________
Group ggender ___________________ Date_______________________________________
Facilitator____________________________ Recorder________________________________

Wealth categories				
Indicators	Category 1 __________	Category 2 __________	Category 3 __________	Category 4 __________
Food/diet (quality and quantity)				
Access to land and size of landholding				
Livestock (types and numbers)				
House (type/size)				
Assets (productive and non-productive)				
Types of employment (e.g. fishing, wage labour, govt., business, etc.)				
Membership in institutions (including CBOs)				
Remittances from abroad				
Water and sanitation (Water sources and toilets)				
Levels of education				
Other				
Number and proportion of HH in this category				

Observations:	

D. Venn Diagrams

The research team should also conduct an institutional and social positioning exercise, in order to describe issues around social capital within the community, including community and household inter-relations. Starting with the community at the center, focus group participants should be asked to describe and then to place the most Important institutions serving community and households. Which institutions do community residents deem to be closest to them; which institutions are furthest from their interests or participation? The research team should facilitate two Venn diagram sessions per community, allowing different groups of men and women to reflect on their position *vis-à-vis* institutions within the community. Residents should be asked to comment why they positioned the institutions in relation to trust and institutional importance.

The Venn diagramming exercise is presented below.

Venn diagramming exercise:

- This is a social and institutional positioning exercise.
- Describe community and household relations with key institutions.
- Begin with community at the centre.
- Describe important community institutions and organisations.
- Which institutions are most important from the perspective of the focal group discussion?
- Which institutions does the community trust and feel closest to?
- From which institutions does the community feel alienated?

Venn diagram exercise process:

- Draw institutions as defined by community.
- Draw the most and least important in relation to community and households.
- Facilitator asks for reflection and feedback.
- Rearrange the Venn diagram.
- Why are these institutions positioned in such a way?
  - Trust and importance of institutions for community
- What would be better?
  - Recommendations
- Does everybody in the focal group discussion agree?
- Draw two Venn diagrams per community: 1 male and 1 female group.
- Compare and contrast male/female Venn diagrams during analysis stage.
- Specifically ask about NGOs.
  - Which NGOs are operating in the community?
  - What are NGOs doing? Describe NGO programming activities.
  - How close is community to NGOs?
  - Assess NGO effectiveness in responding to community priorities and needs.

E. Opportunity analysis of resilient or ‘positive deviant’ households

As part of the focus group discussions, researchers should ask community participants to identify ‘positive deviant’ households representing success stories in managing risks. These households, who share similar attributes to other focal group discussion participants, have nevertheless managed to be more successful, through their adoption of different types of adaptive strategies. The team should interview four such households within each village in an effort to understand the enabling factors contributing to household self-resilience.

The household opportunity analysis topical outline is presented below.

Household opportunity analysis using positive deviance: Topical outline:

Theme: What are the enabling factors that contribute to household self resiliency?

1. Characteristics of this household
   - Landholdings;

- Asset base;
- Income sources;
- Education.

2. Household decision making by different members of household

3. What shocks have affected this community in the last five years?
   - How have you prepared for such shocks?
   - How did you cope with these shocks?
   - What have you done to recover from these shocks?

4. Capacity to adapt to vulnerability
   - What opportunities exist and have been used by the household? Probe.
   - Is there some behaviour that makes your household unique? Please explain.
   - What are some of the enabling factors for your household to become self-resilient? Probe.

5. What does it mean to be self-resilient in the community?

F. Community Based Organisation (CBO) case study:

The assessment team can garner information from a CBO or other community-based social institution to understand to what level the principles of good governance are practised by that institution. The tool can also be used to capture information to understand the power dynamics that exist in the community between the organisation or institution being studied and other entities in or around the community.

The CBO topical outline is presented below.

Tropical outline for CBO case study:

(The field team leader should make the decision on the type of CBO or village leadership institution)

Name of the Village: ____
Name of the CBO: ____
Type of CBO: ____

Person(s) interviewed:

Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________
Name: __________________________ Position: __________________________

I. History and profile of organisation

a. Organisational purpose
   - What is the purpose of the organisation?
b. Formation
   - When was the organisation formed?
   - How was it formed?
   - How has the organisation changed over the years since it was formed?

c. Membership:
   - What is the composition of the organisation? Who are members of the organisation?

d. Organisational Vision:
   - What is the vision for the organisation?
   - What does the organisation want to look like in the future, ten years from now?

II. Programme activities:

a. Current activities:
   - What are the current activities of the organisation?
   - How long have these activities been underway?
   - Why have these activities been undertaken?

b. Beneficiaries:
   - Who are the targeted beneficiaries for these activities?

c. Completed activities:
   - What other activities has the organisation undertaken in the past that are now completed?
   - What was the impact of these activities?

d. Planned future activities:
   - What kinds of activities would the organisation like to undertake in the future?
   - Why these activities?
   - What is the organisation doing to make these activities a reality?

e. Success story:
   - Of all of the activities presently undertake or undertaken in the past, of which of these is the organisation most proud? Why?

III. Resources:

a. Human resources
   - What human resources does the organisation have?
   - What are the roles of the various officers?

b. Material assets
   - What material resources does the organisation have (buildings, furnishings, office equipment, vehicles)?
   - How were these obtained?

c. Financial assets
   - What is the current annual budget for the organisation?
   - What are the sources of revenue?
   - How have these changed over the years?

d. External relations
   - What relationships does the organisation have for resources, technical support, political support or other reasons?

e. Government relations
   - Describe your relationship with the government.
   - Is anybody monitoring your activities?
   - When was the last time monitoring took place?
   - What was the impact of the monitoring?

IV. Governance system:

- Who are the leaders of the organisation?
- How were they chosen?
- For how long do they serve?
- What process is in place for changing leadership?
- How often are changes in leadership supposed to occur?
- Who are the members of the organisation?
- How many are men and how many are women?
- How much of the village does the membership represent?

- Are there any parts of the village that are not represented within the organisation? Why not?
- How does the organisation decide what kinds of activities to undertake?
- Who is involved in developing plans for these activities?
- How does the organisation report back to constituents on implementing progress and use of resources?

V. Current issues:

- What are the current issues that the organisation is working on?
- When was the last meeting of the organisation?
- What were the issues that were discussed?
- Why are these issues important?
- Who decided to work on these issues?

VI. Perceptions of the underlying causes of poverty:

a. Priority problems
   Of all of the problems in the village, what are the five most important? Rank these in priority order. Why are these five issues the most important?
   1.
   2.
   3.
   4.
   5.

b. Most important underlying causes of poverty
   - Considering the priority problems discussed above, what is the most important fundamental or underlying cause of poverty and social injustice?
   - If, while working together, we had the power to eliminate one cause of poverty and injustice, what should we do?

2. Household survey

Members of each of the assessment teams should visit ten households in each village. The wealth ranking exercise serves as a selection mechanism. Households should be were selected based on proportional identification by community members of wealth categories, which normally range from very poor to poor to middle to relatively rich. Assessment team members should then administer a household questionnaire to each selected household participating in the survey.

The household questionnaire is presented below.

Household survey questionnaire:

Questionnaire ID number: __________

I. Identification

team ___ village______ HH

SL	Particulars	
1.1	DS division	
1.2	GS division	
1.3	Village	
1.4	Interviewer signature	
1.5	Date	

II. Demographic information

- Name of the respondent: ____
- Religion: for example, Buddhist/Christian/Muslim/Hindu/Others (specify)_________________
- How many years has your household lived in the village? ____________________
- Wealth category: ____

- Number of family members:
  Male adults ________ Female adults _____________
  Male youth (ages 12-17) ________Female youth (ages 12-17) _________
  Male children (ages 6-11)________Female children (ages 6-11) ________
  Male children under 5 years _____ Female children under 5 years ________
  Total household members ___________
- Total earning members of the family Male________ Female______ Total_______

List the above in the table below and provide the information shown.

First name (start with family head)	Sex	Age	Education	Livelihood activities (food production or income generation)		
				Most important	Next most important	Other activities

Education: None=N; Primary=P; Secondary=Sec; University=Un; Technical school=Tec

III. Livelihoods assets:

- In the 12 months, has the household lost possession of any assets (excluding sales)? ____
- Which assets? ____
- What is the estimated value of the assets lost? Relevant currency ______________
- What happened? ____
- Household assets:

Type of asset	Current quantity	Value of asset (relevant currency)	# of assets sold in past 12 months	Why was asset sold?
Crop paddy land *(select unit of area)*				
Crop highland *(select unit of area)*				
Homestead land *(select unit of area)*				
Tubewell				
Open well				
Shared well				
Cows				
Sheep or goats				
Chickens				
Ducks				
Other livestock or poultry				
House for residence				
Shop or other building				
Toilet				
Plough				
Mammotty				
Sprayer				
Water pump				
Boat (type) _____________				
Boat (type) _____________				

Type of asset	Current quantity	Value of asset (relevant currency)	# of assets sold in past 12 months	Why was asset sold?
Fishing nets				
Cart with bullock				
Skill tools				
Bicycle				
Motor bike				
Mobile phone				
Savings (monthly in rupees)				

IV. Livelihood activities:

a. Food production activities
   i. Please provide the following information on the sources of food for the family over the last month.

Source of food	Percentage of household food
Food crop production	
Livestock production	
Poultry production	
Fishing	
Food rations	
Purchased food	
Borrowed food	
Total	100%

   ii. For how many months in the past 12 months did your family eat three meals per day? _______________
   iii. Which months did you have food shortage? ____
   iv. What were the major causes of this food shortage? (state major two)

   ____

	Household food consumption by food group	Yes	No
iv. Has your household consumed any food falling under the following food groups in the last 24 hours?	a. Grain staples (rice, sorghum, maize, millet)	1	2
	b. Tubers (potato, sweet potato, manioc)	1	2
	c. Pulses (dhal, beans, cow peas)	1	2
	d. Yellow to orange fruits and vegetables (papaya, pumpkin, mango, carrot)	1	2
	e. Fruits (banana, pineapple, jackfruit, grapes)	1	2
	f. Green leafy vegetables	1	2
	g. Other vegetables (tomatoes, gourds)	1	2
	i. Dairy (milk, cheese, yoghurt)	1	2
	j. Meats (beef, mutton, chicken, other poultry, …)	1	2
	k. Fish (fresh fish, dried fish, smoked fish)	1	2
	l. Eggs	1	2
	m. Sugar	1	2
	n. Oils/fats (soybean oil, mustard oil, cooking oil, ghee)	1	2
	o. Beverages (tea, coffee, toddy)	1	2

b. Income-generation activities:

i. Please provide information on the estimated annual total income on major income sources of the family and income earned in the last month.

Income sources	Average monthly amount in relevant currency over last 12 months
Agriculture	
Poultry	
Non-farm day labour	
Livestock	
Farm day labour	
Handicraft products	
Small business or petty trade	
Fishing/fish catch/drying	
Toddy or jaggery sales	
Skilled trades (masonry, carpentry, etc.)	
Service trades (barber, etc.)	
Government salary	
NGO salary	
Government payment (widow's fund, etc.)	
Remittances from relatives abroad____________________	
Others (specify)	

ii. How have your sources of income changed in the last five years? Better/Same/Worse (Circle) Why? (2 possible reasons) ____

____

iii. Are there other income generating activities you would like to pursue? Yes______________________
No________________________

iv. What are these other activities? ____

v. What do you need to pursue these activities? ____

c. Health security

- How many days were different household members sick last year?

Adult or child	Sex	Number of days sick	What type of illness	Cost

d. Asset building activities:

i. Technical advice

- Have you received any technical advice from anyone that enabled you to increase your food production or income? Yes _____No _______
- Who provided this advice? ____
- What kind of advice was it? ____

ii. Education

1. Please list the members of the household under 21 years old who are/were attending school.

Age of HH member	Sex	Grade/Level	Cost	If dropped out of school why

iii. Social capital

2. Please list the members of the household who are members of various groups in the table below.

Household member	Name of group	Attend meetings or other events? How often?

3. If you do not belong to a CBO or group, why not? ____
____
4. Would you like to belong to a group or CBO? Yes ________ No __________
5. What group would you like to join? ____
6. Why? ____

iv. Access to capital for expanding livelihoods or for household emergencies

- Has anybody in the household taken a loan for any reason in the past three years?
  Yes__________ No__________
- Please list all loans:

Source of the loan	Amount borrowed (relevant currency)	What was the main purpose of the loan?	Annual interest rate	Amount repaid

e. Asset conversion activities

i. Regular production marketing

Please indicate items the household produced that were sold in the market last year:

Product	Quantity	Where sold (Which market)?	Total amount received

- How many times per week do household members go to the market to sell production?
  ____

ii. Input supply

Describe your household use of inputs to produce food or generate income in the last 12 months.

Type of input	Purpose of input	Amount spent on input

iii. Distress sales

- In the last 12 months, have any members of the household sold something in order to generate cash for an emergency? Yes ____________No ____________
- What was sold? ____
- What was the emergency? ____

V. Shocks and coping strategies

During the last three years, did your household suffer any shocks due to conflict, natural disaster, or other shocks?	Yes____ No ____
Please specify the shocks (up to 3)	1.
2.	3.

During that time, if there have been times when you did not have enough food or money to buy food, how often did your household have to:

SN	Coping option	Times per week			
		Every day	2-6 times per week	1-6 times per week	Never
a	Rely on less preferred and less expensive foods?				
b	Borrow food, or rely on help from friends or relatives?				
c	Purchase food on credit?				
d	Gather wild food?				
e	Consume seed stock held for next season?				
f	Send household members to live elsewhere?				
g	Limit portion sizes at mealtimes?				
h	Restrict consumption of adults so children can eat?				
i	Reduce the number of meals eaten in a day?				
j	Skip entire days without eating?				
k	Sell jewelry or household items to purchase food?				
l	Sell livestock to purchase food?				
m	Sell farm or fishing implements to purchase food?				
n	Other (specify)				
o	Other (specify)				

The survey questionnaire should solicit data about:

- Demographics, including education and economic activities;
- Food consumption and food expenditure patterns;
- Household expenditures, incomes and assets;
- Savings and loan patterns;
- Household livelihood strategies;
- Health security; and
- Shocks and coping strategies

The following is quoted directly from (http://www.mangrovesforthefuture.org/Assets/documents/RTC-Semarang-18-11-2008/Document/RTC-Coastal%20Climate%20Change%20considerations%20and%20Disaster%20 Risk%20Reduction/RTC-Summary%20of%20CRISTAL%20(April%205%2007)-18-11-2008.pdf and Hammill, A., www.c3d-unitar.org/c3d_private/modules/knowledgebox/io/file.php-).?entry=235&field=1-).

Ecosystem management and restoration can reduce vulnerability to climate-related disasters but climate-related disasters will worsen. In this context, IUCN, the International Institute for Sustainable Development (IISD), the Stockholm Environmental Institute (SEI-US) and Intercooperation - the Swiss Foundation for Development and International Cooperation developed a decision-support tool called CRISTAL[19] to help project planners and managers better understand the links between climate change, livelihoods, and their work. By focusing on community-level projects, CRiSTAL promotes the development of adaptation strategies based on local conditions, strengths and needs. Its goal is to promote the integration of climate change adaptation into community-level projects (Hammill, A., www.c3d-unitar.org/c3d_private/modules/knowledgebox/io/file.php?entry=235&field=1-).

CRISTAL seeks to:
- help users to understand systematically the links between livelihoods and climate;
- enable users to assess a project's impact on community-level adaptive capacity; and
- assist users in making project adjustments to improve its impact on adaptive capacity.

Designed for community-level project designers and managers, it is user-friendly and offers multiple formats and as part of a suite of tools (Hammill, A., www.c3d-unitar.org/c3d_private/modules/knowledgebox/io/file.php?entry=235&field=1 -).

CRISTAL intends to enhance local adaptive capacity through a better understanding of:

- how current climate hazards and climate change affect a project area and local livelihoods;
- how people cope, looking specifically at the resources needed to cope with climate stress;
- how project activities affect livelihood resources that are vulnerable to climate risk and/or important to local coping strategies; and
- how project activities can be adjusted so they adaptive capacity.

CRISTAL is designed around two modules. The first module synthesises information about climate and livelihoods. It asks two questions:
- What is the climate context, examining the impacts of climate change, current hazards, the impacts of hazards and copies strategies.
- What is livelihood context, examining resources, how they are affected by hazards, how important they are to coping.

Module 2 plans and manages projects for adaptation. Again, it asks two questions:
- What are the impacts of project activities on livelihood resources that are a) vulnerable to climate risks; and b) important to coping.
- How can project activities be adjusted to reduce vulnerability and enhance adaptive capacity, and looks at synergies and barriers.

CRISTAL has been field tested in planned or ongoing natural resource management projects in Mali, Bangladesh, Tanzania, Nicaragua and Sri Lanka.

CRISTAL can be downloaded from http://www.sei-us.org/Cristal/Cristal_Setup.exe.

[19] http://www.mangrovesforthefuture.org/Assets/documents/RTC-Semarang-18-11-2008/Document/RTC-Coastal%20Climate%20Change%20considerations%20and%20Disaster%20 Risk%20Reduction/RTC-Summary%20of%20CRISTAL%20(April%205%2007)-18-11-2008.pdf

IUCN's Best Practice Guidelines for Environmentally Sound Reconstruction After the Tsunami

After the Indian Ocean tsunami of December 2004, IUCN Sri Lanka was requested by various government agencies to produce some documentation on introducing environmental safeguards into post-tsunami reconstruction. A series of 14 best practice guidelines[20] were produced, published and disseminated in both national languages as well as in English. The guidelines presented the issues, impacts, the need, guiding principles and key steps to follows for a series of 14 topics: 1) Where to build; 2) Invasive alien species; 3) Materials for reconstruction; 4) Beach clean ups; 5) Solid waste management; 6) Recovery of marine ecosystems; 7) Restoring tourism; 8) Preparing for natural disasters; 9) Environmental laws; 10) Restoring terrestrial ecosystems; 11) Water pollution; 12) Restoring wetlands; 13) Restoring home gardens and 14) Safeguarding marine protected areas.

These guidelines can be adapted easily to fit a specific situation in a specific locale.

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 1 After the tsunami: where to reconstruct environmental issues

The issues:
Environmental concerns are not receiving adequate attention in the process of identifying locations for reconstruction and resettlement.

- There is an urgent need to rehabilitate displaced human communities and set them on the path to sustainable lives and livelihoods.
- A coastal no-build zone of 100m in the south and west and 200m in the north and east has been proposed by the government.
- The government of Sri Lanka and other parties are seeking actively suitable land for construction and alternate building areas.
- A danger and immediate threat to ecologically and economically important sites such as wetlands and mangroves could be posed if they are cleared to provide relocation sites for temporary and permanent housing. If this is within or near protected areas, this is illegal under various laws of the country (the Fauna and Flora Protection Ordinance, the Forest Ordinance, the Coast Conservation Act and the National Environmental Act, among other laws).
- Many state and non-governmental agencies as well as many private individuals are working on reconstruction and restoration. Knowledge about existing zoning laws and protected habitats is not circulated adequately. Therefore, laws are not always enforced.

The impacts:

- Habitats such as mangroves are home to a wide range of economically and ecologically important species such as fish and crustaceans. They provide a range of livelihoods for coastal communities. Already damaged by the tsunami, further loss and clearing of mangroves will, in the long term, worsen the living conditions of coastal communities.
- Mangroves buffer the coastline against extreme weather and thereby prevent erosion, limit salt-water intrusion and protect communities against tidal surges and storms. Further loss of coastal vegetation will leave coastal communities even more vulnerable to recurrent extreme weather events such as cyclones and storms.
- Low lying wetlands function like sponges to retain water and prevent floods. They also trap and retain sediments that are washed off to the sea from rivers. Wetlands also purify water by filtering sediments and decomposing matter and converting them into usable nutrients. Construction on wetlands could result in flash floods, loss of topsoil, increased sedimentation and a very quick reduction in the capacity of the ecosystem to support coastal livelihoods.
- Construction on low-lying wetlands would also cause changes to the water-table by reducing the amount of water retained and reducing the amount that reaches deep. This could lead to increased water-shortage during periods of drought.
- Construction in wetland areas would reduce drainage and increase the likelihood of flooding.
- Housing in wetland areas where water is usually stagnant could also increase diseases such as those that are borne by mosquitoes.
- Haphazard and unplanned building will worsen the above impacts.

[20] Citation: IUCN (2005). http://data.iucn.org/places/asia/coastalinfo/best_practise.htm

The need:
There is an urgent need to select construction sites based on sound guidelines that also integrate environmental concerns. Ensuring that natural ecosystems are not destroyed is essential to securing sustainable livelihoods for coastal populations. Natural ecosystems are also vital in protecting human settlements and maintaining essential services such as flood and storm protection, water supply and quality and easing the effects of floods.

Guiding principles:

- Uphold and follow the existing laws and policies that relate to environmental management and protection.
- Avoid clearing ecologically sensitive sites such as mangroves, scrubland and forests.
- Avoid building on/filling lowland wetlands and watershed areas.
- Minimise destruction by clearing only the essential, minimal area for each building.
- Ensure that natural water courses, watershed areas, flood plains, etc. are not blocked by construction.
- Make efforts to restore and conserve ecosystems as part of the reconstruction process.
- Integrate environmental concerns in development. The methodology for carrying out very rapid Initial Environmental Examinations (RIEE) is currently available. It is advisable that such RIEEs should be carried out prior to reconstruction.

Key steps:

- Prior to selecting sites for construction, consult the Urban Development Authority (UDA) - which has offices in affected districts - to identify whether the site is ecologically sensitive. (See Box 1 for details.)
- Consult the Coast Conservation Department (CCD) if the proposed construction is within 300m of the Mean High Water Line (MHWL). (See Box 3 for details.)
- Consult the Forest Department if the proposed construction is close to a forest area and/or on mangrove/ wetland state land. (See Box 2 & 3 for a list of proposed conservation areas and details.)
- Construction within nature reserves protected by the Department of Wildlife Conservation (DWC) (Strict Natural Reserves, National Parks, Nature reserves, Jungle corridor refuges and Marine reserves) is prohibited. (See Box 2 for a list of protected areas in affected districts.)
- Consult the DWC if proposed constructions are within a Sanctuary or Buffer zone. (See Box 3.)
- Consult the CEA/DWC if proposed constructions are within 200m radius of a Sanctuary or one kilometre radius of any other protected area.
- Construction within a buffer zone needs approval under the National Environmental Act. Consult the CEA. (See Box 3 for details.)
- Involve affected communities in the process of reconstruction, and invest in providing alternate livelihoods and immediate source of income as part of the reconstruction process.

