THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY

TEEB for National and International Policy Makers

Chapter 1: The global biodiversity crisis and related policy challenge

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Chapter 1
The global biodiversity crisis and related policy challenge

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Key Messages of Chapter 1

Ecosystems and their biodiversity underpin the global economy and human well-being and need to be valued and protected. The world's 'natural capital' is not a luxury for the rich but a necessity for all. The figures speak for themselves: over a billion people in developing countries rely on fish as a major source of food and over half of all commercial medicines derive from natural substances, mostly sourced in rainforests.

Damage to global ecosystem services and biodiversity is acute and accelerating. In the last century we have lost 35% of mangroves, 40% of forests and 50% of wetlands. 60% of ecosystem services have been degraded in fifty years. Species loss is 100 to 1,000 times than in geological times and will get worse with climate change. 80% of the world's fisheries are fully- or over-exploited. Critical thresholds are being passed: for example, coral reefs risk collapse if CO2 emissions are not urgently reduced.

Ecosystem damage carries costs for business and society: the number of sectors benefiting from natural capital represents a far larger share of the economy than many policy-makers appreciate. Failure to halt biodiversity loss on land may cost $500 billion by 2010 (estimated value of ecosystem services that would have been provided if biodiversity had been maintained at 2000 levels). At sea, unsustainable fishing reduces potential fisheries output by an estimated $50 billion/year.

Growing demand from an expanding wealthier population is a key cause of biodiversity loss. At a deeper level, economic signals from policy and market prices fail to reflect the true value of biodiversity. Incentives are not in place to encourage sustainable practices or to distribute costs and benefits efficiently and fairly. The imbalance between private gain and public loss runs through most of today's policy failures.

Understanding value is critical to inform trade-offs in decision-making on land conversion and ecosystem management. When the true value of ecosystem services are included, traditional trade-offs may be revealed as unacceptable. The cost of acting to sustain biodiversity and ecosystem services can be significantly lower than the cost of inaction.

Understanding the limited substitution potential of ecosystem services and the scale of the social and economic impacts caused by loss or degradation of natural capital, is critical for policies that seek to integrate environmental, economic and social concerns. Finding substitute sources of services - water, fuel wood, food provision - or creating substitutes - e.g. water purification - can lead to higher social costs, to higher economic costs beyond the reach of some social groups and to potential loss of quality. In some cases (e.g. species extinction) there are no substitutes.

Investing in ecological infrastructure can offer greater returns than man-made alternatives and thus makes economic sense. It can also help alleviate poverty and address commitments under the Millennium Development Goals.

1 The global biodiversity crisis and related policy challenge

"In our every deliberation,
we must consider the impact of our decisions
on the next seven generations."

From The Great Law of the Iroquois Confederacy

Chapter 1 provides an overview of key issues and priorities related to the global biodiversity crisis. **1.1** introduces policy-makers to **basic terms, concepts and the reasons for urgent concern** at the highest levels. **1.2** highlights the **seriousness of current biodiversity loss**, backed by concrete examples, and analyses the causes of ongoing and future projected losses. **1.3** summarises the critical **importance of ecosystem services for economic prosperity** and shows how valuation can support informed and cost-effective policy trade-offs and investments. **1.4** emphasises the scale of **human dependence on ecosystem services and biodiversity**, particularly for the poor with limited access to alternatives, and the need to engage communities in developing and implementing policy solutions.

1.1 WHAT IS BIODIVERSITY AND WHY DOES IT MATTER

'Biodiversity' is an umbrella term that covers all life on the planet, from the genetic level to terrestrial, freshwater and marine habitats and ecosystems. It underpins our global economy as well as human well-being. **Biodiversity offers essential benefits to people** and contributes to society as a whole by providing knowledge, protection, medicine and community identity. Eco-systems in their turn provide a range of vital services, including regulation of nutrient and carbon cycles (see Box 1.1 for key terms).