Box 1 provided information on the following, related to the UDA:

Location	District	Name of officer-in-charge	Address	Contact details

Box 2 detailed protected areas in coastal districts affected by the tsunami:

District	Name	Status
Protected Areas under the Department of Wildlife Conservation (Source: Department of Wildlife Conservation)		

Box 3 gave contact details of focal personnel in relevant organisation such as:

- The Urban Development Authority;
- The Central Environmental Authority;
- The Forest Department;
- The Department of Wildlife Conservation;
- Coast Conservation Department;
- IUCN.

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 2 After the tsunami: tealing with Invasive Alien Species

What is an Invasive Alien Species (IAS)?
Invasive alien species are those non-native (non-indigenous or exotic species) that, when introduced outside their natural range, have the capability to exceed their limits imposed on them. They grow rapidly, compete vigorously and in the absence of their natural predators, push out native species and alter ecosystems. They have the potential to cause damage to the environment, human health, livelihoods and the economy.

The issue:
Coastal IAS have been transported inland by the tsunami and are now spreading rapidly, posing a threat to native biodiversity. Degraded ecosystems are very vulnerable to invasion by alien species. Debris collection areas can become ideal places for the spread of IAS. Species such as Mesquite (*Prosopis juliflora*) prefer saline soils, and hence may establish themselves in areas that have been flooded with seawater.

Displaced domestic cats and dogs could also cause problems to wildlife in protected areas.

Common IAS spreading inland as a result of the Tsunami:

Prickly pear
(Opuntia dillenii)

Mesquite
(Prosopis juliflora)

Some potential impacts of IAS:
- They alter ecosystems.
- They destroy and deplete native species.
- They become agricultural pests.
- They transmit diseases and can cause illness and/or death.
- They facilitate the spread of forest fires.
- They cause pollution of water bodies.
- Because they are agricultural pests, they reduce native species and cause fires and pollution. They are economically very damaging to communities.
- They are also costly to control and eradicate, once they have been established.

The need:
There is an urgent need to prevent the spread of IAS that have been transported inland by the tsunami. (Examples include the Prickly pear cactus, and seeds of Mesquite.)

Guiding principles:
Encourage the re-establishment of native species and eliminate invasive alien species during the process of rehabilitation.

Key steps:

- Prevent spreading by uprooting known IAS plants such as the Prickly pear Cactus and Mesquite.
- Ensure that the roots are also uprooted.
- Prevent dumping these uprooted IAS on the roadside or in rubbish dumps because they will start growing on site.
- Burn what has been removed in a safe place, away from other vegetation.
- Use native species where replanting is needed.
- Ensure that displaced domestic dogs and cats are sent to animal shelters and do not become feral (wild).
- Watch for exotic species known to be invasive in Sri Lanka (see Box 1) and contact the Department of Wildlife Conservation or IUCN for advice on eradication/control measures that should be adopted.

Contact details of relevant organisations were listed.

Box 1: List of species known to be invasive to Sri Lanka:
(from Bambaradeniya C. N. B. (2001) Aliens in Sri Lanka: The status of invasive alien species, IUCN Sri Lanka).

Animals:

Name	Habitat/Ecosystem affected
Rainbow trout *(Oncorhynchus mykiss)*	Streams
Clown knife fish *(Chitala ornata)*	Tanks, ponds, slow flowing rivers, marshes
Plectosomus catfish *(Hypostomus plecostomus)*	Tanks, ponds, slow flowing rivers, marshes
Walking catfish *(Clarias batrachus)*	Marshes, streams and canals
Guppy (*Poecilia reticulata)*	Tanks, ponds, slow flowing rivers, marshes
Western mosquito fish *(Gambusia affinis)*	Marshes, streams and canals
Mozambique tilapia *(Oreochromis mossambicus)*	Tanks, ponds, slow flowing rivers, marshes
Carp (*Cyprinus carpio)*	Tanks, reservoirs
Snake-skin gouramy *(Trichogaster pectoralis)*	Tanks, ponds, slow flowing rivers, marshes
Red-eared slider turtle *(Trachemys scripta)*	Marshes, streams, canals
Golden apple snail *(Pomacea bridgesii)*	Tanks, ponds, marshes
Giant African snail *(Achatina fulica)*	Natural and managed terrestrial habitats
Slug (Laevicaulis alte)	Natural and managed terrestrial habitats
Garden slug (*Deroceras reticulatum)*	Disturbed and managed terrestrial habitats
House mouse (*Mus musculus)*	Natural and managed terrestrial habitats
Ship rat *(Rattus rattus)*	Natural and managed terrestrial habitats
Feral cat *(Felis catus)*	Natural and managed terrestrial habitats
Feral dog *(Canis familiaris)*	Natural and managed terrestrial habitats
Feral buffalo *(Bubalus bubalus)*	Forests

Plants:

Name	Habitat/Ecosystem affected
Water hyacinth *(Eichhornia crassipes)*	Tanks, ponds, marshes, streams
Salvinia *(Salvinia molesta)*	Tanks, ponds, streams
Water lettuce (*Pistia stratiotes)*	Tanks and marshes
Hydrilla (*Hydrilla verticillata)*	Tanks, ponds, streams, canals
Pond weed *(Najas marina)*	Coastal aquatic habitats
Alocasia macrorhiza	Marshes and riparian areas
Colocasia esculenta	Marshes and riparian areas
Cattail *(Typha angustifolia)*	Estuaries, tanks and marshes

Plants contd.

Name	Habitat/Ecosystem affected
Phragmites karka	Marshes, riverbanks
Annona glabra	Coastal lagoons, marshes, riverbanks, stream banks
Cocklebur (*Xanthium indicum*)	Marshes, villus, tank margins
Dillenia suffruticosa	Marshes, streambanks, riverbanks
Giant sensitive plant (*Mimosa pigra)*	Riverbanks
Alligator weed *(Alternanthera philoxeroides)*	Fallow fields, marshy/riparian areas
Prickly Lantana *(Lantana camera)*	Shrub Scrubland, degraded open forests
Gorse *(Ulex europae)*	Montane forests, wet grasslands
Mistflower *(Eupatorium riparium)*	Shrub Montane forests
Siam weed *(Chromolaena odorata)*	Forest edge and pathways
Cestrum aurantium	Shrub Montane forests
Mesquite (*Prosopis juliflora)*	Thorn scrublands
Prickly pear cactus *(Opuntia dillennii)*	Thorn scrublands
Koster's curse *(Clidemia hirta)*	Rainforests
Mahogany *(Swietenia macrophylla)*	Disturbed forests
Mimosa invisa	Disturbed forests
Ipil ipil (Leucaena leucocephala)	Dry-mixed evergreen forests
Clusia rosea	Rock outcrop in forests
Congress weed *(Parthenium hysterophorus)*	Fallow fields, marshy areas
Wedelia *(Wedelia trilobata)*	Forest edge
Myroxylon balsamum	Dry-mixed evergreen forests
Velvet plant *(Miconia calvescens)*	Disturbed forests
Tithonia diversifolia	Secondary forests
Mile-a-minute weed *(Mikania micrantha)*	Disturbed forests and scrubland
Strawberry guava *(Psidium littorale)*	Montane forests
Alstonia macrophylla	Secondary forests
Millingtonia hortensis	Disturbed forests and scrubland
Imperata cylindrical	Disturbed forests and scrubland
Guinea grass *(Panicum maximum)*	Disturbed forests and scrubland
Fern (*Pteridium aquilinum)*	Disturbed montane forests and wet grasslands

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 3: After the tsunami: materials for reconstruction

The issues:
Present post-tsunami clearing up and reconstruction efforts may have an adverse impact on the environment and therefore on human well-being.

- There is an urgent need to reconstruct almost 80,000 completely destroyed and more than 40,000 partially destroyed housing units, as well as schools, private and public sector buildings.
- The construction process itself, as well as human settlements, could give rise to undesirable environmental impacts.
- This massive reconstruction process is leading to an enormous increase in the demand for building materials.
- As a consequence of this increased demand, there is a sudden and excessive demand for natural resources such as sand, clay, timber, metal aggregates, coral-based lime, etc.
- There is already a ban on coastal sand and coral mining and a restriction on river sand mining. The increased demand for these natural resources is likely to cause an increase in illegal activities.
- There is a moratorium on logging of timber in forest reserves. The increased demand for timber (for temporary housing) is already resulting in the clearance of ecologically sensitive areas such as mangroves and may cause an increase in illegal tree felling.
- It is illegal to clear mangroves, wetlands and forests on state land

The impacts:

- Extraction of river and coastal sea sand will intensify coastal erosion and seawater moving up rivers (saline intrusion).
- Untouched sand dunes provide protection to the coastline. Extraction of sand from these sand dunes will, again, intensify erosion and leave coastal communities more vulnerable to extreme weather events.
- Coral reefs, which have been damaged and are already stressed from the impacts of the tsunami, will be under increased pressure by coral extraction. This would have serious negative impacts, as reefs are known to absorb the majority of wave energy. They not only protect the shoreline from erosion but also build up beaches (accretion) over many centuries.
- Further damage to coral reefs through extraction for lime will affect and retard the restoration of livelihoods in coastal communities as part of the ecosystem on which they depend will be destroyed.
- Destruction of the existing tree stands for timber will, again leave the coastline and coastal communities more vulnerable to natural disasters. There are clear data to prove that large mangrove stands functioned to reduce the impacts of the tsunami.
- Destruction of mangroves affects the retention of floodwater and increases surface water run off. This will intensify extreme floods in urban areas.
- Increased extraction of clay and to a lesser extent metal aggregates would involve the clearing of more vegetation leaving soil exposed to erosion.
- All of the above leaves the coastline and coastal communities more vulnerable to recurrent natural disasters such as cyclones, heavy storms, floods and droughts.

The need:
There is an urgent need to ensure that post-tsunami reconstruction does not further damage already affected ecosystems, which in turn affects coastal communities that are dependent on these ecosystems for their livelihoods.

Guiding principles:

- Reconstruct according to sound land use principles, based on minimum land use and minimum environmental impact at an acceptable cost.
- Follow proper building design and construction practices, including respecting relevant laws and policies.
- Reconstruct in a manner that does not further damage the environment.
- Environmentally friendly alternatives should be used as raw materials wherever possible for reconstruction.
- Ensure that from the beginning, relevant government departments - such as the Coast Conservation Department, Central Environmental Authority, the Forest Department, the Department of Wildlife Conservation and the Urban Development Authority - are consulted.
- Ensure that from the beginning, government agencies, local communities, local and national NGOs, humanitarian and donor agencies etc. integrate environmental concerns into reconstruction.

Key steps to be taken:

- Immediately stop extraction of coastal sand and coral, and any illegal river sand mining.
- Reuse and recycle as much building material as possible. For example, concrete debris could be crushed and used as a coarse base for road reconstruction, intact tiles can be reused etc.
- Encourage the use of environmentally friendly alternatives such as recycled wood, recycled glass; use masonry cement for plastering, etc.
- Use alternatives to tropical hardwood timber, for example, plantation timber or timber aggregates.
- As an immediate measure, explore the possibility of using offshore sand already extracted.
- Consult the Central Environmental Authority, Coast Conservation Department and the Geological Survey and Mines Bureau to explore the possibility of extracting sea sand by offshore dredging and to identify sites that are not environmentally sensitive for offshore dredging.
- Identify metal aggregate quarry sites (for producing both coarse and fine aggregate) that would cause minimal environmental damage.
- Recruit affected communities for the process of reconstruction, thus providing alternate livelihoods and immediate sources of income.

(Contact details of focal persons in relevant officers were given.)

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 4: After the tsunami: cleaning up reefs and beaches

The issues:

Coral reefs have been damaged by the tsunami in a variety of ways. Abundant debris and litter on and adjacent to the reefs is causing additional damage.

- In some areas, the receding tsunami waters carried with them waste and debris from land. Much of this debris (both organic and human-made) has been deposited on coral reefs and beaches.
- Debris can physically damage the reef structures and can also stress the corals, preventing successful recovery of these important marine ecosystems.
- Debris and litter on beaches is an eyesore and discourages tourists. It can also injure people walking on the beach.
- Human-made litter can be consumed by living organisms, with sometimes fatal consequences, or it can form potentially lethal obstacles, either causing entrapment or physical harm.

The impacts:

- Coral reef ecosystems provide habitats, breeding and feeding grounds for many important species of fish harvested for commercial purposes or as food for families. The livelihoods of many coastal communities already affected by the tsunami in the short term through loss of gear and materials, can therefore also be seriously affected in the longer term by damage to the ecosystem that sustains them.
- Clean beaches and healthy coral reefs are vital for tourism. Tourism is the fourth largest contributor to Sri Lanka's GDP and brought in a revenue of nearly 400 million USD in 2004. About 50% of the registered hotels in affected areas in Sri Lanka were damaged by the tsunami and income from tourism has dropped sharply with losses estimated between 65 - 130 million USD. Debris-filled beaches and coral reefs will retard seriously the revival of coastal tourism, and the much needed revenue this brings to coastal communities.
- Reefs protect low lying coastal areas from extreme, recurrent weather events such as tropical storms and cyclones. Damage to these reefs will leave coastal communities vulnerable to recurrent natural disasters and will, therefore, weaken community development.
- Reef systems act as buffers, protecting coastal areas from erosion. Depleted reef areas can lead to coastal erosion, which will adversely affect livelihoods and infrastructure.

The need:

There is an urgent need to remove the debris and litter that has been deposited on the reefs and beaches as this is preventing the natural recovery of the coral reef ecosystem and thereby retarding the restoration of the livelihoods of coastal communities.

Guiding principles:

- Ensure that reef clean-up operations are carried out under the guidance of experienced marine specialists. Contact IUCN for further information and assistance in debris clearance. (See Box 1 for contact details.)
- Beaches with debris still remaining should be identified and cleaned. Care should be taken during the reconstruction process not to leave additional debris on the beaches as this can create a negative visual impact, or can be washed into the sea and be deposited on the reefs.
- Plan, well beforehand, the clean up process so that the necessary equipment and the expertise are available and necessary approvals obtained.
- Care and attention towards the living reef is vital – participants should be patient, and move in a slow, non-destructive way, with the minimum of disturbance to the reef as possible. The cleanups should not cause additional stress to the reef.
- Human safety is also extremely important. A safety coordinator with first aid training should be appointed, medical kits should be readily available, emergency telephone numbers should be known, and all participants should be briefed on working signals and any potential hazards.
- Debris should be sorted, separating recyclable components from non-biodegradable litter. All recyclable debris should be separated and reused, and all other debris taken to official dumping grounds.
- Ensure that collected debris is taken away and disposed in designated disposal sites. A list of dumping sites is given in Box 2. If you are uncertain about where debris should be taken, please check with the relevant authority.

Key steps (adapted from Good environmental practices: underwater cleanup: © CORAL)

- *Snorkelling*
  - Diving is not always necessary, but planning and setting protocols even when snorkeling is essential. Although snorkellers may work alone, they should follow the same basic safety protocols as divers, have the same cleanup targets, and take similar care of the reefs.
- *Planning the dive*
  - Always dive with a buddy and be sure to check equipment and review diver signals beforehand.
  - Make sure underwater conditions and weather are suitable for diving to ensure safety of divers and underwater organisms.
- *Gearing up*

  In addition to normal dive gear, divers will need:
  - Mesh sacks;
  - Gloves for protection from rubbish and sharp objects;
  - Shears or scissors for cutting fishing line and tin cans.
- *Dive protocol*
  - Work slowly and carefully.
  - Dive in a head-down position with fins up to avoid making contact with the bottom.
  - Adjust buoyancy throughout the dive as collected garbage gets heavier.
  - Make sure equipment is secured and the mesh sack is held so that nothing can trail or snag on corals.
  - One diver should collect garbage with gloves on while another holds the mesh sack.
  - Place glass, needles and hooks inside other garbage for safety.
  - Never try to remove anything that cannot be easily lifted, such as tires or car batteries.
- *Cleanup targets*
  - Plastics, especially plastic bags;
  - Cloth items or rice sacks;
  - Fishing line, netting, and broken lobster pots or fish traps;
  - Batteries, bottles without marine growth, and tin cans;
  - Cigarette butts and bottle caps;
  - Concrete debris;
  - Wood from furniture, boats;
  - Organic debris.
- *What to remove and what to leave*
  - Be cautious not to remove articles that have already been incorporated into the reef and are helping to support life.
- *Check it before you bag it*
  - Make sure nothing is living in or on each item before removal.
  - Do not remove bottles that are covered in growth.
  - Cut open tin cans to ensure that there is nothing living inside.
  - Hold cups or cans close to sandy parts of the sea bed and shake out sand or silt.
- *What to leave*
  - Anything that is ‘stuck’ or encrusted with growth;
  - Anything, no matter how ugly, which has become overgrown with marine life;
  - Anything that may be dangerous;
  - Heavy items - never use your buoyancy control device to lift heavy objects;
  - Metal drums and containers that might contain hazardous materials.
- *Plastic fishing line*
  - Never try to pull fishing lines free. Cut and remove it.
  - Use shears or scissors rather than a knife.
  - Wrap the line around an object or hand to control it.
- *After the dive*
  - Arrange for garbage to be collected or taken to an official site - do not leave it on the beach.

(Contact details of focal persons in relevant organisations were given.)

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 5: After the tsunami: solid waste management

The issue:

The recent tsunami damaged buildings, infrastructure and natural vegetation. The debris created from this damage has generated a considerable amount of solid waste, both biodegradable and non-biodegradable.

- This solid waste needs to be cleared up and disposed of properly, ensuring that there is no further damage to the environment.
- Under normal circumstances, certain wastes – such as hazardous and flammable wastes – are required to be disposed with extra care. Such wastes released because of the tsunami from damaged industrial plants and fuel stations can be dangerous to human health and damaging to ecosystems.
- Solid waste can also serve as breeding grounds of disease vectors such as flies and other pests. Because of this, debris from the tsunami can increase the spread of infectious diseases.
- Debris detracts from the beauty of the environment.

The impacts:

- Dumping of debris into the sea and in lagoons will cause further damage to already damaged ecosystems and will further retard the recovery of livelihoods such as fisheries that are dependent on the healthy functioning of these ecosystems.
- Dumping of debris in low lying wetlands will affect their ability to act like sponges to absorb the run off from rainwater and damage the normal functioning of mangrove ecosystems, which have been proven to act as buffers to protect coastal communities against the action of waves. It will also increase the probability of floods during the rainy season.
- Debris that is contaminated with chemicals such as petrol, kerosene and diesel, as well as industrial chemicals can contaminate ground water for many years to come and affect potable sources of water. Numerous coastal sources of fresh water - such as wells and tanks - have already suffered damage due to the infiltration of salt water from the tsunami waves. Already 62,000 wells and other sources of fresh water have been contaminated with salt water. Further contamination can place these communities at high risk from chemical poisoning.
- Chemical contamination of groundwater from solid waste, can lead to grave water shortages, particularly in arid areas such as the Hambantota district that are already annually affected by drought.
- Biodegradable solid and liquid waste - from damaged sewage tanks and cesspits or overflowing mains or waste material blocking water drainage systems and sewers - can seriously affect sanitation, and increase the risk of spreading water borne diseases such as typhoid, dysentery, cholera, respiratory tract infections and skin diseases.
- Hazardous wastes such as carcinogens in containers washed out by the tsunami, asbestos from roofs and medical waste that has been displaced from disposal sites have the potential of causing cancers in the future.
- The communities most at risk will be those displaced and already severely disadvantaged.
- Unsightly debris and dumping debris into the sea can retard the recovery of tourism, the fourth biggest contributor to the GDP and an industry that supported both directly and indirectly a total of 130,000 jobs in 2004.

The need:

There is an urgent need for solid waste to be disposed of effectively and efficiently, to carefully selected sites of disposal, in a manner that does not further damage livelihoods, affect human health or negatively impact the environment.

Guiding principles:

- Waste needs to be separated into biodegradable (vegetative) waste and non-biodegradable in a rapid manner.
- Waste needs to be disposed of safely, both for humans and for the environment.
- Recycle and reuse wherever possible.

Key steps:

- Before disposing debris, contact the Central Environmental Authority for identification of recommended disposal sites. (See Box 1 & 2 for details.)
- Prevent the irresponsible dumping of wastes.

- Provide safety training and involve communities in sorting waste.
- Ensure that those who are engaged in clearing debris have adequate protection in the form of gloves and boots as well as anti-tetanus coverage.
- Monitor the disposal sites over time, to check for chemical and biological pollutants leaching into groundwater.
- Separate biodegradable from non-biodegradable waste and recycle as much as possible as follows:

Type of waste	Potential use	Comments
Non-biodegradable waste		
Construction and demolition debris: such as aggregates, gypsum, tiles, asphalt, concrete, bricks, road masonry and stone.	Reuse tiles and bricks wherever possible. Impact and use for landfill and for road bases.	The debris should not contain hazardous chemicals or by-products.
Wood	Use in reconstruction or as part of vegetative matter. (See below.)	
Dirt (non-specific, including sand deposited by the tsunami)	Use as fill for potholes and eroded areas.	The dirt needs to be screened to remove other waste products.
Plastic (non-specific)	Send for recycling.	The debris should not include hazardous chemicals.
Metal (all types)	Send for recycling.	Cut or crush for easy transportation.
Asbestos	For careful disposal.	Should be handled very carefully when wet, bagged and buried. Masks should also be worn when handling asbestos.
Glass	Send for recycling.	
Biodegradable waste		
Vegetative waste, paper, spoilt food items etc.	Compost for land regeneration	Most waste should be shredded before composting in order to quicken the composting process.

Adapted from: Pasche and Kelly (2005).

(Contact details of focal persons in relevant organisations were given.)

Literature reviewed:
Pasche, A. and C. Kelly (2005). Concept Summary: Improving the Disposal of Tsunami-Generated Waste UNDAC/Sri Lanka.

WMinE Group (2005). Waste Management following Asia Tsunami Earthquake: Key Issues. http://www.redr.org/WMinE/TsunamiWasteAction.pdf

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 6: After the tsunami: recovery of marine ecosystems

The issues:
Key marine ecosystems - such as coral reefs and seagrass beds - have been damaged by the tsunami. The successful recovery of these ecosystems may be threatened by poorly planned reconstruction activities.

- Certain areas of coral reef and seagrass habitat were damaged physically by the mechanical impact of the tsunami, as well as increased sedimentation and deposition of debris as a direct result of the tsunami.
- In many of these areas litter and debris are still present and pose a threat to the successful recovery of these systems.
- Planned reconstruction activities and livelihood activities must be carried out in an environmentally sensitive manner so as not to further threaten these already stressed habitats.

The impacts:

- Reefs protect low lying coastal areas from extreme weather events such as tropical storms and tsunamis and need to be maintained for the future security of coastal communities. If marine habitats are not allowed to recover, there will be a severe reduction in the capacity of natural ecosystems, as well as human economic and social systems, to withstand future extreme weather events.
- Marine ecosystems - such as reefs and seagrass beds - support important subsistence and commercial marine species. Failure to rehabilitate these ecosystems will compromise the sustainability of livelihoods in areas affected by the tsunami, both in the short and longer term.
- Illegal use of resources – mining for lime, sand mining in rivers, blast fishing – are still widespread in certain parts of the coast. These damaging methods of extraction seriously affect the productivity of reefs and in turn, affect coastal livelihoods.
- Reef systems and mangroves act as buffers, protecting coastal areas from erosion. The damage of reefs through mining for lime, and sand mining in rivers (which interrupts the natural deposition of sand to beach areas), has lead to severe coastal erosion – measured at one metre per year. This may adversely affect current and planned coastal developments. The rehabilitation of reef systems will reduce the susceptibility of the coastline to erosion.
- Clean beaches and healthy coral reefs are important for tourism. If marine and coastal ecosystems are not effectively rehabilitated the revival of coastal tourism will be negatively affected.

The need:

There is an urgent need to facilitate the recovery of tsunami-damaged marine habitats because they provide vital economic, livelihood and ecosystem functions.

Guiding principles:

- Management of marine ecosystems should focus on stress relief rather than active restoration.
- Emphasise the urgent need to remove negative pressures – such as increased sedimentation and pollution through the inappropriate discharge of waste, unsustainable exploitation of marine resources (damaging fishing practices, sand and coral mining, etc) - on marine ecosystems in order to facilitate natural recovery. This is imperative.
- Allow reef and seagrass habitats to recover naturally. (The composition and structure may change and the recovery rate will depend on external influences.) The active restoration of reef habitats should only be carried out by experienced personnel and is only appropriate in certain circumstances. (See Box 1 for details.)
- Apply an adaptive management approach (for example, modifying and continuously reviewing management techniques in line with up to date information) in the planning and implementation of ecosystem rehabilitation. This is necessary given the complexity and uncertainty of the current situation, and the knowledge gaps that still exist about the post-tsunami status of many marine habitats.

Key steps:

- Do not dispose tsunami debris and waste on the shoreline and in marine areas. Use designated waste disposal sites. (See Box 2 for a list of disposal sites recommended by the CEA.)
- Disposal of waste is prohibited under the National Environmental Act No. 47 of 1980 (NEA) as amended, Marine Pollution Prevention Act No. 59 of 1981, Nuisance Ordinance enacted in 1862, the Penal Code enacted in 1880 and the Criminal Procedure Code No 15 of 1979 in concurrence with Section 261 of the Penal Code. (See Information paper no 9: Knowing about environmental laws and policies.) Even disposal of treated waste requires permits from the Central Environmental Authority and the Coast Conservation Department.
- Existing debris should be removed from coral and seagrass areas. However, it is important that this is done using appropriate methods (see After the tsunami: cleaning up reefs and beaches, Information Paper 4). Contact IUCN for further information on and assistance in debris clearance. (See Box 3 for contact details.) Such clean up operations have already been carried out by IUCN at Hikkaduwa and Unawatuna.
- Damaging resource use practices such as blast fishing, coral mining (which are illegal under the Coast Conservation Act) and other destructive fish harvesting practices targeting ornamental fish should be prevented, so that already stressed marine systems are not degraded further.

Box 1: The active restoration of reef habitats should only be carried out by experienced personnel and is only appropriate in certain circumstances.

Contact IUCN for support on coral transplantation. (See Box 2 for details.)

Coral reef restoration may be achieved by enhancing rates of natural colonisation through providing artificial substrates, or by using active restoration techniques such as transplanting coral to areas that are degraded (using either existing substrates or artificial substrates). It is important to remember that:

- Coral restoration techniques tend to be labour intensive and expensive, and are only suitable in special circumstances.
- Transplanted corals may have lower rates of growth and survivorship than surviving colonies and new recruits. Similarly,
- species diversity may be lower in transplanted coral colonies.
- Even if restoration is pursued, removing external pressures on reef systems is the key to ensure the survival of transplanted, as well as existing, corals.
- The extent to which restoration can be carried out is limited.
- Natural recovery is recommended strongly as it is faster and will encourage higher species diversity.

Box 2 listed street addresses of disposal sites in each affected coastal district.

Box 3 listed contact details of focal persons in relevant organisations.

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 7: After the tsunami: restoring tourism - environmental issues

The issues:
Tourism, the fourth largest contributor, in terms of foreign exchange earnings, to GDP in Sri Lanka, was affected severely by the tsunami.

- The tourism industry makes a major contribution to the Sri Lankan economy, at both national and local levels. Directly and indirectly tourism supports nearly 120,000 jobs per annum and generates about 350 million USD per year in foreign exchange earnings.
- Many hotels were damaged by the tsunami and tourist arrivals to the island decreased drastically. As a consequence, many people lost their jobs and livelihoods are at risk.
- There is a danger that in the rush to restore the tourism industry, environmental concerns may not be addressed adequately.
- Reconstruction is taking place slowly but delays have been encountered mainly due to importation of materials, insurance related issues and confusion about where to rebuild.
- Ecotourism and environmentally-friendly tourism represent a high-value growth market which could be integrated successfully into planning for future tourism sector developments.

The impacts:

- The damage from the tsunami to hotels is an estimated 200 million USD to rooms and another 50 million USD for tourism related structures (souvenirs shops, etc.). The Sri Lanka Tourist Board carried out a survey to estimate the cumulative value of loss based on book values and estimates this at 50 million USD. Neither of these estimates includes attendant losses associated with coastal communities such as the losses to livelihoods or the multiplier effects of tourism on related sectors (such as transport, recreation, restaurants, souvenirs and other support industries) or employment (the many families that rely on earnings from tourism).
- Clean beaches and healthy coral reefs are vital for tourism. The receding tsunami waters carried with them waste and debris from land and much of this – both organic and human-made - has been deposited on coral reefs and beaches. There are also some reports that debris cleared from inland is being dumped in the sea. Debris on beaches and coral reefs will seriously retard the revival of coastal tourism, and the much-needed revenue this brings to coastal communities.
- Nature tourism has been known to cause changes in behaviour patterns in communities from consumptive use of natural resources to non-consumptive use - for example, from collecting turtle eggs for sale to taking tourists to view marine turtles lay eggs. There is a real danger that without regular income, there could be a reversal to previous habits and unsustainable use of natural resources.

- Reconstruction without reference to environmental issues could lead to wastage of scarce resources such as energy and water, and the discharge of wastes without attention to recycling. This will, in the long term, have negative impacts on the environment.

The need:
Global trends towards nature-based tourism are on the increase. There is also a demand and high willingness to pay for environmentally-friendly tourism on the part of foreign tourists to Sri Lanka. Many hotels in Sri Lanka are already conscious of the need to conserve the environment and to develop non-consumptive and sustainable consumptive use of natural resources. The reconstruction and rehabilitation process offers an unique opportunity to maximise environmental and socially sustainable design and construction, benchmark key performance areas such as energy and water conservation, minimise pollution, ensure adequate land use planning and management, enhance ecosystem conservation, and reduce harmful environmental, social and cultural impacts from tourism.

Guiding principles:
- Ensure that policy guidance issued by TAFREN on re-building is followed.
- If new construction is envisaged, then obtain fresh approvals from the Coast Conservation Department, the Urban Development Authority and the Central Environmental Authority, in keeping with relevant Sri Lankan laws.
- Ensure that a wide consultative process is followed in planning reconstruction, in order to adhere to legal requirements and to ensure that all stakeholders are kept informed.
- In the long term, aim for globally accredited best practice guidelines in relation to environmental management such as Green Globe 21 or ISO 14000 accreditation.
- Ensure that community based programmes are integrated in to reconstruction in order to maximise corporate social responsibility.

Key steps (adapted from the Green Globe 21 company standards):
- Ensure that all national and local laws are followed before and while reconstructing. (See also ‘After the tsunami: knowing about environmental policies and legislation.)
- Ensure that environmental management, ecosystem conservation and community outreach programmes are integrated into company policy.
- Where complete reconstruction is required, use low-impact designs, materials and construction methods. (See also After the tsunami: materials for reconstruction, Information Paper 3.)
- Set baseline environmental performance benchmarks in key performance areas, in order to ensure vigilant environmental monitoring. These key areas should include:
  - Energy conservation and optimisation (such as energy efficient lighting and solar heating);
  - Water conservation (such as dual flush toilets and low-flow showerheads, collection of rain water);
  - Waste water management (such as sewage treatment plants);
  - Maintenance of air quality and reduction of emissions of greenhouse gases (such as banning aerosols and careful selection of environmentally friendly cleaning agents);
  - Erosion control and landscaping (such as using only indigenous species, moving away from monoculture);
  - Reducing, recycling and reusing natural resources (such as composting kitchen waste, recycling glass and paper);
  - Switching to using environment-friendly products (such as switching from plastic to glass, wood and ceramic products; using environment-friendly cleaning agents).
- Once these benchmarks are achieved, consider working toward achieving international standards such as Green Globe 21 standards, for value-addition to the service provided.
- Incorporate sustainable use of natural resources and enhancing local livelihoods through community outreach, training and education programmes and adopting focussed programmes of corporate social responsibility.
- Ensure that due consideration in given to designs so that they take into consideration extreme weather events such as tidal waves and storm surges.
- Ensure that natural barriers such as mangroves and sand dunes are protected and enhanced as these acted as effective barriers against the tsunami.
- Establish early warning systems, evacuation and disaster management plans - in case of any eventuality.

(Contact details of focal persons in relevant organisations is given.)

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 8: After the tsunami: learning to prepare for natural disasters

Recurrent natural disasters:

Tsunamis in the Indian Ocean are not frequent, and a tsunami of the magnitude and impact of the recent tsunami on December 26th 2005 is not likely to recur in the near future. However, climate change experts have predicted that as a result of global warming, recurrent natural disasters - extreme weather events such as intense rainstorms, cyclones, floods, fires, and worsened droughts - will become more frequent.

The issues:

Certain communities in Sri Lanka are extremely vulnerable to recurrent natural disasters, which are predicted to become more frequent. Such recurrent natural disasters could weaken social welfare, equity, and sustainable development of coastal communities.

Coastal communities are vulnerable to the after effects of cyclones and storms. In addition, recent research indicates that the structure of the seabed has changed as a consequence of the tsunami and hence, regular monsoonal waves may become stronger. Therefore, these communities are not only already vulnerable, but have been made even more vulnerable after the tsunami.

- Communities in the Sabaragamuwa Province are vulnerable to earth slips and floods as a consequence of the instability of hill slopes. Year in year out, many people are made homeless during monsoonal rains that cause floods and earth slips.
- Communities in the arid zone - particularly in the Hambantota and Mannar districts - are affected severely by drought, as there is little or no rain annually from May to September.
- Ecosystems such as coral reefs and mangroves in the coast as well as forests on slopes have been proven to serve as barriers against natural disasters, acting as natural buffers. Degradation of these ecosystems have left communities more vulnerable to the full forces of these natural disasters.
- Inadequacies in existing methods of communication to spread news quickly of extreme weather events can endanger many lives.
- The lack of disaster management plans including planned methods of evacuation can, again, endanger many lives.
- The lack of a permanently established and well-coordinated programme for providing relief and rehabilitation to people displaced in these recurrent extreme weather events seriously hampers community development.

The impacts:

- Most coastal communities have already been affected severely by the tsunami. They are at risk of further damage from the imminent south west monsoons on south western coast, and/or other tropical storms arising in the Indian Ocean, that are predicted to recur, as a result of climate change. This will worsen the living conditions of communities that have already lost their meagre assets, their resources and livelihoods.
- In 2003, heavy monsoonal rains, accompanied by intense winds caused landslides and flooding in the southern districts of Kalutara, Galle, Matara and Hambantota districts and the Sabaragamuwa province, the extent of which was the worst in 50 years. Massive infrastructural damage was also inflicted, seriously retarding the progress of development in those areas.
- Fifty five thousand people were affected by drought in the Hambantota district in 2001. Due to the drought nearly 15,000ha of arable land was abandoned and damage to livestock was also reported. Even when the rains came the following year, many small-scale farmers were unable to recover because they had had no income. Thus, traditional livelihoods are seriously affected by recurrent natural disasters.
- Change in weather patterns, predicted as a consequence of climate change, results in geographical changes in the range of disease carrying species - such as mosquitoes - with the result that epidemics of vector-borne diseases can spread rapidly. It is estimated that some families may spend 10% of their annual income per episode of malaria, which is substantial when family income has been depleted due to natural disasters.

The need:

It is essential that vulnerable communities are empowered to adapt and cope with recurrent natural disasters. Given that coastal communities - already been battered by the tsunami - are now even more vulnerable to extreme weather events, there is an urgent need to ensure that preventative actions are taken now to reduce the after effects of extreme weather events.

Guiding principles (Adapted from the Guidelines for natural disaster prevention, preparedness and mitigation, UNISDR 1994):

- Planning in anticipation of an event is better than reacting hurriedly to it.
- Some communities (such as those listed above) are more at risk than others and they should be given priority attention.
- Disaster prevention should be integrated into development planning.
- Creating awareness and educating vulnerable communities to cope with recurrent natural disasters is essential.
- Empowering vulnerable communities by including them in decision-making and creating a sense of community ownership is also essential.
- Environmental protection as a component of sustainable development is urgently needed as a tool for the management of natural disasters.

Key steps:

- Prioritise, through wide stakeholder participation, the needs and capabilities of vulnerable communities to respond to natural disasters.
- Formulate, using wide stakeholder participation, practical disaster preparedness plans for vulnerable communities such as coastal communities, those at risk from droughts and those at risk from floods and landslides. These plans should include, among other components, early warning systems, rapid and effective communication of warnings, set evacuation routes, set evacuation shelters, apid and planned relief operations.
- Ensure that where infrastructure and buildings need reconstruction/construction, due attention is given to strengthening such structures against recurrent natural disasters. For example, households are not built on sharp and bare slopes in the Sabaragamuwa province and houses on the coast are not built out of temporary materials that are not proof against the elements.
- Actively conserve those ecosystems – such as coral reefs, mangroves sand dunes and lowland rainforests - that provide protection to vulnerable communities. Where necessary, these ecosystems should be restored.

(Contact details of focal persons in relevant organisations were given.)

Series on Best Practice Guidelines (Sri Lanka) Information paper No. 9: After the tsunami: knowing about environmental policies and legislation (prepared in collaboration with the Environmental Foundation Ltd.).

The issue:
There is a need to enhance awareness about existing policies and laws concerning tsunami-affected areas, as there is currently a great deal of confusion about what is permissible.

- Given the large number of governmental, non-governmental, and international organizations involved in post-tsunami reconstruction, and the rush to rebuild, many existing policies, laws and regulations are not being given due consideration.
- There is great uncertainty about whether, and which, new policies and regulations have been established post tsunami.
- This has resulted in much confusion about where to reconstruct, and is slowing down the process of rehabilitation.
- It is reported that many people are concerned about the lack of clarity in newly-established policies.
- It is reported that many people are going ahead with reconstruction without due regard to established policies, existing laws and regulations or ecologically sensitive sites.
- All the above could further damage already affected ecosystems, thereby exacerbating adverse impacts on livelihoods.

The impacts:
Many laws and regulations have been established in Sri Lanka in order to regulate human behaviour so that ecosystems and species, and thereby the goods and services provided by them, are conserved. This, in turn, ensures the protection of livelihoods. Failing to uphold these laws and regulations leads to many far reaching and damaging impacts, including increased vulnerability to coastal erosion and recurrent weather events, decreased agricultural production, and diminishing natural resources, including fish stocks. Laws also ensure that our natural capital is managed sustainably and equitably.

The need:
There is an urgent need to ensure that post-tsunami reconstruction is carried out in a timely and equitable manner with reference to existing laws and regulations, as well as to proposed laws and new policies.

Legal definition of the coastal zone:
The coastal zone is defined in the Coast Conservation Act no 57 of 1981 ‘as the area lying within a limit of 300m landward from mean high water line (MHWL). In the case of rivers, streams, lagoons or any other body of water connected to the sea, either permanently or periodically, the landward boundary extends to a limit of two kilometres 2km measured perpendicular to the straight base line drawn between the natural entrance points thereof and includes waters of such rivers, streams and lagoons or any other body of water so connected to the sea.’

Guiding principles:
- Reconstruct according to existing laws and regulations.
- Become aware of and be knowledgeable about new policies and laws with respect to construction and use of natural resources in affected areas. Contact relevant authorities if in doubt. (See Box 2.)

Key steps to be taken:
(A list of ordinances and acts relevant to environmental issue related to reconstruction is given in Box 1. See also ‘Rebuilding after the tsunami keeping it legal’ by the Environmental Foundation Ltd.)

Know the legal boundaries of where reconstruction cannot occur. (See also IUCN Information paper 1: After the tsunami: where to reconstruct – environmental issues)
- The government has proposed a no build zone of 100m in the south and west and 200m in the north and east.
- Unauthorised construction is banned within the coastal zone as defined by the Coast Conservation Act (CCA).
- It is mandatory that a permit be obtained from the Coast Conservation Department (see Section 14 of the CCA) for any developmental activity (any activity that is likely to alter the physical nature of the Coastal Zone in anyway). These activities include
  - building,
  - deposition of wastes,
  - removal of sand, sea shells, natural vegetation, sea grass and other substances,
  - dredging and filling,
  - land reclaiming and
  - mining and mineral extraction.

For any of the above activities, the Director of the Coast Conservation Department may call for an Environmental Impact Assessment (EIA).
- No construction activities are permitted in National Reserves (under the jurisdiction of the Department of Wildlife Conservation – see the Fauna and Flora Protection Ordinance No. 2 of 1937 as amended) and Forest Reserves (under the jurisdiction of the Forest Department – see the Forest Ordinance of 1907 as amended), which are state lands.
  The following are National Reserves
  - a Strict Natural Reserve
  - a National Park
  - a Nature Reserve
  - a Jungle Corridor
  - a refuge
  - a Marine Reserve
  - a buffer zone
  (See Information Paper 1 for a list of protected areas in affected districts.)

- Sanctuaries, also declared under the Fauna and Flora Protection Ordinance, may include privately held land. Consult the Department of Wildlife Conservation if reconstruction is proposed in sanctuaries.
- Construction within one mile radius of a national reserve, sanctuary or buffer zone needs permission from the Department of Wildlife Conservation. (See the Fauna and Flora Protection Ordinance No. 2 of 1937 as amended.)
- Any development activity within a fishery reserve requires the permission and approval of the Director of Fisheries and Aquatic Resources. (See the Fisheries and Aquatic Resources Act No. 2 of 1996.)
- Under the National Environmental Act No. 47 of 1980, the environmental impact assessments process is applicable to certain prescribed activities. Under the National Environmental Act No. 47 of 1980, the environmental impact assessment process is applicable to certain prescribed activities. IEE/EIAs are mandatory for the following activities. The list is representative and not complete. Please check with the regional offices of CEA for details.
  - All river basin development and irrigation works;
  - Reclamation of land, wetlands exceeding four hectares;
  - Conversion of forests covering areas exceeding one hectare into non-forest uses;
  - Clearing of land exceeding 50ha;
  - Housing and building construction;
  - Resettlement;
  - Water supplies;
  - Pipelines;
  - Hotels.
- No development or encroachment of any kind is permitted in archaeological reserves declared under the Antiquities Ordinance No 9 of 1940 as amended (Section 34). The Director General of Archaeology is empowered to conduct an archaeological impact assessment of areas that may be affected by development, industrial or other projects proposed by the government or any person. (Antiquities Ordinance No. 9 of 1940 as amended, Antiquities (Amendment) Act No. 24 of 1998.)
- Using paddy land for a purpose other than agricultural cultivation without the written permission of the Commissioner General is a punishable offence under the Agrarian Development Act No. 46 of 2000 (Section 32).
- Local government approval should be sought prior to reconstruction to ensure that the proposed area does not fall within an area allocated for a public purpose/reservation etc.
- There are also subsidiary laws that must be complied with for land use and allocation.

Know what you may build.

- Approval from the local authority under which a land is situated i.e., the Urban Development Authority, the Municipal Councils, the Urban Councils and the Pradeshiya Sabhas is required when reconstruction and rebuilding take place. Structural and other specifications are taken into consideration when processing an application.

Know which activities are prohibited. (See also IUCN Information Paper 2.)

- Extraction of corals. (See Coast Conservation Act No. 57 of 1981 (CCA) as amended.)
- Removal of sea sand except in areas identified by Coast Conservation Department under permits granted by them. (See Coast Conservation Act No. 57 of 1981 (CCA) as amended.)
- Removal of river sand. (See Mines and Mineral Act No. 33 of 1993.)
- Extraction of any resources from designated protected areas. (See the Fauna and Flora Protection Ordinance No. 2 of 1937 as amended, the Forest Ordinance of 1907 as amended.)
- Extraction or excavation in archaeological reserves (See the Antiquities Ordinance No 9 of 1940 as amended and Antiquities Ordinance No. 9 of 1940 as amended, Antiquities (Amendment) Act No. 24 of 1998.)
- Any development activity that will significantly degrade the quality of any area designated as being exceptional ecosystems and habitats of threatened species, for enhancing the natural beauty of the wilderness of Sri Lanka. (National Heritage Wilderness Act, No 3 of 1988.)
- Indiscriminate disposal of waste. (National Environmental Act No. 47 of 1980 (NEA as amended), Marine Pollution Prevention Act No. 59 of 1981, Nuisance Ordinance enacted in 1862 The Penal Code enacted in 1880, Criminal Procedure Code No 15 of 1979 in concurrence with Section 261 of the Penal Code further elaborates on Public Nuisance.)