Despite these benefits, damage to global biodiversity is acute and accelerating. Ongoing and predicted future losses are discussed in 1.2 below but we can already highlight alarming statistics. Species are going extinct 100 to 1,000 times faster than in geological times (Pimm et al. 1995). During the last century, the planet has lost 50% of its wetlands, 40% of its forests and 35% of its mangroves. Around 60% of the Earth's ecosystem services have been degraded in just 50 years (Millennium Ecosystem Assessment 2005a).

Box 1.1: Key definitions: biodiversity, ecosystems and ecosystem services

Biological diversity means *"the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (Article 2, Convention on Biological Diversity (CBD)). The term covers all the variety of life that can be found on Earth (plants, animals, fungi and micro-organisms), the diversity of communities that they form and the habitats in which they live. It encompasses three levels: ecosystem diversity (i.e. variety of ecosystems); species diversity (i.e. variety of different species); and genetic diversity (i.e. variety of genes within species).

Ecosystem means *"a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit"* (Article 2, CBD). Each ecosystem contains complex relationships between living (biotic) and non-living (abiotic) components (resources), sunlight, air, water, minerals and nutrients. The quantity (e.g. biomass and productivity), quality and diversity of species (richness, rarity, and uniqueness) each play an important role in a given ecosystem. The functioning of an ecosystem often hinges on a number of species or groups of species that perform certain functions e.g. pollination, grazing, predation, nitrogen fixing.

Ecosystem services refer to the benefits that people obtain from ecosystems (Millennium Ecosystem Assessment 2005a). These include: ***provisioning services*** (e.g. food, fibre, fuel, water); ***regulating services*** (benefits obtained from ecosystem processes that regulate e.g. climate, floods, disease, waste and water quality); ***cultural services*** (e.g. recreation, aesthetic enjoyment, tourism, spiritual and ethical values); and ***supporting services*** necessary for the production of all other ecosystem services (e.g. soil formation, photosynthesis, nutrient cycling).

These **losses harm the economy** (see 1.3) **and human well-being** (see 1.4). Unfortunately, we usually appreciate what we have lost too late and/or where there are no available substitutes. The poorest people and developing countries are hit hardest by the loss, but richer nations are not immune. For example, the loss of bees sparks global concern because it directly affects natural pollination capacity. Declining fish stocks are worrying for all but especially the one billion or more people in developing countries who rely mainly on fish for protein. Over half of the world's fish stocks are already fully exploited and another quarter over-exploited or depleted (FAO 2009a).

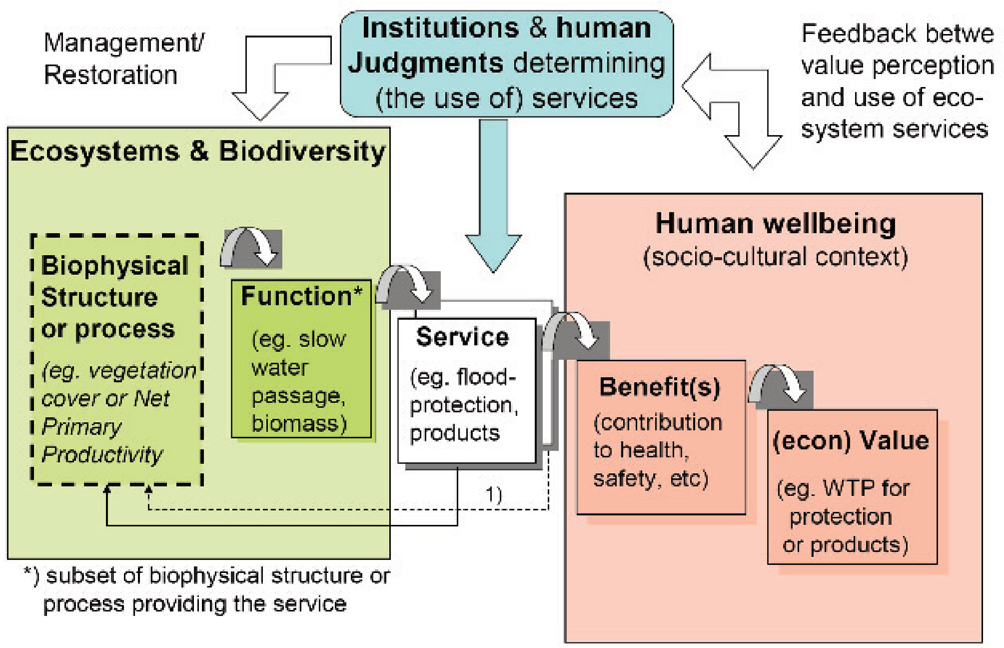
The relationship between biodiversity, ecosystems and delivery of their services is complex (see Box 1.2).