Know which activities within the coastal zone require a permit from the CCD.
- Dwelling houses and related structures;
- Tourism, commercial and industrial structures;
- Recreational and/or water sport facilities;
- Harbour structures and navigation channels;
- Roads, bridges and railway lines;
- Public and religious structures;
- Shoreline protection work to be carried out by any private individual or group;
- Sewage treatment facilities and ocean outfalls;
- Aquaculture facilities;
- Disposal of solid waste;
- Dredging, filling, grading and breaching of sand bars;
- Mining and mineral extraction;
- Removal of sand or seashells;
- Removal of vegetation;
- Removal of coral for research purposes;
- Power generation projects;
- Reclamation and grading;
- Construction of conveyance lines;
- Construction, mining and breaching related to flood control or hazard control by any private individual or group;
- Any other activity likely to alter the physical nature of the Coastal Zone.

Know which activities may be conducted without a permit.
- Fishing;
- Cultivation of crops that do not destabilise the coast.
- Planting of trees and other vegetation. Caution must be used in the choice of species which should, ideally, be species common in the area.
- Construction and maintenance of coastal protection work carried out by the Coast Conservation Department in accordance with the Coastal Zone Management Plan.

Box 1 presented laws relevant to the reconstruction process. (See Volume 2 page 23 for this list.)

Series on Best Practice Guidelines (Sri Lanka) Information paper No.10: After the tsunami: restoring terrestrial coastal ecosystems

The issues:
Terrestrial coastal ecosystems, such as palm plantations, home gardens, mangroves, lagoons and other tree-dominated landscapes (*Casuarin*a plantations, scrub forest, etc.) suffered considerable damage from the tsunami. In some areas these have been further threatened by post-tsunami rehabilitation and reconstruction activities. Limiting further damage to these important ecosystems and restoring them in a participatory and sustainable manner is therefore a key priority.
- Terrestrial coastal ecosystems such as mangroves, home gardens, lagoons, palm and other coastal tree plantations are important livelihood resources for many coastal communities and provide a range of vital ecosystem goods including nutrition, timber, fuelwood, medicines and fisheries. They also provide services such as protecting the coastline, absorbing, storing and releasing carbon in a form that plants can use, and providing habitats for biodiversity.
- These ecosystems have been damaged significantly by the tsunami.
- In some areas, post-tsunami rehabilitation and reconstruction activities, for example, through land clearance for setting up temporary shelters, are further threatening these habitats.
- The Sri Lankan government has proposed the development of a no-build coastal green belt aimed at restoring tree/vegetation cover along coastal areas.
- However, restoration activities such as mangrove replanting, establishment of shelterbelt plantations, etc. need careful thought and implementation, and framed within the broader context of integrated coastal zone management based on the existing land uses prevalent in the area.

The impacts:

- Habitats such as mangroves are home to a wide range of economically and ecologically important species such as fish and crustaceans. They provide a range of livelihoods for coastal communities. Already damaged by the tsunami, further loss and clearing of mangroves will, in the long term, worsen the living conditions of coastal communities.
- On the ground assessments have revealed that intact and mature mangrove stands buffered the coastline against damage from the tsunami. Broad intact stands of mangroves, shelterbelt plantations, stablised and vegetated sand dunes are known to protect communities against tidal surges, storms and extreme weather conditions and thereby prevent erosion and limit salt-water intrusion. Further loss of coastal vegetation will leave coastal communities even more vulnerable to recurrent extreme weather events such as cyclones and storms.
- Managed coastal vegetation such as palm (coconut and palmyrah) plantations and home gardens, were affected severely by the tsunami. These managed systems help to support the livelihoods of local people in several areas by providing food, timber and thatching for housing/fencing, fuelwood and sources of other income.

The need:

There is an urgent need to restore damaged terrestrial ecosystems as they provide vital goods and services and support local livelihoods.

Guiding principles:

- Carry out ecosystem restoration in coastal terrestrial areas with reference to existing national laws.
- Carry out ecosystem restoration in coastal terrestrial areas by matching local needs and priorities with the goods and services that ecosystems provide, rather than implementing predetermined and inflexible land use configurations in a top-down manner.
- Ensure that from the beginning, the process is participatory involving sufficient consultation among all stakeholders within that landscape and builds on traditional knowledge available on the management of natural and managed ecosystems within the local communities.
- Ensure that, from the beginning, all relevant government departments – such as the Forest Department, the Coast Conservation Department, Central Environmental Authority, Urban Development Authority and the Department of Wildlife Conservation – are consulted and play a central role in restoration together with the local communities.
- Ensure that, from the beginning, restoration activities are carried out in a way that does not harm the interests of the poor, the displaced and other marginalised communities. Activities should, therefore, be not only participatory but also transparent and negotiated fairly. Activities should strive to provide direct livelihood benefits in an equitable manner i.e., through the provision of employment for planting, nursery activities, etc.
- Formulate a clear vision that links and balances restoration with medium to long-term benefits to local communities as well as the environment. When restoration options are selected, make every effort to ensure that the trade-offs, wherever they arise, are equitably (not necessarily equally) distributed among all stakeholders and that the balance between ecosystem and human livelihood needs is maintained.
- Adopt a landscape approach to restoration. Ecosystems do not function as closed units but as open systems that are affected by ecological process that occur on a larger scale. Because of this, every effort at restoration should be assessed in the context of the landscape i.e., it is necessary to look at the broader picture, not just the specific restoration site alone.
- Use indigenous, multiple-use and locally beneficial species while carrying out restoration.
- Follow adaptive management practices that are based on continuous monitoring and improvement, because complexity and uncertainty makes it impossible to predict accurately the outcomes of restoration. There is a need to recognise that the balance of goods and services provided by ecosystems today may not be the goods and services required in the future. Thus, adaptive management practices are critical.

Key steps:

- Tsunami-debris should be removed from affected ecosystem areas – beaches, home gardens, palm plantations, lagoons, etc. Fallen timber and other recyclable material (bricks, tiles, etc.) should be salvaged for use or sale. (See After the tsunami: beach and reef clean ups, Information paper 4; and After the tsunami: solid waste management, Information Paper 5, for more details.)

- Great care should be taken to ensure that restoration activities do not harm or displace existing natural ecosystems of each area. For example, turtle nesting sites or sea grass beds should not be replaced by planted mangroves or *Casuarinas*/other tree plantations.
- While undertaking cleanup operations or reconstruction activities in tsunami-affected areas, measures should be taken not to harm ecosystems/vegetation that are undamaged by the tsunami, or that which can regenerate naturally.
- Care should be taken to preferentially use indigenous species and not to introduce invasive alien species such as Mesquite (*Prosopis juliflora*) as a part of restoration process.
- Specific areas should be identified, where ecosystem restoration is a priority and have high support from the local communities and from the government.
- Local communities and government officials should be consulted to identify and agree upon local needs, local restoration priorities, preferred species, division of roles and responsibilities, and mechanisms for sharing costs and benefits of restoration over the short, medium and long term. (See below for a list of recommended species for specific ecosystems.)
- The specific restoration action needed for a particular area (i.e., protection/social fencing in areas with good root stock, assisted natural regeneration, ground preparation, planting, etc.) needs to be identified.
- Local forest department officials should be consulted for technical guidance on how to start planting activities in the selected areas. (For example, what should be the specific area, the mix of species, the spacing between the saplings, etc.)
- It is essential that before commencement of restoration, sufficient nursery material (For example, seeds, propagules, saplings, etc.) is available.
- It is also essential that a system for regular maintenance and monitoring of the plantation (For example, removal of weeds, control of pests, thinning, guarding against grazing/browsing, illegal extraction, etc.) is established.
- Immediate measures should be taken to bring under control the unsupervised and free-roaming livestock that have been feeding on undamaged natural/managed vegetation and agricultural areas after the tsunami.

Box 1 listed contact details of focal persons in relevant organisations.

Box 2 listed names of divisional forest officers and thier contact numbers.

Box 3: Suitable woody plants for site rehabilitation in tsunami affected areas – for dry/arid zones (Ampara, Batticaloa, Hambantota, Jaffna, Mullaitivu and Trincomalee districts)					
Name			Site preference		
Sinhala name	Tamil Name	Scientific name	Behind beach	More interior	Remarks on site suitability
		Acacia auriculiformis		X	
Beli	*Vilvam*	*Acronychia marmelos*		X	Homegardens
Suriya mara	*Kona/Vakai/Vagei*	*Albizia lebbeck*		X	
Rukattana	*Elilaippalai*	*Alstonia scholaris*		X	
Caju	*Montin-kai*	*Anacardium occidentale*		X	Homegardens
Kohomba	*Vembu*	*Azadirachta indica*	X	X	
	Ichanku/Iynaku	*Azima tetracantha*	X	X	
Halmilla	*Chavandalai*	*Berrya cordifolia*		X	
Thal	*Panai*	*Borassus flabellifer*	X	X	
Ketakela	*Mul-venkai*	*Bridelia retusa*		X	
Ranawara	*Avarai*	*Cassia auriculata*	X	X	
Ehala Tirukkontai		*Cassia fistula*	X	X	
Ratu-wa	*Vakai*	*Cassia roxburghii*	X	X	
Burutha	*Mutirai*	*Chloroxylon swietenia*		X	
Lolu	*Naruvilli/Vidi*	*Cordia dichotoma*		X	
Thimbiri	*Panichchai*	*Diospyros malabarica*		X	Riverine
Kolon	*Manchal Kandampa*	*Haldina cordifolia*		X	
Godakirilla	*Ayil/Kauchia/Velaylii*	*Holoptelea integrifolia*	X		
Makulu	*Makul*	*Hydnocarpus venenata*		X	Riverine
Divul	*Willa maram*	*Limonia acidissima*	X	X	
Mee	*Illupai*	*Madhuca longifolia*		X	Riverine
Amba	*Mangai*	*Mangifera indica*		X	Homegardens
Palu	*Palai/Passippayeru*	*Manilkara hexandra*	X		
Murunga	*Murungamaram*	*Moringa oleifera*		X	Homegardens
Bakmee	*Atuvangi, Vammi*	*Nauclea orientalis*		X	Riverine
Wathabanga	*Lecchai kedda*	*Pisonia grandis*	X	X	
Karanda	*Poona/punka/punku*	*Pongamia pinnata*	X	X	
Delum	*Madalai/Madalunkai*	*Punica granatum*		X	Homegardens
Malittan	*Viyay*	*Salvadora persica*	X	X	
Para Mara	*Enal vakai*	*Samanea saman*		X	Avenue plant
Kon	*Puvu*	*Schleichera oleosa*		X	
Kathurumurunga	*Akatti/Agati-keerai*	*Sesbania grandiflora*		X	Homegardens
Goda-kaduru	*Eddi/Kanchurai*	*Strychnos nux-vomica*		X	
Madan	*Naval/Perunaval*	*Syzygium cumini*	X	X	
Siyambala	*Puliyem*	*Tamarindus indica*		X	
Teak	*Thekku*	*Tectona grandis*		X	
Kumbuk	*Marudu*	*Terminalia arjuna*		X	Riverine
Kottamba	*Kottai*	*Terminalia catappa*	X	X	
Suriya	*Kavarachu/Puvarachu*	*Thespesia populnea*	X	X	
Milla	*Kaaddamankku*	*Vitex altissima*		X	

Box 4: Suitable woody plants for site rehabilitation in tsunami affected areas – for the wet zone (Kalutara, Galle and Matara districts)					
Name			Site preference		
Sinhala name	Tamil Name	Scientific name	Behind beach	More interior	Remarks on site suitability
		Acacia auriculiformis		X	
Rukattana	*Elilaippalai*	*Alstonia scholaris*		X	
Kos	*Pala/Pila*	*Artocarpus heterophyllus*		X	Homegardens
Una	-	*Bambusa vulgaris*		X	Homegardens
Mudilla	-	*Barringtonia asiatica*	X		
Domba	*Dombakottai/Punai*	*Calophyllum inophyllum*	X	X	
Kasa	*Chanku/Chabukkai*	*Casuarina equisitifolia*	X		
Pulungas/ Pulum ibmul	-	*Ceiba pentandra*		X	Homegardens
Burenda	*Dangamkuppi/Koika*	*Clerodendron inerme*	X		
Pol	*Thangai*	*Cocos nucifera*	X	X	
Mal mara	*Mayaram*	*Delonix regina*		X	Avenue plant
Erabadu	*Mulumurukku*	*Erythrina spp.*	X	X	
Pihimbiya	*Chittirai vempu*	*Filicium decipiens*		X	
Kona	*Kona*	*Gliricidia sepium*		X	Homegardens
Belipatta	*Artia/Nir-paraththi*	*Hibiscus tiliaceus*	X		
Makulu	*Makul*	*Hydnocarpus venenata*		X	Riverine
Mee	*Illupai*	*Madhuca longifolia*			Riverine
Amba	*Mangai*	*Mangifera indica*		X	Homegardens
Lunumidella	*Malaivembu*	*Melia azedarach*		X	Homegardens
Na	*Nagacuram/Naka*	*Mesua ferrea*		X	Avenue plant
Murrunga	*Murungamaram*	*Moringa oleifera*		X	Homegardens
Wetakeyiya	*Talai*	*Pandanus odoratissimus*	X		
Wathabanga	*Lecchai kedda*	*Pisonia grandis*	X	X	
Araliya	*Arali*	*Plumeria rubra*	X	X	Homegardens
Karanda	*Poona/Punka/Punku*	*Pongamia pinnata*	X	X	
Pera	*Koyia*	*Psidium guajava*		X	Homegardens
Para Mara	*Enal vakai*	*Samanea saman*			Avenue plant
Kathurumurunga	*Akatti/Agati-keerai*	*Sesbania grandiflora*		X	Homegardens
Madang	*Naval*	*Syzygium cumini*		X	Homegardens
Mahogany	*Nangi*	*Swietenia mahogoni*		X	Homegardens
Siyambala	*Puliyem*	*Tamarindus indica*		X	Homegardens
Teak	*Thekku*	*Tectona grandis*		X	
Kumbuk	*Marudu*	*Terminalia arjuna*		X	Riverine
Kottamba	*Kottai*	*Terminalia catappa*	X	X	
Suriya	*Kavarachu/Puvarachu*	*Thespesia populnea*	X	X	

Series on Best Practice Guidelines (Sri Lanka) Information paper No.11: After the tsunami: water pollution (Prepared in collaboration with the International Water Management Institution - IWMI)

The issue:

The Tsunami waters and debris have contaminated groundwater, wells and other water storage tanks.

- Most sources of drinking and bathing water including wells, tanks and groundwater in the coastal area were contaminated with seawater after the tsunami and were salinised initially and inconsumable.
- Sludge, dirt and debris were also brought in with the waters and contaminated sources of drinking and bathing water.
- Chemicals such as petrol, kerosene and diesel, as well as industrial chemicals can contaminate ground water for many years to come and affect potable sources of water.
- Manholes and sewers, which overflowed as a result of the tsunami, could also have contaminated freshwater, increasing the risk of water borne-diseases.
- Improper disposal of organic matter and post-tsunami debris could lead to further contamination of water. Debris is being dumped in abandoned paddy fields, marshy lands and roadsides, creating breeding grounds for mosquitoes and other pests. This could lead to outbreaks of disease in the future.
- Natural flushing and purification of contaminated sources of water has occurred in some affected areas but in other areas it has been too dry, particularly in the southeast and east.

The impacts:

- Numerous sources of fresh water in the coastal zone - such as wells and tanks - have already suffered damage due to the infiltration of salt water from the tsunami waves. Already 62,000 wells and other sources of fresh water have been contaminated with salt water.
- There is considerable potential for negative health impacts such as diarrhoea and dysentery in the short term due to lack of access to adequate supplies of good quality water, general environmental pollution and the lack of sanitation.

The need:

Freshwater sources need to be restored completely in order to provide people with access to clean water for domestic and agricultural use. This is a priority need that is being addressed by the Task Force for Rebuilding the Nation (TAFREN). (See Box 1 for details.)

Guiding principles:

- Provide all residents with easy access to adequate quantities of clean, safe, freshwater for drinking, preparing food and bathing.
- Immediate solutions will require innovation and improvisation, leading to gradual improvement, progressing from basic to robust and sustainable services.
- Water resources must be protected from further contamination, especially of faecal waste.
- Organic and inorganic debris should be disposed of in a proper manner so that water bodies are not polluted. (See After the tsunami: solid waste management, Information Paper 5.)
- All interventions should be undertaken in full consultation with the appropriate authorities such as the Urban Development Authority (UDA), the Rural Development Authority (RDA), the Government Agent (GA) and the National Water Supply and Drainage Board (NWSDB). They should also be undertaken in accordance with national plans by TAFREN. (See Box 1 for details.)
- All plans should also be devised in full consultation with local communities to ensure needs are met in a culturally acceptable way and in accordance with local practices and water use rights. Such traditions may be over ridden in times of disaster but it is necessary to avoid actions that enhance tensions or lead to conflict.
- Housing and new construction should ensure good sanitation facilities and sewage systems. The UDA may be contacted for further information and guidance. (See Box 2 for contact details.)
- Emergency water-supply responses should be implemented in conjunction with hygiene promotion to reduce the risk of the disaster impacting on health.
- Construction designs should ensure good drainage systems in place as approved by relevant local authorities.
- The rebuilding process should take into consideration disaster preparedness for possible future disasters (not only tsunamis). This should include vulnerability assessments (of people and infrastructure), robust designs and disaster mitigation plans.

Key steps to be taken:

- *Quantity of drinking water:*
  - The minimum quantity recommended by the WHO in post-disaster situations is 15 litres per person per day. However, it is recommended that this should increase to a minimum of 50 litres per person per day for drinking water, hygiene, sanitation and food preparation when conditions improve.
- *Quality of drinking water*:
  - Advise people on the quality of water required for certain activities and suitable sources for that water. Drinking water and water for making baby food must obviously be of higher quality than water for bathing or washing dishes.
  - Ensure that all bottled water comes from a safe source.
  - Educate people to boil water for drinking purposes. Boiling water is the preferred way to kill harmful bacteria and parasites. Bringing water to a rolling boil for one minute will kill most organisms. However, boiling brackish water for longer than five minutes can increase concentrations of sea salts and other contaminants.
  - Water can also be treated with chlorine tablets, iodine tablets, or unscented household chlorine bleach (5.25% sodium hypochlorite). If chlorine is used, levels should be such that a free chlorine residual of 0.4-0.5mg/l is achieved immediately after treatment or 0.2-0.5mg/l at the point of distribution (WHO, 2002, p.119). (See Box 3 for details on chlorination.)
  - Store water in covered tanks to allow sediment to settle out. This makes the water more drinkable and also improves the effectiveness of chlorination.
- *Wells*:
  - Prior to use, chemical analysis should be carried out on wells and other water sources that were either contaminated or suspected of being contaminated. See WHO (2004) guidelines for recommendations and methods.
  - For wells that have not been cleaned, a modified cleaning method is to just pump moderately (say total volume equal to 0.5-1m^3 or a depth of 30cm in a 1.5m diameter well), with the submersible pump at the bottom, to extract salty water as well as accumulated sludge. Water should be replenished by more freshwater from the shallow groundwater. Then, the well should be left for further natural flushing and cleaning from rainfall. (See Box 4 for further details.) Chlorination may be performed according to suitable standards (See Box 3 for further details.)
- *Aquifers*:
  - In some areas aquifers have also been contaminated and these should be left for natural restoration when the rains arrive.
- *Surface water*:
  - Ground water should be used in preference over surface water for drinking but this may not always be possible. In such cases, surface water should be protected from contamination by segregating water uses and protecting water sources.
- *Disposal of waste*:
  - Remove solid waste from open water bodies and dispose of appropriately. (See After the tsunami: solid waste disposal, Information Paper 5 for a list of CEA recommended sites.)
- *Construction of septic tanks*:
  - Septic tanks should be constructed at a minimum of 9.144 metres and ideally, 15.24 metres from water sources such as wells.

Box 1 listed the steps in the action plan by the Sri Lankan Presidential Task Force for Rebuilding the Nation (TAFREN).

Box 2 listed contact details of focal persons in relevant organisations.

Box 3: Disinfecting drinking water

The most common method of disinfecting water in emergency situations is chlorination, because it is the simplest. Calcium hypochlorite it generally used. All chlorine compounds should be handled with care. Free residual chlorine levels of more than 0.3mg/l for more than 30 minutes are required to kill bacteria and most viruses. Chlorination of stored water for consumption is best achieved using a one percent stock solution of chlorine. This contains 10% of chlorine per litre, which is equivalent to 10,000mg/l or 10,000ppm. Skin contact should be avoided when making or using the solution, as should inhalation of fumes. The solution should be made fresh everyday in the following way:

To make one litre of one percent stock solution mix the following quantities with water and make up to one litre in a glass, plastic or wooden container:

Chemical source	% available chlorine	Quantity required	Approximate measures
Bleaching powder	35	30g	2 heaped tablespoons or 8 teaspoons
Stabilised / tropical bleach	25	40g	3 heaped tablespoons or 12 teaspoons
High-test hypochlorite	70	14ml	1 tablespoon solution
Liquid laundry bleach	5	200ml	1 teacup or 6oz milk tin
Liquid laundry bleach	7	145ml	10 tablespoons
Javelle water	1	It is a 1% stock solution	

Source: WHO (2002)

Box 4: How to clean contaminated wells:

- Wells should only be cleaned and pumped by qualified and trained personnel with reporting to the local authorities (NWSDB).
- Wells should not be pumped to decrease salinity. Natural recovery is the best method for this.
- To remove sludge and debris, pump slowly (preferably with a sludge pump at the bottom). The drawdown (the extent of lowering of water) in the well must not exceed 0.5m for more than 15 minutes.
- If the well has been pumped or cleaned before, and the salinity has increased, then the well should not be cleaned again.
- When wells are cleaned, salinity at the top and bottom should be monitored, both before and after cleaning.
- Do not repeatedly chlorinate wells.
- Do not repeatedly empty wells.
- Drinking water should be purified separately (for example, by chlorine tablets or by boiling, or by the SODIS (Solar Disinfection) method.
- Wells that are salty or becoming salty should be pumped less or abandoned temporarily.
- Abandoned wells should be covered to reduce risk of mosquito breeding, and to indicate that the well is not in use.
- Deep wells (more than 5m deep) and wells pumped with motorized pumps should be regularly monitored for salinity as they stand a greater risk of salinisation.
- Wells should not be deepened in the coastal aquifers in an attempt to avoid saltwater.
- New deep wells should not be drilled in the coastal aquifers in an attempt to get fresh water.
- Stagnant water bodies should be cleaned for debris. In case of suspicion of pollution of the water body (for example, by visible oil film on the surface) cases should be reported to the authorities who should take action in the clean-up.

Series on Best Practice Guidelines (Sri Lanka) Information paper No.12 After the tsunami: restoring terrestrial coastal wetlands (Prepared in collaboration with the International Water Management Institute - IWMI)

Coastal Wetlands:

The Ramsar Convention on Wetlands defines wetlands as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.'

This information paper restricts itself to discussion on coastal wetlands, and hence, wetlands referred to in this paper will include the following habitats:

- *Estuarine waters* (permanent water in estuaries and estuarine systems);
- *Inter-tidal mud flats, inter-tidal marshes* (including salt marshes, salt meadows, salt flats, raised salt marshes, tidal brackish and freshwater marshes);
- *Mangroves and coastal brackish/saline lagoons* (brackish to saline lagoons with at least one relatively narrow connection to the sea).

The issues:

Coastal wetlands such as mangroves, lagoons and mudflats, under severe considerable threat due to coastal development demands, suffered considerable damage from the tsunami. In some areas they are further threatened by post-tsunami rehabilitation and reconstruction activities. Minimising the damage to these important wetlands and restoring them in a sustainable manner through participatory mechanisms has become a priority.

- Coastal wetlands already under considerable threat were further damaged significantly by the tsunami.
- In some areas, post-tsunami rehabilitation and reconstruction activities, for example, through land clearance for temporary shelters and by infilling through the disposal of rubble, are further threatening these habitats.
- The Sri Lankan government has proposed the development of a 'no-build' zone along the coast.
- Restoration activities such as mangrove replanting, removal of rubble, and preventing pollution need careful thought and implementation, and should be framed within the broader context of integrated coastal zone management.

The impacts:

- Mangroves are home to a wide range of economically important species, such as fish and crustaceans, supporting a range of livelihoods for coastal communities. Damage caused by the tsunami and further loss and clearing, pollution of lagoons, estuaries and marshes, and indiscriminate infilling will, in the long term, worsen the living conditions of coastal communities who depend on these resources.
- Tsunami-generated debris accumulating in wetlands impedes fishing activities by the reduction in capacity of lagoons and estuaries.
- Natural waterways that facilitate exchange of water between different wetland habitats have been blocked by debris/sediment carried by the tsunami.
- Coastal wetlands not only provide important livelihood resources for rural coastal communities, but also supply other vital ecosystem services, such as protection against extreme weather events and erosion, limits salt-water intrusion and buffers tidal surges and storms. Empirical evidence in some locations has revealed that mature, intact stands of mangroves served as effective barriers against the tsunami waves. Loss of coastal vegetation will leave coastal communities more vulnerable to recurrent extreme weather events such as cyclones and storms.
- Low-lying wetlands function as sponges and limits the impact of floods. Loss of wetland areas can lead to increased flash floods.
- Wetlands trap and retain sediments that are carried in by rivers and floodwaters. Degraded wetlands are less likely to trap and retain sediments and could also contribute sediments to floodwaters through increased erosion. Increased erosion within the wetlands will further reduce the capacity of the ecosystem to support coastal livelihoods.
- Coastal wetlands also function as traps of carbon and other minerals and with time convert them into useable nutrients.
- Coastal wetlands provide many habitats for species uniquely adapted to changes in salinity and water levels. They are important storehouses of biodiversity. We need to recognise that the diverse wetlands affected by the tsunami are part of a connected ecosystem and that many species move between them to feed or breed.

The need:
There is an urgent need to restore degraded coastal wetland ecosystems as they provide vital goods and services and support local livelihoods.

Guiding principles (adapted from the Ramsar Wetland Convention's principles and guidelines for wetland restoration):

- Carry out wetland restoration in coastal areas with reference to existing national laws.
- Carry out wetland restoration within the context of the national wetlands policy and action plan.
- Carry out wetland restoration only in areas where similar habitats had been damaged by the tsunami or by human activities. The establishment of wetlands in other places, such as sandy beaches that did not previously support wetlands, is not recommended and could undermine the successful functions already provided, for example, a reduction in coastal protection currently provided by sand dunes.
- Ensure that the goals and objectives of restoration will achieve as many purposes as possible, in recognition of the fact that wetlands provide a diversity of services (i.e., biodiversity conservation, flood control, water purification, food resources etc).
- Ensure that, from the beginning, the process is transparent and participatory involving effective and fair consultation and negotiation with all stakeholders within the landscape (both nearby as well as upstream).
- Integrate appropriate traditional knowledge into the restoration and management of wetland ecosystems and encourage multiple uses, through the re-establishment of indigenous and locally beneficial species.
- Ensure that, from the beginning, all relevant government departments – such as the Forest Department, the Coast Conservation Department, Central Environmental Authority, Urban Development Authority and the Department of Wildlife Conservation – are consulted and play a central role in restoration together with the local communities.
- Adopt a landscape approach to restoration - ecosystems do not function as closed units but as open systems that are affected by ecological processes that occur on a larger scale. Every effort at restoration should be assessed in the context of the landscape i.e., it is necessary to look at the broader picture and all wetland types within it - not just the local area or one wetland in isolation.
- Follow adaptive management practices that are based on continuous monitoring, learning and improvement, because complexity and uncertainty makes it impossible to predict restoration outcomes accurately. There is a need to recognise that the balance of ecosystem services provided by wetlands may not be the services required for in the future.

Key steps:

- Tsunami-debris should be removed from wetlands. Fallen timber and other recyclable material (bricks, tiles, etc.) should be salvaged for use or sale. [See information papers on beach and reef clean ups (Information Paper 4) and Solid waste management (Information Paper 5) for more details.]
- Great care should be taken to ensure that restoration activities do not harm or displace existing natural wetlands. For example, mangrove replanting or replanting of any other vegetation should not replace turtle nesting sites or seagrass beds.
- While undertaking cleanup operations or reconstruction activities in tsunami-affected areas, measures should be taken to avoid harming wetlands/vegetation that were relatively unscathed by the tsunami, or those that can regenerate naturally.
- Wetland species should be planted only in wetland habitats and not in other areas such as sandy beaches.
- Care should be taken to replant with indigenous species suitable for the area and not introduce exotics species as a part of the restoration process.
- Any invasive alien plants such as Prickly pear (*Opuntia dillennii*) that may have been deposited in coastal wetland habitats by the tsunami should be removed.
- Priority for restoration should be given to specific wetlands that have high support from within the local communities and from the government.
- Local communities and government officials should be consulted to identify and agree upon local needs, local restoration priorities, preferred species division of roles and responsibilities and mechanisms for sharing costs and benefits of restoration over the short, medium and long term. (See below for a list of recommended species for restoration of wetlands.)
- The specific restoration action needed for a particular area (i.e., protection/social fencing in areas with good nursery stock, assisted natural regeneration, ground preparation, planting, etc.) needs to be identified.
- It is essential that before commencement of restoration sufficient nursery material is available.
- It is essential that a system for regular maintenance and monitoring of the restored wetland (for example, guarding against illegal extraction of vegetation, etc.) be established.

Box 1 listed contact details of focal persons in relevant organisations.

Box 2 listed divisional forest officers and contact numbers.

Box 3: Suitable species for mangrove rehabilitation in Tsunami affected areas
N: north NE: North East E: East SE: South East S: South W: West NW: North West

Name			General site suitability in Sri Lanka								Remarks
Sinhala name	Tamil name	Scientific name	N	NE	E	SE	S	SW	W	NW	
-	*Kannamaram/ Venkandal*	*Avicennia marina*	X	X	X	X	X	X	X	X	
-	*Kanna/Upatha*	*Avicennia officinalis*	X	X	X	X	X	X	X	X	
-	-	*Bruguiera cylindrica*			X				X	X	
Mal-kadol	-	*Bruguiera gymnorhiza*	X	X	X	X	X	X	X	X	
-	-	*Cerbera manghas*	X	X	X	X	X	X	X	X	Tidal influence is not so critical
	Chiru-kandal	*Ceriops tagal*		X	X	X	X	X	X	X	
Diyadanga	*Vilpadri*	*Dolichandrone spathacea*			X				X		Tidal influence is not so critical
Attoona/ Homediriya	*Chonmuntiri*	*Heritiera littoralis*		X	X	X	X	X	X	X	
Ginpol	-	*Nypa fruticans*					X	X	X		
Kadol	*Kandal*	*Rhizophora apiculata*	X	X	X	X	X	X	X	X	
Kadol	*Kandal*	*Rhizophora mucronata*	X	X	X	X	X	X	X	X	
Kirala	*Kinnai*	*Sonneratia caseolaris*	X	X	X	X	X	X	X	X	Tidal influence is not so critical

Series on Best Practice Guidelines (Sri Lanka) Information paper No.13 After the tsunami: restoring home gardens (Prepared in collaboration with Rainforest Rescue International (Pvt) Ltd.)

The issues:
In the aftermath of a natural disaster, ensuring a proper nutritional balance in food intake becomes important. In many households affected by the tsunami, traditional gruels and curries made from herbs and trees from home gardens provided a variety of vitamins and other nutrients. However, many of these home gardens have been affected by the tsunami.
- The intrusion of salt water destroyed the production capacity of most home gardens.
- Food plants in home gardens were destroyed.
- There is no accessible source of these traditional foods in refugee caps or in returnee households.
- With this lack of accessibility from regular food sources, there is a risk that people may become malnourished.
- Home gardens provided income for women, who tended them.

The impact:
Displaced persons returning from camps to re-build their homes are left with home gardens with poor production capacities and the additional burden of purchasing nutritional supplements from outside sources.

The need:
There is thus an urgent need to restore the productivity of home gardens with a unique mix and diversity of species. There is also a concomitant need to identify and restore soils that have been contaminated by salt water intrusion and ensure their recovery.

Guiding principles:
- Identify affected soils.
- Identify an effective suite of plants to restore nutritional security in affected households.
- Identify an effective suite of plants to restore ecological functionality.
- Encourage rapid restoration programmes for home gardens as a source of subsistence and livelihoods restoration.
- Encourage the use of natural fertilisers in the restoration of home gardens.

Key steps to be taken

- Assess the growing capacity of soils before attempting home garden restoration. (See Box 1 for details.)
- If soil is salinised or otherwise affected, then proceed with soil restoration. (See Box 2 for details.)
- Develop a list of utility plants that are fast growing and that provide a good mix. (See Box 3 for complete details of suitable species.) Seedlings are available with RRI. (See Box 5 for contact details.)

  Suitable trees species:
  - *Murunga* (*Moringa oleifera*), which has leaves of high nutritive value as well as pods that are edible. It grows fast in salinated soil and helps to reduce soil salinity.
  - *Katuru Murunga* (*Sesbania grandiflora*) is a very fast-growing, nitrogen-fixing species that breaks up the soil and makes a good texture for agriculture. It also has edible leaves and flowers.
  - Papaya (*Carica papaya*) will withstand some salt breeze, grows rapidly and provides valuable fruits.
  - Curry leaves (*Murraya koenigii*) is a flavour giver and has many medicinal properties. Its roots encourage soil growth.
  - Lime or lemon (*Citrus spp.*) is indispensable in cooking, provides a rich source of vitamin C and has valuable medicinal properties.

  Suitable herbaceous plants:
  - *GotuKola* (*Centella asiatica*), Spinach (*Basella alba)*, Kang Kung (*Ipomoea aquatica*), are all easily grown vegetables that provide a dark green leafy dietary input. They are used in *mallungs* (leaf salads) and *kola kenda* (porridge) and form a very important part of the daily nutritional intake. They are also creeping plants that cover the soil and prevent erosion.
  - Lemon Grass (*Cymbopogon citratus*) and Pandanus *(Pandanus odoratissimus*) are herbs, which provide the flavours that are appreciated in traditional cooking. These plants are fairly long-living and maintain the soil ingood condition.

    These plants begin the process of restoring the soil as well as providing essential nutrition to families. They also provide the focus around which other horticultural activities can begin.

- Restoring and tending the home garden may also provide a source of comfort and healing for the mind as well as the body.
- Develop effective methods of integrating the plant stock into households and transit camps.

Box 1: A simple test to determine the growing capacity of the soil (Developed by Rainforest Rescue International (RRI))
- Take two containers of equal size.
- Ensure that there is adequate drainage.
- Fill each with an equal quantity of soil. One with tsunami affected soil that needs testing and one with good farmyard soil from a farm, unaffected by the tsunami.
- Place 10 seeds of Mung bean or Green gram or 20 mustard seeds in each container.
- Water and place in a sunny spot.
- After one week, observe the growth of plants. (Observe both germination and the colour and health of seedlings that grow.)
- If growth in both containers is about equal, begin farming.
- If growth is affected, then it is very likely that the soil has been affected by the tsunami. If so, begin soil restoration (See Box 2.)

Box 2: Restoring affected soils.
If the soil tested (See Box 1) is found to be affected by salinisation, then one of two paths may be followed.

1 Allow for natural regeneration. The speed at which the original ecosystem recovers will depend on the level of rainfall washing and leaching, assisted by vegetation growth. In cases where the salinisation is heavy in slow draining soils natural regeneration will be slow. Often exotic species may invade the disturbed habitat. If these species are known to be invasive species such as *Prosopis* and *Opuntia*, they should be eradicated.
or
Assist in regeneration. This can range from the removal of exotic species to building up farmyard and home garden soils. As the soil ecosystem has been affected a primary goal is its restoration. This is best effected by using plants that assist in the restoration of the soil ecosystem. (See Box 4 for a list of species that assist in such restoration.)

2 Also, household crops can be grown in raised beds. These are formed by placing a rectangle defined by planks, bamboos or similar barrier to a height of about eight inches and filling the rectangle with good soil or compost. Because the bed is above the affected soil, it will grow crops effectively. While the crops are growing in the raised beds, the transfer of plant waste and microorganisms into the soils below will assist in the recovery process. Plants could also be grown in sacks that have been filled with good soil and compost. Various plants can be planted in slits made at different levels and fed with water through an inserted bamboo.

Box 3: Potential plants for tsunami affected home gardens, developed by Rainforest Rescue International (RRI)				
Common name	*Sinhala name*	*Tamil name*	*Scientific Name*	Remarks
Gotukola	*Gotukola*	*Vallarai*	*Centella asiatica*	Leafy vegetable
Papaya	*Gas labu/Papol*	*Pappali*	*Carica papaya*	Fruit
-	*Katurumurunga*	*Akatti/Agati-keerai*	*Sesbania grandiflora*	Leafy vegetable + Nitrogen fixing
Lime	*Dehi*	*Thesikai*	*Citrus aurantifolia*	Essence + Medicinal
Horse radish tree	*Murunga*	*Murungamaram*	*Moringa oleifera*	Vegetable, Leafy vegetable + Live fence
Sweet potato	*Bathala*	*Vel-kelengu*	*Ipomoea batatas*	Edible yam
Bird pepper	*Kochchi*	*Kochchi*	*Capsicum frutescens*	Condiment
Ginger	*Inguru*	*Inji*	*Zingiber officinale*	Medicinal
	Mukunuwenna	*Ponankani*	*Alternanthera sessilis*	Leafy vegetable
Sweet orange	*Pani dodang*	-	*Citrus sinensis*	Fruit
Banana	*Kehel*	*Valappalam*	*Musa sp.*	Fruit
Chaya			*Cnidoscolus chayamansa*	Leafy vegetable
Coriander	*Koththamalli*	*Koththamalli*	*Coriandrum sativum*	Condiment
Mustard	*Aba*	*Kaduku*	*Brassica juncea*	Condiment
Bitter gourd	*Karavila*	*Pavakkai*	*Momordica charantia*	Vegetable
Spinach	*Nivithi*	*Pasalai*	*Basella alba*	Leafy vegetable
Lemon grass	*Sera*	*Serai*	*Cymbopogon citratus*	Condiment + insect repellent
Curry leaves	*Karapincha*	*Karivempu*	*Murraya koenigii*	Essence + medicinal
Passion fruit	*Vel dodang*		*Passiflora edulis*	Fruit + leafy vegetable
Pomegranate	*Delum*	*Madalai /Madalunkai*	*Punica granatum*	Fruit
Grape jasmine	*Watu-sudda*	*Nandi-battai*	*Tabernaemontana divaricata*	Flower is used for religious activities

Box 4: Plants that assist in soil restoration developed by Rainforest Rescue International (RRI)			
Sinhala name	*Tamil name*	*Scientific name*	Benefit to soil
Katurumurunga	*Akatti/ Agati-keerai*	*Sesbania grandiflora*	Adds organic nitrogen to the soil.
Murunga	*Murungamaram*	*Moringa oleifera*	Adds soil colloids.
Papol	*Pappali*	*Carica papaya*	Breaks up the salt aggregated soils.
Karapincha	*Karivempu*	*Murraya koenigii*	Encourages growth of soil macrorganisms
Kangkung		*Ipomoea aquatica*	Helps reduce the soil toxicity, especially in swampy situations.
Lunuwila		*Bacopa monnieri*	Helps reduce the soil toxicity, especially in swampy situations.

Box 5 listed contact details for relevant organisations and their focal personnel.

Series on Best Practice Guidelines (Sri Lanka) Information paper No.14 After the tsunami: safeguarding Special Area Management sites (SAM), Ramsar Sites and Marine Protected Areas (MPAs)

Special Area Management (SAM) sites: (A map showed locations of these sites.)
Special Area Management uses local and geographically specific planning and active stakeholder participation in order to plan for optimal sustainable use of natural resources, ensure economic well-being as well as ecological

integrity, and to practise sound natural resource management. This key concept was introduced in the 1980s as a tool for resource management in the coastal zone and has been an integral part of the coastal zone management plan of the Coast Conservation Department, since the 1990s.

Since the late 1990s, nine SAM sites have been chosen based on agreed criteria such as severity of issues relating to resource use, richness of biodiversity, economic significance and the process of participatory management. Work in these sites is already ongoing. Benefits gained from the SAM process include zoning of sites to maximise ecological protection yet allowing sustainable use, poverty alleviation by provision of facilities for the enhancement of livelihoods, social upliftment through various community-based training programmes and improvement of water quality and waste management. A further 27 sites have been proposed using the same criteria and are identified as high priority areas. These SAM sites are managed under the aegis of the Coast Conservation Department and the Coast Conservation Act of No. 57 of 1981 and its amendments.

Listed after this was the district, location and name of SAM and proposed SAM sites.

Marine Protected Areas (MPAs): (A map showed locations of these sites.)
Marine Protected Areas (MPAs) are marine areas of outstanding national significance, conserved by law under the jurisdiction of the Department of Wildlife Conservation, to provide protection of their valuable natural resources. MPAs fulfil a number of functions, including the conservation of biodiversity, sustainable management of natural resources for livelihoods, protection of endangered species and habitats, as well as their contribution to the tourist industry.

Four MPAs have been declared under the Fauna and Flora Protection Ordinance (FFPO) in 1993a. The district and names of these MPAs were listed.

Ramsar Sites: (A map showed locations of these sites.)
In addition to these SAM sites and MPAs there are three declared Ramsar sites, i.e., wetlands of international importance, both for the conservation of migratory waterfowl and for the sustenance of local livelihoods. Coastal areas in two of these declared sites - Bundala National Park, and Maduganga estuary (a SAM site and also a proposed sanctuary) - were affected by the tsunami.

The issues:
There is a risk that reconstruction activities in areas close to SAM and Ramsar sites, and MPAs may not be carried out with due environmental consideration. This could mean that these sites that provide vital livelihood and environmental functions may be affected adversely.

- Improperly planned reconstruction may cause pollution, both during reconstruction and also in the long term as a result of poor design, thus damaging SAM and Ramsar sites, and MPAs.
- Continuation of illegal activities such as mining for lime, sand mining in rivers (which interrupts the natural deposition of sand to beaches) and blast fishing will have a huge negative impact on SAMs, Ramsar sites, and MPAs.

The impacts:

- SAM sites are noted for the economic and livelihoods value of the resources they hold, and the effective management of natural resources in these areas are important for sustainable livelihoods and local economies. Destruction of valuable natural resources in these areas will have a severe impact on communities with high levels of dependence on these resources for their livelihoods.
- SAMs, Ramsar sites and MPAs can help protect low lying coastal areas from extreme weather events such as tropical storms and tsunamis and need to be maintained for the future security of coastal communities. These sites also act as buffers, protecting coastal areas from erosion. Damage sustained to these during the reconstruction effort may increase the vulnerability of coastal populations to extreme weather events and lead to severe coastal erosion, which may adversely affect current and planned coastal developments.
- Marine ecosystems are three-dimensional - the water column supports different species from that of the seabed – and many marine species rely heavily on water currents for the dispersal of larvae and seed. MPAs provide a vital function in serving as sources from which seed and larvae can disperse naturally to other marine areas. Thus, proper conservation and management of existing MPAs is critical for natural regeneration of marine ecosystems beyond the boundaries of the MPAs themselves.
- Many fish stocks are already seriously depleted due to over fishing. SAM sites and MPAs provide a refuge for many species, and healthy populations within SAM sites and MPAs can spill over to non-managed areas, replenishing stocks of fish that are targeted by fishermen. SAM sites and MPAs therefore assist in maintaining

populations of commercially significant marine species and are important to the sustainable management of coastal fisheries. Damage to SAM sites and MPAs due to reconstruction activities, mining, increased water pollution and unsustainable resource use practices may endanger the future sustainability of populations thereby negatively affecting communities that are dependent on fisheries for their livelihoods.

- SAMs, Ramsar sites and MPAs serve as valuable tourist attractions. Sound management is therefore important for the revival of coastal tourism and the much-needed revenue this brings.
- These have acted as important reserves of biodiversity, in the recent past providing many models for novel bio-resources. The preservation of these resources will provide greater options for resource management in the future and provide models for scientific and industrial innovation. Severe damage incurred to these sites will threaten the preservation of key biodiversity resources that may not currently be perceived as being important economically but have enormous monetary potential in the future.

The need:
Reconstruction activities must be carried out in a way that does not adversely affect these sites. This is essential because of their immense value in natural replenishment, protection of coastal areas, support for livelihoods and conservation of biodiversity, all of which are particularly important in a post-tsunami context.

Guiding principles (adapted from the 12 Guiding Principles for rehabilitation and reconstruction of the coastal zone in the tsunami-affected countries):

- Ensure that existing laws and regulations relevant to the coastal zone are upheld.
- Enhance public awareness on existing laws and regulations relevant to the coastal zone.
- Manage existing SAM and Ramsar sites and MPAs effectively so that the ability of natural systems to protect the coastline from extreme weather events is enhanced.
- Manage existing SAM and Ramsar sites and MPAs support sustainable livelihoods.
- Involve all stakeholders in the effort to protect these sites. This is effected easily for SAM sites as a participatory approach is an integral part of the SAM planning process.
- Develop tools to monitor and communicate the impacts of the reconstruction process.

Key steps:

- Consult the Coast Conservation Department and the Department of Wildlife Conservation in order to ensure that reconstruction and rehabilitation are carried out within the existing framework of planning such as the SAM process.
- Consult the CEA prior to carrying out any developmental activities to ensure that environmental impact assessments are carried out if necessary. (See also After the tsunami: knowing about environmental laws and policies, Information Paper 9.)
- Consult the relevant Regional Offices of the Department of Wildlife Conservation (DWC) (see Box 1 for contact details) if the proposed development is within one kilometre of any MPA. (See also After the tsunami: where to rebuild environmental concerns, Information Paper 1.)
- Consult the Department of Wildlife Conservation to ensure that reconstruction and rehabilitation does not adversely affect Ramsar Sites.
- Prevent the dumping of waste – in any form (an illegal activity) - on beaches and in the sea. (See also ‘After the tsunami: knowing about environmental laws and policies, Information Paper 9.)
- Prevent the sourcing of building materials (such as sand and lime) from the coastal zone. These activities are prohibited. (See also After the tsunami: materials for reconstruction, Information paper no.13; After the tsunami: knowing about environmental laws and policies, Information Paper 9.)
- Prevent the use of illegal fishing practices such as blast fishing and coral mining. (See also ‘After the tsunami: knowing about environmental laws and policies, Information Paper 9.)
- Prevent the removal of natural resources from MPAs. Extraction of any resources from designated protected areas is prohibited under the Fauna and Flora Protection Ordinance No. 2 of 1937 as amended. (See also ‘After the tsunami: knowing about environmental laws and policies, Information Paper 9.)

Box 1 listed the regional offices of the Department of Wildlife Conservation responsible for specific MPAs, and contact details for officers-in-charge.

Box 2 listed relevant organisations and contact details for focal personnel.


181
188
196
200
247

Community-based Disaster Risk Management

(Sourced directly from http://www.adpc.net/v2007/Programs/CBDRM/Default.asp and ADPC, 2004[21])

'Communities are at the frontline of disasters. Over the last two decades it has become apparent that top-down approaches to disaster risk management alone fail to address the specific local needs of vulnerable communities, often ignoring the local capacities and resources. At times, this approach further increases the vulnerability of the community. In response to the limitations of this top-down methodology, the community-based disaster risk management (CBDRM) emerged as an alternative approach, during the decades of 1980s and 1990s' (http://www.adpc.net/v2007/Programs/CBDRM/Default.asp).

'Community-based disaster risk management (CBDRM) is a process of disaster risk management at which communities at risk are engaged actively in the identification, analysis, treatment, monitoring and evaluation of disaster risks in order to reduce their vulnerabilities and enhance capabilities. Communities at risk therefore, are at the heart of decision making and implementation of disaster risk management activities. The involvement of the most vulnerable is paramount and the support of the least vulnerable is necessary (ADPC-CBDRM-11, 2003, in ADPC, 2004).

'The CBDRM process has seven sequential stages, which can be executed before a disaster or after to reduce risk. Each stage grows out of the preceding one. Together, these steps build up a planning and implementation system, which can become a powerful disaster risk management tool.

Step 1. Selecting the community (choosing the most vulnerable community based on a set of given criteria).

Step 2. Rapport building and understanding the community (building the relationship and trust with the selected community).

Step 3. Participatory Disaster Risk Assessment (PDRA), a diagnostic process to identify the risks that the community faces and how people overcome those risks. This process involves hazard, vulnerability and capacity assessment.

Step 4. Participatory Disaster Risk Management Planning follows after the analysis of the PDRA. The community themselves identifies risk reduction measures to reduce vulnerabilities and enhance capabilities.

Step 5. Building and Training a Community Disaster Risk Management Organisation (CDRMO). Such organisations will ensure that risks are reduced through the implementation of the above plan.

Step 6. Community-managed implementation. This is the CDRMO led implementation of the plan.

Step 7. Participatory Monitoring and Evaluation is a communication system in which information flows amongst all people involved in the project – the community, the implementing staff and the support agency as well as government agencies and donors ' (ADPC, 2004).

The Asian Disaster Preparedness Center (ADPC) believes that community action for disaster risk management is a crucial element in promoting a 'culture of prevention' and creating safer communities (http://www.adpc.net/v2007/Programs/CBDRM/Default.asp).

[21] ADPC (2004). Community-based disaster management field practitioners' handbook. Bangkok: ADPC

Annotated guiding principles for post-tsunami rehabilitation and reconstruction (Cairo Principles)[22]

Introduction:

The global problem and the need for principles:
The recent tragedy of the tsunami in the Indian Ocean has generated an unprecedented amount of relief and support from the donor community and private organisations, and extraordinary generosity from neighbouring communities adjacent to those devastated. Because of the scale of the impact and the immediate humanitarian needs, actions were initially focused on emergency needs for shelter, food, and medical care. Another priority has been to begin immediately to design and build a warning system for such disasters. The biggest and most protracted challenge will be to rebuild and rehabilitate hundreds of kilometers of devastated coastline, and re-establish livelihoods for over a million displaced people.

This is a huge challenge since many of the affected shorelines are densely populated - in most cases by poor people. Before the rebuilding begins we must commit to avoid needlessly repeating the mistakes of the past – for example, forms of coastal development that pushed the poor into the most unhealthy and hazardous corners of the coast and produced patterns of construction that are inefficient, inequitable, and unsustainable.

To guide the massive coastal reconstruction effort, the United Nations Environment Programme (UNEP) Tsunami Disaster Task Force in cooperation with the UNEP Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA), convened a meeting on February 17th, 2005 in Cairo to discuss coastal zone rehabilitation and management in the tsunami-affected region. Attendees from the affected nations and supporting international institutions endorsed twelve key principles (hereafter referred to as the Guiding Principles) consistent with an advance to more sustainable forms of coastal development and the United Nations Millennium Development Goals.

If adopted and applied throughout the affected region, the guiding principles will:
- Allow those involved to sequence their actions following a common set of priorities;
- Strengthen our collective commitment to rehabilitate and protect coastal communities and increase the efficiency of our actions;
- Provide the basis for regional workshops and discussions to pinpoint local needs and priorities;
- Facilitate the exchange of experience and the rapid dissemination of emerging good practices.

The guiding principles:

Over-arching principle:
1. Reduce the vulnerability of coastal communities to natural hazards by establishing a regional early warning system; and applying construction setbacks, greenbelts and other no-build areas in each nation, founded on a science-based mapped ‘reference line.’

Using concepts of integrated coastal management, including public engagement in local decision-making, employ a rapid assessment zoning and planning process to:
2. Promote early resettlement with provision for safe housing; debris clearance; potable water, sanitation and drainage services; and access to sustainable livelihood options.
3. Enhance the ability of the natural system to act as a bio-shield to protect people and their livelihoods by conserving, managing and restoring wetlands, mangroves, spawning areas, seagrass beds and coral reefs; and by seeking alternative sustainable sources of building materials, with the aim of keeping coastal sand, coral, mangroves and rock in place.
4. Promote design that is cost-effective, appropriate and consistent with best practice and placement of infrastructure away from hazard and resource areas, favouring innovative and soft engineering solutions to coastal erosion control.
5. Respect traditional public access and uses of the shoreline, and protect religious and cultural sites.
6. Adopt ecosystem based management measures; promote sustainable fisheries management in over-fished areas, and encourage low impact aquaculture.
7. Promote sustainable tourism that respects setback lines and carrying capacity, benefits local communities and applies adequate management practices.

[22] Drafted by UNEP/GPA in cooperation with Stephen Bloye Olsen, et al, University of Rhode Island, USA. The entire draft is reproduced here. http://www.cobsea.org/Cairo%20Guiding%20Principles.pdf

How things are done is as important, sometimes more important, than what is done. Local knowledge and insights are critically important to successful planning and decision-making, and local citizens must be engaged in the rehabilitation and reconstruction process at every stage. It is essential that the application of the construction set back line and the boundaries of bio-shields are defined in consultation with the local communities coastal reach by coastal reach.

8. Secure commitments from governments and international organisations to abide by these Principles and build on and strengthen existing institutional arrangements where possible.
9. Ensure public participation through capacity building and the effective utilisation of all means of communication to achieve outcomes that meet the needs and realities of each situation.
10. Make full use of tools such as strategic environmental assessment, spatial planning and environmental impact assessment, to identify trade-offs and options for a sustainable future.
11. Develop mechanisms and tools to monitor and periodically communicate the outcomes of the reconstruction through indicators that reflect socio-economic change and ecosystem health.
12. Widely disseminate good practices and lessons learned as they emerge.

Applying the Principles place by place:

A feature critical to the successful practice of coastal management is the ability to tailor principles such as those adopted in Cairo to the unique needs and conditions present in a specific locale. For example, on low lying shores like those in Bangladesh and the Maldives, a construction setback may not be effective in reducing the vulnerability of people to rising sea level, waves and flooding. In such places, focusing on building cyclone shelters and community-based emergency plans is the best approach. However, in other situations relocating damaged roads, railroads and dwellings to higher ground is both feasible and sensible. Setbacks, greenbelts and no-build zones have been repeatedly shown to be effective in reducing hazards and enhancing environmental qualities in a wide diversity of settings within the region affected by the tsunami and elsewhere. In all cases, protecting and restoring coral reefs, dunes, estuaries and seagrass beds makes coastal systems more resilient and capable of sustaining a diversity of livelihoods and a flow of benefits to the people of the place.

It has been learned repeatedly that successful implementation of a set of principles and a plan of action rests on the active and sustained participation, support and understanding of the affected communities. Without such support, investments in planning and implementation are likely to be ignored or resisted and will not generate a sustained flow of benefits. In this booklet, we use the term 'coastal reach by coastal reach' and 'reach by reach' to describe a process of planning and decision making that addresses stretches of coastline with similar characteristics and of an appropriate size to make the engagement of local people practical and possible. A coastal reach typically extends between headlands or demarcates a length of shoreline with similar rural or urban characteristics typically extending five to 20 kilometers. For the purposes of coastal management, reaches often need to be smaller for intensely utilised coasts where a diversity of activities are competing for space. Thus, while it is the responsibility of national governments to set the policies and procedures that require setbacks, bio-shields, priorities for settlement and re-establishing livelihoods, the details of how such policies will be applied in a specific locale must make provision for local consultations and tailoring to existing conditions and needs. The precise delineation of a construction setback and identification of additional no-build areas within bio-shields requires soliciting local knowledge and responding to local needs and local conditions.

The principles adopted in Cairo and the more detailed guidance offered in this booklet are divided into two groups. Principles 1 though 7 focus on the priority technical measures. These address what must be done in order to better prepare shorefront communities for future change and to design and implement a rehabilitation and reconstruction process that, where possible, creates conditions superior to those that were present before the tsunami struck. They draw on the scientific knowledge that has evolved in recent decades as coastal processes and their interaction with human activities have been analysed. The lessons learned from the reconstruction and rehabilitation following other natural disasters form the substance of the first seven principles.

In any emergency, the order in which actions are taken is important. The delineation of construction setbacks and improving the long-term conditions of the poor are top priorities and are, therefore, addressed first in both the Cairo Principles and the guidance offered in this booklet.

Principles 8 through 12 deal with how to apply the principles. These principles draw upon the experience in dozens of nations over the past forty years in the evolution of what has come to be called 'integrated coastal management' (ICM). These principles address the processes of public participation, the usefulness of setting unambiguous goals at both national and local scales, the evaluation of results, and the dissemination of experience and new knowledge.

I. Priority technical measures:

Principle 1 (Over-arching principle):

Reduce the vulnerability of coastal communities to natural hazards by establishing a regional early warning system; and applying construction setbacks, greenbelts and other no-build areas in each nation, founded on a science-based mapped 'reference line.'

It is not possible to sustain any development in coastal areas if the huge energy and natural dynamics of coastal systems are ignored. Many of the adverse social and economic impacts of the tsunami have occurred because people have been made more vulnerable to natural hazards through poor planning and the ineffective management of coastal development. The technical difficulties and financial costs of opposing the natural dynamics of coastal systems far outweigh the long-term benefits that can be gained by working with the natural processes that create and maintain healthy ecosystems and a flow of social and economic benefits to humankind.

At a time when human populations are becoming increasingly concentrated along coastlines, sea level is rising and long established weather patterns are changing. We therefore know that hazards created by storms, the reshaping of coastlines by processes of erosion and accretion, instabilities produced by new patterns of land use as well as such relatively rare occurrences as tsunami will together make shorelines increasingly hazard-prone.

The nations of the region and several international organisations are working together to develop an effective tsunami early warning system that will reach the entire regional community, particularly the most vulnerable groups.

- What is known about past and future coastal change can be applied to define a reference line showing where the shoreline is anticipated to be, for example, by 2050. Detailed aerial photographs could be prepared reach by reach for all of the region's shoreline, showing conditions as they were before and after the tsunami. A reference line could be drawn on such photographs showing the mean high water mark anticipated by the 2050 median projection for a sea level rise of 30cm made by the Intergovernmental Panel on Climate Change (IPCC). This reference line should be modified by other tectonic and coastal data affecting anticipated coastal change in specific areas. Where information is available, data on the anticipated effect of historical trends in erosion and accretion to 2050 and the inland extent of flooding in past storms should also be integrated into estimates of the future position of shorelines.
- A recommended construction setback line should be established by each government as a set distance and/or elevation inland of the reference line. The area seaward of the setback line should be designated as a strictly enforced 'no-build' zone. It is essential that such setbacks are incorporated into the existing regulatory system and are applied equitably to the wealthy and the poor.
- On low-lying shorelines with little topographical relief, practical disaster preparedness plans should be developed and tested that feature speedy evacuation of people to protected shelters.
- The width of the no-build zone determined by the setback should be greater in as-yet-undeveloped shores than in already urbanised areas.
- Designate setback lines with permanent on-site markers and enforce them uniformly as a regulatory measure.
- Exceptions for building structures seaward of the setback line should be granted only where required to support such water-dependent activities as fishing and navigation (not tourist facilities or permanent settlements). Where such exceptions are granted, structures should be temporary or built to withstand flooding by strengthened structural members and elevated first floors that permit flood waters to flow through unimpeded. Attention should be given to the impact of such structures on adjacent coastal areas, and mitigation actions taken.
- The granting of such exceptions for construction seaward of the setback line should be based on clear and uniform criteria and applied through a highly transparent process with opportunities for comment by the local community.

Principle 2:

Promote early resettlement with provision for safe housing; debris clearance; potable water, sanitation and drainage services and access to sustainable livelihood options.

Putting people first in rehabilitation requires moving quickly to resettle those displaced by the tsunami in a manner that provides the poor with living conditions and services that are better than those that existed before the disaster. Those that have lost property and cannot rebuild because their properties are within the no-build zone must be compensated adequately.

- Where practicable, identify sites beyond the ‘no build zone’ for permanent housing for those displaced by the tsunami, and for reconstruction of essential infrastructure, such as access to roads, water supply and sanitation, waste water treatment and solid waste disposal.
- Avoid or minimise involuntary resettlement - in accordance with the Guiding Principles on Internal Displacement presented to the UN Commission on Human Rights and the General Assembly. A ‘no build zone’ applied to a settled coastline may have severe consequences for those deprived of land tenure or 120 rights of residence. Where relocation is judged to be in the best long-term interest of those affected, provide adequate compensation for land and property. Also, establish channels for grievance resolution at the appropriate levels of government.
- Adopt appropriate building codes for all structures, including seismic codes in earthquake prone areas.
- Provide potable water, sewage collection and treatment, and adequate drainage systems in all new and reconstructed communities.
- Favour standardised, modular systems with interchangeable components to achieve cost savings and reduce future maintenance costs.
- Encourage the use of local labor in all phases of the reconstruction process thereby generating employment and enhancing the marketable skills of the poor.

Principle 3:

Enhance the ability of the natural system to act as a bio-shield to protect people and their livelihoods by conserving, managing and restoring wetlands, mangroves, spawning areas, seagrass beds and coral reefs; and by seeking alternatives.

Natural barriers to flooding and coastal erosion, such as coral reefs, near-shore rock outcrops, sandbars, and sand dunes should be protected from construction activity and uses that compromise their structural integrity. They reduce, absorb and redirect waves and floodwaters. Wetlands, lagoons, river estuaries, and reefs are essential to sustaining fisheries, public health and the many livelihoods that support coastal populations. They contribute to a healthy and aesthetically pleasing environment for a seaside holiday. A portion of the funds for rehabilitation should therefore be assigned to protect and restore these habitats.

Reconstruction will require thousands of cubic meters of sand for cement and for fill, and building materials of every description. Traditionally, many of these materials have been taken from the coast itself. When sand is mined from beaches, dunes and coastal rivers, mangroves are cut for timber, and wetlands filled as building sites coastal settlements become more vulnerable to hazards of every description.

- Conduct rapid assessments that involve local people in the identification of natural areas important to fisheries production, the recycling of wastes, shoreline stabilisation and scenic quality, including coastal wetlands and mangroves, seagrass beds, and coral reefs. The aerial photographs and maps used for establishing setback lines can be used in this process of identifying critical areas.
- Incorporate these natural features and habitats into a designated coastal bio-shield that maximises the protection from coastal hazards and the associated benefits provided by these natural features. Adopt measures to protect bio-shields from activities that compromise their natural qualities. Protect them from future disturbance and, where feasible, restore them.
- Where feasible, plant trees seaward of the setback line to form a greenbelt that buffers the shore from waves, floods and erosion.
- Prohibit the mining of sand, coral and stone from coastal waters within the 20m depth contour.
- Regulate sand mining from rivers.
- Declare wetlands and mangroves as off limits for harvest of wood.
- Prohibit the filling of wetlands and estuaries.

Principle 4:

Promote design that is cost-effective, appropriate and consistent with best practice and placement of infrastructure away from hazard and resource areas, and favouring innovative and soft engineering solutions to coastal erosion control.

The reconstruction is an unprecedented opportunity to relocate communities away from hazardous and unhealthy areas, rectify badly designed infrastructure and services, and reduce previous inequities in their availability and distribution.

- Place arterial roads, railroads and other transportation infrastructure well inside the setback line, and site access-ways perpendicular to the coast.

- Limit investments in erosion control to those situations where pre-existing infrastructure or settlements make it cost-effective, and where it is considered environmentally justifiable; favour soft solutions (placement of sand, planting vegetation) over hard solutions (breakwaters, groynes, shoreline armouring).
- Identify natural barriers to flooding and coastal erosion, specifically coral reefs, near-shore rock outcrops, sand bars, and sand dunes; protect them from construction activity and uses that compromise their structural integrity.

Principle 5:

Respect traditional public access and uses of the shoreline, and protect religious and cultural sites.

- Identify with permanent on-site markers and preserve public rights of way to the shore. All coastal development initiatives should respect the customary rights of local communities to the coastline, and recognise these areas as public domain.
- Assure that landing sites for local fishers and associated facilities for cleaning catches and storing fishing gear are restored or relocated to an equivalent or better nearby location.
- Identify with permanent on-site markers and preserve religious or cultural sites valued by local residents. Coastal development should keep these special coastal features accessible and protect their visual integrity.

Principle 6:

Adopt ecosystem based management measures; promote sustainable fisheries management in over-fished areas, and encourage low impact aquaculture.

The rehabilitation of hundreds of kilometers of shoreline should generate many opportunities for more diversified and more sustainable livelihoods. A primary concern must be the future prospects of communities dependent upon fishing. These same communities contain a high proportion of the region's poorest people. A recent statement prepared by WorldFish points out that coastal fisheries in Asia were depleted severely and over-fished before the tsunami. Too many boats taking too many fish had in some areas reduced fish stocks to less than 10% of their original levels and destroyed or degraded the habitats upon which these potentially renewable resources depend. A trend toward the use of damaging gear and the use of increasingly destructive fishing methods -such as small mesh nets that take juveniles - has made the situation progressively worse. The tsunami has only added to the problem.

- While assisting fishers by replacing equipment and rebuilding boats, ensure that less destructive and more sustainable fishing practices are adopted.
- Assist fishers who do not wish to return to fishing by developing alternative livelihoods. This will contribute to reducing fishing effort and restoring natural resources.
- Promote employment-intensive fisheries operations that contribute directly to poverty alleviation and food security.
- Implement integrated coastal fisheries management (ICFM). This approach is centered on the development of management plans that incorporate social, economic and biological objectives.
- Develop investments, training and infrastructure that reduce post-harvest losses. In rebuilding destroyed infrastructure and processing facilities and creating new ones, make investments to minimise postharvest losses and add value to catches. This will also provide additional livelihoods, particularly for women, when it emphasises the use of employment-intensive, low-cost, hygienic technologies.
- Encourage investment in community-based aquaculture and other livelihoods that bring benefits to local populations and do not degrade coastal ecosystems. Rehabilitated aquaculture must adopt environmentally sound management practices that do not pollute, damage habitats or cause long-term harm, including use of feed that is taken from sustainable sources and seeds that are raised in environmentally sound hatcheries or taken from sustainable fisheries.
- Modify the placement and density of shrimp aquaculture operations to reduce environmental degradation and adverse impacts on other coastal activities. In particular, subject shrimp ponds to siting criteria that protect natural systems and coastal water quality, and limit the intensity and extent of operations in each coastal reach.
- Avoid the 'privatisation' of inshore waters and the consequent disruption of fishing operations and livelihoods.

Principle 7:

Promote sustainable tourism that respects setback lines and carrying capacity, benefits local communities and applies adequate management practices.

- Identify vulnerable sectors of the population and develop strategies (for example, training, micro-enterprise development) to redirect these to such income generating activities as value-added processing, eco-tourism and cottage industries that reduce pressure on ecosystem services.
- Ensure that tourism planning is responsive to the needs of the local community and seeks to ensure community benefits. Local communities should be involved in the tourism planning process and development of associated recreational activities. This will help ensure that economic benefits are adequately distributed.
- In coastal tourism development, use appropriate siting, improved engineering designs and appropriate construction management practices that respect the dynamic nature of the coastal areas and ecosystem function. Such measures help control the negative impacts that can come with coastal tourism, including the loss of habitat and landscape, degradation of water quality, erosion of beaches and loss of beach access and income by traditional resource users. Such siting and design also helps minimises risks from storms, hurricanes, tsunamis and erosion and will reduce the need for prohibitively costly restoration and rehabilitation measures. Construction setbacks are one of the most appropriate proactive means of reducing risk of natural hazards. National and local authorities must support the industry through public sector planning, development control and provision of construction standards.

II. Process measures:

Principle 8:

Secure commitments from governments and international organisations to abide by these Principles and build on and strengthen existing institutional arrangements where possible.

- Mobilise rapid or immediate endorsement of these principles and enunciate their implications for all reconstruction activities. The adoption of the principles need not add time to the reconstruction process and, if unequivocally endorsed by the highest levels, will reduce uncertainty.
- Set specific measurable goals (for example, to double the number of people with potable water over pre-tsunami levels) for the reconstruction by each participating nation and its partner organisations. This will help focus the effort and provide a basis for measuring successful implementation of the principles.
- Use the opportunities created by the intense activity brought by the reconstruction process to strengthen the relationships among these institutions and to address weaknesses in the current coastal management system. Responsibility for coastal planning and decision-making - including the necessary enforcement powers - are invariably distributed among a number of governmental agencies at the national and sub-national levels. In some nations non-governmental organisations also play major roles in coastal management.
- Embrace opportunities to strengthen each nation’s coastal management system and encourage investments in associated training and institution building.

Principle 9:

Ensure public participation through capacity building and the effective utilisation of all means of communication to achieve outcomes that meet the needs and realities of each situation.

- First, consult with local people to review conditions as they existed before the tsunami to identify potentially significant habitats, rights of way to the shore and significant cultural or religious sites. The provision of detailed before and after aerial photographs and maps showing the reference line will assist in this process. It is essential that representatives of the poorer segments of the community are present and participate actively and that traditional leadership such as village leaders and religious leaders provide guidance and assist in the mediation of disputes.
- Second, envision the conditions and specific features of the coastal reach in question that would be seen as meeting local needs and local goals. This will address the specifics of marking the setback line and engaging in a rapid planning and zoning process. These discussions are likely to reveal competing views and conflicts. Therefore, it is important that decisions be guided by the precise demarcation of the setback line and that the boundaries of bio-shields be based on pre-defined and unambiguous criteria and that these be applied in a transparent manner.
- Adapt strategies for applying these principles as appropriate. It will be important to learn and adjust as the reconstruction and rehabilitation efforts unfold. Local knowledge combined with technical expertise and guided by national goals is the recipe for success.

Principle 10:

Make full use of tools such as strategic environmental assessment, spatial planning and environmental impact assessment, to identify trade-offs and options for a sustainable future.

- Tailor coastal management principles to the unique conditions present in every coastal reach. This favors a decentralised approach and a co-management structure in which local institutions assume significant roles in planning and decision making.
- Assist the governmental and non-governmental institutions with coastal management responsibilities to refine their abilities to identify threats and their root causes, to negotiate goals and strategies with a diversity of stakeholders, to practice conflict resolution and to prioritise their actions.
- Promote the use of economic assessment tools that help set priorities for investments, define and meet financing needs and sequence investments so as to maximise inter-sectoral collaboration and the advance towards sustainable development.
- Encourage the application of the Precautionary Principle and to its use in impact assessments that should be used to evaluate proposals for major construction projects.

Principle 11:

Develop mechanisms and tools to monitor and periodically communicate the outcomes of the reconstruction through indicators that reflect socio-economic change and ecosystem health.

- Set clear goals for the desired outcomes of the reconstruction and rehabilitation process reach by reach and subsequently use these as a reference point for assessing progress and the practice of adaptive management.
- Define and monitor simple, practical indicators for assessing progress towards goals and monitoring the coastal reconstruction and rehabilitation process.
- Report periodically on the results of the reconstruction processes and the lessons that emerge from the application of the principles; document failures as well as successes.
- Make it easy for the print, radio and television media to stay involved in the reporting process by establishing and updating a website and registering it with the main search engines.

Principle 12:

Widely disseminate good practices and lessons learned as they emerge.

- Annually invite experts and leaders from the region and elsewhere to review progress and widely disseminate throughout the region the emerging good practices.
- Celebrate success. Create incentives to, and publicly recognise successes - particularly when they result from local initiatives and local creativity in problem solving.

Conclusion:

Formulating principles to guide the rehabilitation and reconstruction is but one first step in the arduous reconstruction process. Those engaged in the process will need to work hard to create conditions that are better than those that existed before the tsunami and make coastal communities - particularly the poor - less vulnerable that they were before. There will be major pressures to simply put things back as they were before and to take advantage of the emergency to further individual interests rather than the common good. These pressures must be resisted. The implementation of these twelve Cairo Principles will help grasp the opportunities generated by such a calamity and thereby create conditions that are more sustainable and more equitable than those that were present before.

Appendix:

Selected literature and references are provided below. Documents accessible through websites have been emphasised due to their easy access worldwide.

General guidance:

- Additional guidance on post-tsunami reconstruction is provided in an IUCN information paper, dated February 2005, entitled ‘Guidance for Ecosystem Rehabilitation incorporating Livelihood concerns’. It is available on the web at: http://www.iucn.org/tsunami/docs/tsunamiguidance-info.pdf#search=’%EF%82%B7%20IUCN%20information%20paper%20%28February%202005%29%20Guidance%20for%20 Ecosystem%20Rehabilitation%20incorporating%20Livelihood%20concerns.’ and :http://www.iucn.org/tsunami/docs/tsunami- guidance-info.pdf
- Asian Wetland Symposium of February 9th 2005 on tsunami and coastal wetlands had recommendations for action: http://www.wetlands.org/news&/docs/AWS_Tsunami.pdf

Reducing vulnerability:

- UNESCO has produced a document entitled 'A proposal for building capacity to generate coastal bathymetry: a critical element in protecting lives, livelihoods and sustainable development in areas prone to ocean-based extreme events.' The IOC/UNESCO website is at: http://ioc.unesco.org/iocweb/index.php
- Information on the Indian Ocean Tsunami Warning System is gathered at: http://ioc.unesco.org/indotsunami

Debris clearance:

- Guidelines on debris disposal are available at several sites including http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter21.htm

Promoting access to sustainable livelihoods:

- The International Tropical Timbers Organization's 1996 paper by C. Field, entitled 'Restoration of mangrove ecosystems' contains ideas about reforestation to assist sustainable livelihoods.
- The UN department of economic and social affairs has publications relating to sustainable development at: http://www.un.org/esa/sustdev/mgroups/success/SARD-6.htm

Conserving, managing and restoring natural systems:

- Links to useful literature on the restoration of near-shore marine ecosystems are provided by http://restoration.nos.noaa.gov/htmls/resources/habitat_pubs.html
- The Florida seagrass restoration project has information that could be adapted to other areas: http://www.fws.gov/CEP/FLGulf.fs.rev.pdf#search='sea%20grass%20restoration'
- The site http://w1.mangrove.org:880/video/rem.html has links to methodology on mangrove restoration. Methodology on mangrove restoration is described in an article at: http://www.tautai.com/Pubs/Mangrove%20Restoration%20Ambio.pdf#search='mangrove%20restoration'
- Links to other information on mangroves can also be obtained at: http://www.ncl.ac.uk/tcmweb/tcm/mglinks.htm
- Dr. Jurgen Primavera and Dr. Anitra Thorhaug have published several peer-reviewed journal articles on restoration of mangroves and seagrasses, respectively
- The National Oceanic and Atmospheric Administration (NOAA) has two websites with useful links to information on coral reefs, their restoration and remediation:
  http://www.coris.noaa.gov/library/other_sites.html and
  http://www.nodc.noaa.gov/col/projects/coral/corallinks/Coral_linkmain.html
- The Intergovernmental Oceanic Commission/United National Educational, Scientific and Cultural Organization (IOC/UNESCO) has also advised about coral reef restoration and remediation at: http://ioc.unesco.org/coralbleaching/gef.htm

Sources of building materials:

- Some ideas on the sourcing of certified timber and other raw materials and strategies on the sound use of wood are presented by the World Wildlife Fund (WWF) at: http://www.unece.org/trade/timber/docs/sem-1/papers/r36Rainey.pdf#search='sourcing%20of%20certified%20timber'

Soft engineering solutions:

- An electronic bibliography on the use of constructed wetlands to improve water is available at http://www.nal.usda.gov/wqic/Bibliographies/eb9701.html
- General links to information on constructed wetlands (including for wastewater treatment) are at http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html

Setting up protected areas:

- Lessons learned from setting up marine protected area designations in the United States that may be adapted and applied to other nations are provided at http://mpa.gov/information_tools/lessons_learned_ table.html

Sustainable fisheries and low-impact aquaculture:

- WorldFish center has produced a briefing paper entitled 'Building a better future for coastal communities affected by the tsunamis.' This contains key recommendations from the project on 'Sustainable management of coastal fish stocks in Asia' documented in Silvestre et al., 2003; In Silvestre et al., (eds): Assessment, management and future directions for coastal fisheries in Asian countries. South and Southeast Asian Coastal Fisheries: Their status and directions for improved management. WorldFish Center Conference Proceedings 67, 1120 pp. This publication is available at: http://www.worldfishcenter. org/trawl/publications/publications.asp

- Guidance on the restoration of small scale fisheries is available at: http://www.idrc.ca/es/ev-28137-201-1-DO_TOPIC.html
- Codes of conduct for sustainable aquaculture are discussed in the following FAO document: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/003/AB412E/ab412e34.htm
- The marine finfish aquaculture network refers to cooperation in sustainable finfish aquaculture: http://www.enaca.org/modules/news/index.php?storytopic=10&storynum=10
- Information on fisheries assessments may be downloaded at: http://earthwatch.unep.net/oceans/oceanfisheries.php and http://www.nefsc.noaa.gov/nefsc/publications/tm/tm184/

Land management/infrastructure issues:

- Ideas that could be adapted to the current situation can be found within the 2003 ‘Final report on the water quality coalition for reef protection project’ by the Rainforest Alliance/National Fish and Wildlife Foundation: http://www.eco-index.org/search/pdfs/707report_1.pdf

Tools for rapid social and environmental assessment:

- The World Bank’s community-driven development is described at: http://lnweb18.worldbank.org/ESSD/sdvext.nsf/09ByDocName/CommunityDrivenDevelopment
- Tools and methods of social assessment are evaluated at: http://www.worldbank.org/socialanalysis sourcebook/socialassess5.htm
- More information on using social assessment and rapid participatory rural appraisal may be found at: http://www.fao.org/docrep/W5830E/w5830e08.htm and http://www.unu.edu/unupress/food2/UIN08E/uin08e0u.htm
- OECS 2003. Technical Manual for Post-Disaster Rapid Environmental Assessment. Volume 1 and 2.
- Organization of Eastern Caribbean Countries, Environment and Sustainable Development Unit. http://www.oecs.org/esdu/
- UN-ECLAC 2003. Handbook for estimating the socio-economic and environmental effects of disasters. United Nations Economic Commission for Latin America and the Caribbean. http://www.proventionconsortium.org/toolkit.htm
- Wetlands International 2005. Assessment of field protocol for rapid wetland and coastal assessment – a guide for staff: http://www.wetlands.org/Tsunami/Tsunamidata.htm

Methods for broader environmental impact assessments:

- Biswas AK and SBC Agarwal (eds.). 1992. Environmental impact assessment for developing countries. Oxford; Butterworth Heinman.
- Lohani BN. 1997. Environmental impact assessment for developing countries in Asia. Asian development bank. Manila.
- Barrow CJ. 2000. Social impact assessment: An introduction. London: Arnold.
- International association for impact analysis provides information at: http://www.iaia.org/Non_Members/Pubs_Ref_Material/pubs_ref_material_index.htm
- DigitalGlobe, a commercial satellite operation has made a donation for post-tsunami reconstruction. Imagery donated and downloadable free of charge at www.landcover.org may aid environmental impact assessments.

Ensuring public participation:

- Guidance on ensuring stakeholder participation, especially the participation of women, is given in the document ‘Biodiversity in development’: http://www.wcmc.org.uk/biodev/index2.html
- Additional guidance on stakeholder participation is presented in ‘Diversity makes the difference.’ http://www.generoyambiente.org/ES/publicaciones_uicn/biodiversity/modulebiodiversity.htm
- FAO has a website dealing with the issue of gender equity in public participation: http://www.fao.org/worldfoodsummit/english/fsheets/women.pdf

Strengthen institutional arrangements:

- UNEP’s ‘10 keys for local and national action on municipal wastewater’ discusses the interactions of the different players in a locality – ranging from the communities themselves to NGOs, local governments and the tourist industry, for example. Ideas in this list could be adapted to fit the current context. http://www.gdrc.org/uem/water/10-keys.html
- More ideas that could be adapted to coastal areas are presented by the Bonn Keys at: http://www.gdrc.org/uem/water/bonn-keys.html

The Hyogo Framework of Action

(Extracted directly from www.unisdr.org/hfa)

The Hyogo Framework for Action (HFA) is the key instrument for implementing disaster risk reduction, adopted by the Member States of the United Nations. Its over-arching goal is to build resilience of nations and communities to disasters, by achieving substantive reduction of disaster losses by 2015 - in lives, and in the social, economic, and environmental assets of communities and countries. The HFA offers five areas of priorities for action, guiding principles and practical means for achieving disaster resilience for vulnerable communities in the context of sustainable development. Since the adoption of the HFA, many global, regional, national and local efforts have addressed disaster risk reduction more systematically, much however, remains to be done. The United Nations General Assembly has called for the implementation of HFA, reconfirmed the multi-stakeholder ISDR System and the Global Platform for Disaster Risk Reduction to support and promote it. The General Assembly has encouraged member states to establish multi-sectoral national platforms to coordinate disaster risk reduction in countries. Many regional bodies have formulated strategies at regional scale for disaster risk reduction in line with the HFA, in the Andean region, Central America, the Caribbean, Asia, Pacific, Africa and Europe. More than 100 governments have designated official focal points for the follow-up and the implementation of the HFA (March 2007). Some have taken actions to mobilise political commitment and establish centres to promote regional cooperation in disaster risk reduction.

Priorities for action:

Principle1: Make disaster risk reduction a priority:

Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.

Strong national and local commitment is required to save lives and livelihoods threatened by natural hazards. Natural hazards must be taken into account in public and private sector decision-making in the same way that environmental and social impact assessments are currently required. Countries must therefore develop or modify policies, laws, and organizational arrangements, as well as plans, programmes, and projects, to integrate disaster risk reduction. They must also allocate sufficient resources to support and maintain them. This includes:

- Creating effective, multi-sector national platforms to provide policy guidance and to coordinate activities;
- Integrating disaster risk reduction into development policies and planning, such as Poverty Reduction Strategies; and
- Ensuring community participation, so that local needs are met.

Principle 2: Know the risks and take action:

Identify, assess, and monitor disaster risks - and enhance early warning.

To reduce their vulnerability to natural hazards, countries and communities must know the risks that they face, and take actions based on that knowledge. Understanding risk requires investment in scientific, technical, and institutional capabilities to observe, record, research, analyse, forecast, model and map natural hazards. Tools need to be developed and disseminated: statistical information about disaster events, risk maps, disaster vulnerability and risk indicators are essential.

Most importantly, countries need to use this knowledge to develop effective early warning systems, appropriately adapted to the unique circumstances of the people at risk. Early warning is widely accepted as a crucial component of disaster risk reduction. When effective early warning systems provide information about a hazard to a vulnerable population, and plans are in place to take action, thousands of lives can be saved.

Principle 3: Build Understanding and Awareness:

Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.

Disasters can be reduced substantially if people are well informed about measures they can take to reduce vulnerability - and if they are motivated to act. Key activities to increase awareness of disaster prevention include:

- Providing relevant information on disaster risks and means of protection, especially for citizens in high-risk areas;

- Strengthening networks and promoting dialogue and cooperation among disaster experts, technical and scientific specialists, planners and other stakeholders;
- Including disaster risk reduction subject matter in formal, non-formal, and informal education and training activities;
- Developing or strengthening community- based disaster risk management programmes; and
- Working with the media in disaster risk reduction awareness activities.

Strategic Goals:

- The integration of disaster risk reduction into sustainable development policies and planning;
- Development and strengthening of institutions, mechanisms and capacities to build resilience to hazards;
- The systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes.

Principle 4: Reduce risk:

Reduce the underlying risk factors.

Vulnerability to natural hazards is increased in many ways, for example:

- Locating communities in hazard-prone areas, such as flood plains;
- Destroying forests and wetlands, thereby harming the capacity of the environment to withstand hazards;
- Building public facilities and housing unable to withstand the impacts of hazards; Not having social and financial safety mechanisms in place.

Countries can build resilience to disasters by investing in simple, well-known measures to reduce risk and vulnerability. Disasters can be reduced by applying relevant building standards to protect critical infrastructure, such as schools, hospitals and homes. Vulnerable buildings can be retrofitted to a higher degree of safety. Protecting precious ecosystems, such as coral reefs and mangrove forests, allow them to act as natural storm barriers. Effective insurance and micro-finance initiatives can help to transfer risks and provide additional resources.

Principle 5: Be prepared and ready to act:

Strengthen disaster preparedness for effective response at all levels.

Being prepared, including conducting risk assessments, before investing in development at all levels of society will enable people to become more resilient to natural hazards.

Preparedness involves many types of activities, including:

- The development and regular testing of contingency plans;
- The establishment of emergency funds to support preparedness, response and recovery activities;
- The development of coordinated regional approaches for effective disaster response;
- Continuous dialogue between response agencies, planners and policy-makers, and development organisations.

Regular disaster preparedness exercises, including evacuation drills, also are key to ensuring rapid and effective disaster response.

Effective preparedness plans and organisation also help to cope with the many small and medium-sized disasters that repeatedly occur in so many communities. Natural hazards cannot be prevented, but it is possible to reduce their impacts by reducing the vulnerability of people and their livelihoods.

Who is responsible for implementing disaster risk reduction and the Hyogo Framework?

Collaboration and cooperation are crucial to disaster risk reduction: states, regional organisations and institutions, and international organisations all have a role to play. Civil society, including volunteers and community-based organisations, the scientific community, the media, and the private sector, are all vital stakeholders. Following is an indication of the variety and diversity of actors and their core responsibilities.

States are responsible for:

- Developing national coordination mechanisms;
- Conducting baseline assessments on the status of disaster risk reduction;

- Publishing and updating summaries of national programmes;
- Reviewing national progress towards achieving the objectives and priorities of the Hyogo Framework;
- Working to implement relevant international legal instruments; and
- Integrating disaster risk reduction with climate change strategies.

Regional organisations are responsible for:
- Promoting regional programmes for disaster risk reduction;
- Undertaking and publishing regional and sub-regional baseline assessments;
- Coordinating reviews on progress toward implementing the Hyogo Framework in the region;
- Establishing regional collaborative centres; and
- Supporting the development of regional early warning mechanisms.

International organisations are responsible for:
- Encouraging the integration of disaster risk reduction into humanitarian and sustainable development programmes and frameworks;
- Strengthening the capacity of the United Nations system to assist disaster-prone developing countries with disaster risk reduction initiatives;
- Supporting data collection and forecasting, information exchange, and early warning systems;
- Supporting States' own efforts with coordinated international assistance; and
- Strengthening disaster management training and capacity building.

The International Strategy for Disaster Reduction (ISDR) system is responsible for:
- Developing a matrix of roles and initiatives related to the Hyogo Framework;
- Facilitating the coordination of actions at the international and regional levels;
- Developing indicators of progress to assist States in tracking their progress towards implementation of the Hyogo Framework;
- Supporting national platforms and coordination mechanisms;
- Stimulating the exchange of best practices and lessons learned; and
- Preparing reviews on progress toward achieving the Hyogo Framework objectives.

The International Strategy for Disaster Reduction

The International Strategy for Disaster Reduction was adopted as a follow-up of the International Decade on Natural Disaster Reduction (IDNDR) 1990-1999 by the Member States of the United Nations in 2000. This strategy aims to achieve substantive reduction of disaster losses and build resilient communities and nations, as an essential condition for sustainable development.

The ISDR System comprises numerous organisations - both states and civil society worldwide working together to reduce disaster losses. All countries are encouraged to establish National Platforms for Disaster Risk Reduction or other coordination mechanisms. At regional level, information sharing and coordination among existing bodies are promoted by the UN/ISDR secretariat and partners as Regional Platforms for Disaster Risk Reduction. The international elements of the ISDR System are the Global Platform for Disaster Risk Reaction and the UN/ISDR secretariat.

The Global Platform for Disaster Risk Reduction is the main global forum for governments, United Nations agencies, international financial institutions, regional bodies, civil society, the private sector, the scientific, and academic communities. It is responsible for raising awareness and reiterates commitments, for sharing experience on implementation among stakeholders and governments, addressing gaps, and for providing strategic guidance and coherence for implementing the Hyogo Framework. Thematic clusters, groups and platforms work on specific topics of the disaster risk reduction agenda, such as: climate change adaptation, education, urban risk, early warning, recovery and capacity development. The Global Platform will appoint a committee to advise on programmatic priorities and direction to the Global Platform.

The UN/ISDR secretariat, accountable to the UN USG, serves as a broker, catalyst, and focal point for disaster risk reduction within the United Nations and among the members of the ISDR System. It advocates for commitment to disaster risk reduction and the implementation of the Hyogo Framework, and reports on progress.

The full text of the Hyogo Framework for Action can be downloaded at http://www.unisdr.org/eng/hfa/hfa.htm.

Asian Disaster Preparedness Center (ADPC)

(Extracted directly from its website http://www.adpc.net/v2007/.)

The Asian Disaster Preparedness Center (ADPC) is a non-profit organization supporting the advancement of safer communities and sustainable development, through implementing programmes and projects that reduce the impact of disasters upon countries and communities in Asia and the Pacific, by:

- developing and enhancing sustainable institutional disaster risk management capacities, frameworks and mechanisms, and supporting the development and implementation of government policies;
- facilitating the dissemination and exchange of disaster risk management expertise, experience and information; and
- raising awareness and enhancing disaster risk management knowledge and skills.

At the recommendation of UN Disaster Relief Organisation (UNDRO) - now known as UN Office for the Coordination of Humanitarian Affairs (UN-OCHA) - ADPC was established in 1986 as an outreach activity of the Asian Institute of Technology in Bangkok , Thailand , with the aim of strengthening the national disaster risk management systems in the region. In 1999, ADPC became an independent entity.

ADPC's Vision:

Safer communities and sustainable development through disaster risk reduction

ADPC's mission:

ADPC's mission is to reduce the impact of disasters on communities and countries in Asia and the Pacific by:

- raising awareness and enhancing knowledge;
- developing and strengthening sustainable institutional mechanisms;
- facilitating exchange of information, experience and expertise; and
- developing and demonstrating innovative disaster reduction practices.

ADPC's goals are to:

- mainstream disaster reduction in development;
- build and strengthen capacity;
- facilitate partnerships and exchange of experiences;
- be recognised as a proactive and responsive regional resource; and
- achieve quality service through a team approach.

Future priorities:

For future activities, ADPC has identified a number of disaster risk management priorities that the countries in the Asia region must address in their attainment of sustainable development. These include:

- mainstreaming of disaster risk management into national development policies and processes (for example, planning, staffing, budgeting, etc.);
- assisting provincial and district governments in developing disaster risk management plans and supporting national governments in developing their national disaster risk management information systems;
- encouraging appropriate legislation and policies for enforcing the incorporation of disaster risk management into development strategies and programs;
- developing financing mechanisms to support the financial sustainability of disaster risk management outcomes and activities;
- reducing vulnerabilities of urban population in Asia projected to increase from 30% to 45% of the population by 2015, increasingly putting urban centers at risk;
- developing and supporting implementation of regional programs on disaster risk management, specifically, ASEAN and SAARC;
- encouraging and developing increased community participation in mine risk education activities and providing greater support to victims assistance; and
- converting vulnerable communities into a resource for undertaking disaster management intervention.

Environmental Personnel Network and
Disaster Environment Working Group for Asia

Emergency Personnel Network

The Emergency Personnel Network (EPN) is a network of humanitarian organisers – professionals and operational managers who meet once a year to discuss best practices, benchmark standards, hear case studies, review new methodologies, examine problems, present solutions and plan for the future (http://www.epn.peopleinaid.org/aboutnetwork.aspx).

Through an online facility, EPN members can share ideas and experience, seek assistance and share information to improve the performance of their organisations.

About 180 organisations, including American, Australian and British Red Cross, Oxfam, CARE, UN Habitat, UNHCR are part of this network.

More information about EPN can be obtained at http://www.epn.peopleinaid.org/aboutnetwork.aspx.

Disaster Environment Working Group for Asia

The Disaster Environment Working Group for Asia (DEWGA) was established in 2007. It acts as a small, semi-formal, open-ended, regional, action-oriented, cross-sectoral partnership to explore avenues through which the partners can work with each other to minimise long term environmental impacts and degradation, as a key disaster risk reduction measure.

DEWGA aims to create a multi-disciplinary community of practitioners in the Asia Pacific region that is concerned with closing the gap among sectors with a view to increasing effectiveness of risk reduction – presuming that environmental sustainability is a key success factor – whether specific interventions on the ground or long-term strategies. It is envisaged that this will be achieved through the following objectives.

i) Serve as a collective body to advocate and promote linkages between disaster risk reduction and environmental management.
ii) Create a space in which the partners can identify and undertake bilateral or joint programmes of work.
iii) Exchange information on new and upcoming initiatives (for example, events, programmes, research and publications) that provide structured opportunities to strengthen these linkages.
iv) Actively promote integration of disaster risk reduction and environmental sustainability into respective work programmes.

DEWGA collaborates with the United National International Strategy for Disaster Reduction (UN-ISDR) and the United Nations Environment Programme (UNEP) and has six founding members: the Asian Disaster Preparedness Centre (ADPC), CARE, the International Environment and Disaster Management, Graduate School of Global Environmental Studies, Kyoto University (IEDM/KU), IUCN – the World Conservation Union, the Stockholm Environment Institute (SEI) and WWF.

Information about DEWGA can be obtained from http://www.sei.se/programmes/risk-livelihoods-a-vulnerability/projects/1472-m-disaster-environment-working-group-for-asia-dewga.html

The Sphere Standards: Humanitarian Charter and Minimum Standards in Disaster Response.

(Quoted directly from (http://www.sphereproject.org/content/view/229/232)

Drawing on international humanitarian law, the Sphere Project is a set of minimum standards, indicators and guidance notes for disaster response, based on a humanitarian charter.

Sphere is based on two core beliefs:

1. That all possible steps should be taken to alleviate human suffering arising out of calamity and conflict, and
2. That those affected by disaster have a right to life with dignity and therefore a right to assistance.

'More than 700 people from 228 relief organisations in 60 countries considered ideas on good practice over three years. The results were published in a handbook in January 2000.

The Sphere handbook contains a humanitarian charter and minimum standards, accompanied by key indicators for five sectors of disaster response:

- Water supply and sanitation,
- Nutrition,
- Food aid,
- Shelter and site management, and
- Health services.

The charter recognises the basic right to assistance of people affected by disasters, enshrined in international law. It highlights the legal responsibility of states to guarantee these rights. The standards are formulated as principles or objectives.The key indicators are quantified indices to measure fulfilment of the standards' (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1121289).

The aim of Sphere:

The aim of Sphere is to improve the quality of assistance to people affected by disaster and improve the accountability of states and humanitarian agencies to their constituents, donors and the affected populations.

Guiding values and principles for the Sphere Project:

The Sphere Project is based on:

- International humanitarian, human rights, and refugee law,
- The code of conduct: principles of conduct for the International Red Cross and Red Crescent Movement and NGOs in disaster response programmes.

Strategic objectives of Sphere:

1. To improve the commitment to and effective use of Sphere by all actors involved in humanitarian action.
2. To strengthen the diversity and regional balance of organisations in the governance and implementation of Sphere.
3. To develop and nurture a cadre of people who are able to use Sphere effectively.
4. To coordinate and interact with other humanitarian initiatives, and work together when that complements Sphere's aim.
5. To understand and increase the impact of Sphere.

More information on the Sphere standards can be obtained from http://www.sphereproject.org/.

The UNHCR Handbook for Emergencies

United Nations High Commissioner for Refugees has developed a Handbook for Emergencies, which was in its third edition in 2007[23] (UNHCR, 2007).

'The United Nations Refugee Organization (UNHCR), is mandated by the United Nations to lead and coordinate international action for the world-wide protection of refugees and the resolution of refugee problems. . . The majority of UNHCR's operations begin as a result of an emergency caused by a sudden influx of refugees and IDPs[24]. . . Much of UNHCR's normal work is, in effect, built upon emergency interventions and responses. There are, however, situations that are clearly exceptional. The UNHCR handbook addresses the needs and requirements for a comprehensive response to such situations.' (UNHCR, 2007).

'The aim of international protection in emergencies is to:

i. Ensure admission and at least temporary asylum;
ii. Prevent forcible return ('refoulement'); and
iii. Ensure refugees are treated according to basic human rights standards.

This comprehensive handbook summarises UNHCR's mandate of international protection and the aim and principles of emergency response; deals with emergency management; covers the vital sectors and problem areas in refugee emergencies, including health, food, sanitation and water, as well as key field activities underpinning the operations such as logistics, community services and registration. The chapters in each section start with a summary so that readers, who might not need the full level of detail in each of these chapters, can understand the basic principles of the subject quickly.

It also gives guidance on the support to field operations, primarily administration and staffing. Also included is a 'toolbox' which gathers, in one location, the standards, indicators and useful references used throughout the handbook' (UNHCR, 2007).

Some selected indicators and standards are listed below.

Table 11. Key emergency indicators
(Source: A Handy Guide to UNHCR Emergency Standards and Indicators, 2007)

	Crude mortality rate	Mortality rate among children under 5yr
Normal rate among a settled population	0.3 to 0.5/10,000/day	1.0/10,000/day
Emergency programme under control	<1/10,000/day	<2.0/10,000/day
Emergency programme in serious trouble	>1/10,000/day	>2.0/10,000/day
Emergency out of control	>2/10,000/day	>4.0/10,000/day
Major catastrophe	>5/10,000/day	

Table 12. Typical infrastructure requirements
(Source: A Handy Guide to UNHCR Emergency Standards and Indicators, 2007)

1 latrine	1 family (6–10 persons
1 water tap	1 community (80–100 persons)
1 health centre	1 camp (of 20,000 persons)
1 hospital	up to 200,000 persons
1 school	1 sector (5,000 persons)
4 commodity distribution sites	1 camp module (20,000 persons
1 market	1 camp module (20,000 persons)
2 refuse drums	1 community (80–100 persons)

[23] Citation: UNHCR, 2007. http://www.unhcr.org/paubl/PUBL/471db4c92.html.
[24] An IDP is an internally displaced person.

Table 13 Site planning for emergencies

Land	30 – 45m^2 per person.
Shelter space	3.5m^2 per person (tents or other structures).
Fire break space	▪ A clear area between shelters 50m wide should be provided for every 300m of built-up area. ▪ A minimum of 1-1.5m should be provided between guy-ropes of neighbouring tents on all sides.
Roads and walkways	20-25% of entire site.
Open space and public facilities	15-20% of entire site.
Environmental sanitation	▪ 1 latrine seat per 20 people or ideally 1 per family sited not farther than 50m from user accommodations and not nearer than 6m. ▪ 1 x 100 litre refuse bin per 50 people. ▪ 1 wheelbarrow per 500 people.
Water	▪ 15-20 litres per person per day of clean water. ▪ Health centre: 40-60 litres/patient/day. ▪ Feeding centres: 20-30 litres/patient/day.
Tap standards	1 per 200 persons, sited not farther than 100 m from user accommodations.
Warehouse space	For food grains in bags, stacked 6m high, allow 1.2m^2 of floor space per ton.
Food	2,100 kcal/person/day. This will require approximately 36 metric tonnes/10,000 people/week of food assuming the following daily ration: ▪ 350-400g/person/day of staple cereal. ▪ 20-40g/person/day of an energy rich food (oil, fat). ▪ 50g/person/day of a protein rich food (legumes).

This comprehensive handbook also provides a checklist for initial assessment as shown below.

UNHCR checklist for initial assessment (UNHCR, 2007)

Who are the refugees, their number and pattern of arrival?

- Approximately how many refugees are there?
- Where have the refugees come from? Why?
- What is the rate of arrival? Is it likely to increase or decrease?
- What is the total number likely to arrive?
- What is the location of the arrival points and of the sites where people are settling (latitude and longitude)?
- Are the refugees arriving as individuals or in groups? Are these family groups, clans, tribal, ethnic or village groups?
- Are families, village groups and communities intact?
- How are the refugees organized? Are there group or community leaders?
- How are the refugees travelling: on foot, in vehicles? What is the gender ratio of the population?
- What is the age profile of the population? Can a breakdown in age be given – under five’s, age 5 to 17 years, 18 years and over?
- How many unaccompanied minors are there? What is their condition?
- What was the social and economic situation of the refugees prior to their flight?
- What are their skills and languages? What is their ethnic and cultural background?
- Are there individuals or groups with special social problems? Are there particular groups made more vulnerable by the situation? (For example, the disabled, separated minors or elderly people in need of support.)
- What are the basic diet, shelter, and sanitation practices of the refugees?
- What is the security situation within the population: is there a need for separation between different groups?
- What is the formal legal status of the refugees?

Characteristics of the location.

- What are the physical characteristics of the area where the refugees are located?
- What is the soil, topography and drainage?
- Is there enough space for those there and those likely to arrive?
- Is there all season accessibility?
- Can the refugees access relief assistance from where they are located?
- What is the vegetation cover?
- Will the refugees need to use wood for fuel and shelter?
- Approximately how many people already live in the local area?
- Who owns (or has usage rights on) the land?
- Is there grazing land and are there potential areas for cultivation?
- What is the actual or likely impact on the local population and what is their attitude and that of the local authorities towards the refugees?
- Are there security problems?
- What environmental factors must be taken into account (for example, fragility of the local environment and extent to which local community relies on it; how rapidly might it be degraded by the refugees, proximity to protected areas)?
- What is the condition of the local population? If assistance is provided to the refugees, should the local population also be assisted?

Health status and basic problems.

- Are there significant numbers of sick or injured persons, is there excess mortality?
- Are there signs of malnutrition?
- Do the refugees have access to sufficient quantities of safe water?
- Do the refugees have food stocks, for how long will they last? Do the refugees have adequate shelter?
- Are adequate sanitary facilities available?
- Do the refugees have basic domestic items?
- Is there sufficient fuel for cooking and heating?

Resources, spontaneous arrangements and assistance being delivered.

- What type and quantity of possessions have the refugees brought with them?
- What arrangements have the refugees already made to meet their most immediate needs?
- What assistance is already being provided by the local population, the government, UN organisations and other organisations, is the assistance adequate, sustainable?
- Is the present assistance likely to increase, continue, decrease?
- What is the government's policy on assistance to the refugees?
- Are there any major constraints likely to affect an assistance operation?
- Has contingency planning for this type of emergency been undertaken?
- What coordination arrangements are required?

Means to deliver protection and assistance.

- Can effective implementing arrangements be made quickly and locally? If not, what are the alternatives?
- Is there already an identified refugee leadership with whom it will be possible to coordinate the delivery of protection and assistance?
- What are the logistical needs and how can they be met?
- Where will the necessary supplies come from?
- How will they reach the refugees?
- What storage is needed, where and how?
- Are there essential items which can only be obtained outside the region and whose early supply will be of critical importance (for example, food, trucks?)
- What are the needs for UNHCR and implementing partner staff and staff support?

The entire handbook can be downloaded at http://www.unhcr.org/publ/PUBL/471db4c92.htm. A summary of the handbook, A Handy Guide to UNHCR Emergency Standards and Indicators can be downloaded at http://www.humanitarianreform.org/humanitarianreform/Portals/1/cluster%20approach%20page/clusters%20pages/CCm/IDP%20Key%20Resources/A%20Handy%20Guide%20to%20UNHCR%20Standards%20and%20Indicators.pdf

Guidelines for gender sensitive disaster management

(quoted directly from APWLD, 2006[25])

'In 2000, the special session of the UN General Assembly, 'Gender equality, development and peace for the twenty-first century' highlighted the inefficiencies and inadequacies of existing approaches and intervention methods in responding to natural disasters and the need for gender perspectives to be incorporated whenever disaster prevention, mitigation and recovery strategies are being developed and implemented. . . However, five years after [these concerns were] expressed, gender blind disaster management recurred in the context of the Indian Ocean tsunami and the earthquake in Paksitan. Survey findings confirmed that women were more vulnerable during disasters [because] women, marginalised and disempowered under normal circumstances, are more at risk because of their lower socio-economic status, barriers to choice and lack of access to resources. . . .There is an urgent need to move from gender blindness to gender sensitivity in helping the victims of natural disasters. Given that disasters will always occur, it is imperative to ensure that a gender perspective is included in all disaster management programmes so that the relief efforts are able to properly address women's needs and prevent violations of women's human rights.

Gender sensitive disaster management must be based on the [following] fundamental principles: 1) Women's rights are human rights, therefore, relief efforts should not only be based on needs, but on ensuring that women's human rights are protected and promoted; 2) Equality of women and men: and 3) Non-discrimination against women' (APWLD, 2006).

The APWLD's guidelines for gender sensitive disaster management include short, medium and long-term guidelines. Each of these guidelines is detailed in the original document, here, only the main guidelines are presented.

Immediate needs:
1. Identifying specific needs of women: Ask the women. Women are the most aware of what family needs are and what immediate responses needed.
2. Ensure that emergency relief supplies include items specially needed by women.
3. Ensure women's access to sufficient and adequate food. Ensure that disaster affected people do not suffer from hunger, thirst and malnutrition.
4. Food distribution should be equitable, transparent and respect human dignity.
5. Aid distribution for women should be handled by women.
6. Ensure that women's menstrual needs are met.
7. Ensure that all disaster affected people have access to adequate shelters.
8. Ensure women's access to adequate toilet and bathing facilities.
9. Ensure women's access to free health care services.
10. Ensure security and safety of women and children.
11. Protect women from violence and abuse.
12. Ensure women's access to psycho-social counselling.

Mid-term responses during the recovery phase:
1. Ensure women's participation in management of camps and temporary shelters.
2. Ensure women's equal access to compensation payments and rehabilitation measures.
3. Eliminate head of household concept.
4. Ensure women's access to information on relief and rehabilitation measures.
5. Ensure children's access to education.

Long-term responses during the reconstruction phase:
1. Ensure women's participation in decision-making processes for rehabilitation and reconstruction.
2. Ensure that reconstruction of houses meets women's and family needs.
3. Enure women's equal ownership rights to land, house and property.
4. Ensure women's equal access to livelihood opportunities.
5. Raise women's awareness of their human rights.
6. Mobilise and empower women to advocate for their human rights.
7. Protect vulnerable and marginalised groups.
8. Protect migrant workers.
9. Reach out to widows and women-headed households, the disabled and elderly.
10. Reach out to low caste people.
11. Ensure stateless people's access to relief support.
12. Protect women – victims of disasters and armed conflict situations.

[25] APWLD, 2006. http://www.apwld.org/pdf/Gender_Sensitive.pdf)

Photocredits

Page number	Caption	Credit
Frontpiece	Dried mud flat, north west coast, Sri Lanka.	© Thushara Ranasinghe
iv	Mangroves, south western Sri Lanka	© Sriyanie Miththapala
vi	Particpants of a training workshop in the field.	© Hanying Li
vii	Particpants of a training workshop analysing data.	© Sriyanie Miththapala
1	Tsunami damage, Thailand.	© IUCN Thailand
2	Mangrove habitat, Simeulue, Indonesia.	© Ben Brown
3	Taking digital pictures of fauna for later identification.	© Sriyanie Miththapala
6	Pugmark of a Rusty-spotted cat, north central Sri Lanka.	© Sriyanie Miththapala
14	CARE staff analysing data, southern Sri Lanka.	© Sanjeewa Lelwala
17	Boats in Nha Trang Bay, Vietnam.	© Nha Trang Bay MPA Authority
18	Blue tiger, Sri Lanka.	© Gehan de Silva Wijeyeratne
27	Papaya tree crown, north central Sri Lanka.	© Nadeera Weerasinghe
28	Garbage dump, Colombo, Sri Lanka.	© Ranjit Galappatti
34	Lone fisherman, south western Sri Lanka.	© Sriyanie Miththapala
54	Traditional fishing, Tonle Sap, Cambodia.	© Sun Visal
76	Fisherfolk mending nets, north west Sri Lanka .	© Niroshan Mirando
78	Tsunami damage, eastern Sri Lanka	© IUCN, Sri Lanka
81	Left: Prickly Pear; Right: Mesquite	© Naalin Perera/IUCN
98	Replanting mangrove in southern Sri Lanka.	© Vimukthi Weeratunge
111	Top: Beach Clean up after the tsunami, Sri Lanka, Bottom: Home garden, southern Sri Lanka	Top: © Jerker Tamelander/IUCN, Bottom: © Vimukthi Weeratunge
112	CBDRM workshop, northern Sri Lanka.	© CARE Sri Lanka
114	Tsunami damage, southern Sri Lanka.	© Asanka Abaykoon/IUCN
124	Persons affected by the 2005 earthquake, Pakistan	© Zabardast Khan Bangash
128	Child and youth development centre at Xienghone province, Laos PDR.	© Save the Children Australia: under the programme of Youth at Risks and Women's Livelihood Creation.
130	Relief items being delivered after the tsunami by IUCN	© Asanka Abaykoon/IUCN
132	Earthquake damage, Pakistan	© Karl Schuler/IUCN
134	Tsunami damage, southern Sri Lanka	© Asanka Abaykoon/IUCN
138	Women at a CBDRM workshop, northern Sri Lanka	© CARE Sri Lanka
141	Top: Beach seine, south west Sri Lanka. Bottom: Fisherfolk, Tonle Sap, Cambodia	Top: © Sriyanie Miththapala Bottom: © Sun Visal

The IUCN Asia region covers 23 countries, stretching from Pakistan in the West to Japan in the East, Indonesia in the South to Mongolia in the North. IUCN maintains offices in Bangladesh, Cambodia, China, Lao PDR, Nepal, Pakistan, Sri Lanka, Thailand and Viet Nam. The Asia Regional Office is in Bangkok, Thailand.

IUCN's seven regional thematic programmes, known collectively as the Ecosystems and Livelihoods Group (ELG), are based in two clusters: one in Colombo, Sri Lanka (environmental economics, marine and coastal, species conservation), and one in Bangkok, Thailand (environmental law, forests, protected areas, wetlands and water resources).

Ecosystems and Livelihoods Group Asia

IUCN
4/1 Adams Avenue
Colombo 4
Sri Lanka
Phone: + 94 11 2559634
Fax: +94 11- 2559637
E-mail: coastalinfo@iucnsl.org
http://www.iucn.org/about/work/initiatives/about_work_global_ini_mangr/oapn/index.cfm