Box 1.2: How does loss of biodiversity affect ecosystem services and benefits to society?

Ecosystems are components of biodiversity; at the same time, species and their diversity are essential components within ecosystems. Biodiversity plays a fundamentally, though variable, role in the provision of ecosystem services. If an entire ecosystem is lost, this has a significant structural impact with direct human, social and economic costs. If other components of biodiversity are lost, this leads to a change in the services provided by an ecosystem but such changes can be more subtle, making ecosystems less stable and more vulnerable to collapse.

The extent and rate of changes to ecosystem services will depend on many factors such as: abundance of species/biomass (e.g. carbon storage); quality and structure of habitats and ecosystems (e.g. landscape values and tourism); and level of diversity (e.g. genetic variety within crops helps to maintain their resistance to diseases). Some ecosystem services (e.g. pollination, many cultural services) are a direct consequence of species' detailed composition and diversity. For others (e.g. flood regulation), the role of physical structures and processes at the ecosystem scale is more important (for more detailed scientific discussion, see **TEEB D0**.

The pathway from ecosystem structure and processes to human wellbeing



1) One function is usually involved in the provision of several services and the use of services usually affects the underlying biophysical structures and processes in multiple ways. Ecosystem service assessments should take these feedback-loops into account.

Source: Adapted from Haines-Young and Potschin 2009 and Maltby 2009

Many economic sectors are directly concerned with biodiversity and ecosystems services, including agriculture, fisheries, forestry, development, health, energy, transport and industry. Several depend on natural capital for their flow of inputs, research, new products and business innovation. An obvious example is the pharmaceutical industry: 25-50% of the sector's turnover (about US$ 650 billion/year) is derived from genetic resources. Ecotourism is another fast-growing sector which generates significant employment and is now worth around US$ 100 billion/year. Biomimicry (learning from nature) is expanding in areas such as architecture, engineering and product development. With appropriate investment, it offers major potential for new markets.

Policy-makers too have a common interest in maintaining this natural capital – to avoid significant financial costs. Nature frequently offers the same services as man-made technological solutions for far less money: examples range from maintaining soil fertility to carbon storage to reducing impacts from storms and tsunamis (see 1.3.4). In times of limited government and private budgets, avoiding unnecessary costs is fundamental to efficient administration.

Failing to take steps to halt global biodiversity loss carries increasing costs in terms of damage to human health and property, erosion of ecosystem services and reduced economic opportunities. The consequences are socially inequitable and economically inefficient. Despite this, our balance sheets and national accounting systems give almost no visibility to biodiversity-related costs and benefits – or to the way they are distributed.

This report shows how and why existing prices, markets and public policies do not reflect the true value (or damage) of ecosystem services and biodiversity. It sets out a roadmap for decision-makers to reform policy frameworks at all levels, building on best practice and innovative solutions from around the world.

Source: Dirk van der Made licensed under http://commons.wikimedia.org/wiki/Commons:GNU_Free_Documentation_License

A canopy walkway disappearing into a cloud forest near Santa Elena, Costa Rica.

1.2 THE BIODIVERSITY CRISIS: SCALE AND CAUSES

"…our natural environment is critical to intelligent economic growth and it is very easy to take for granted what nature provides for free."

Chris Carter, Minister of Conservation, New Zealand

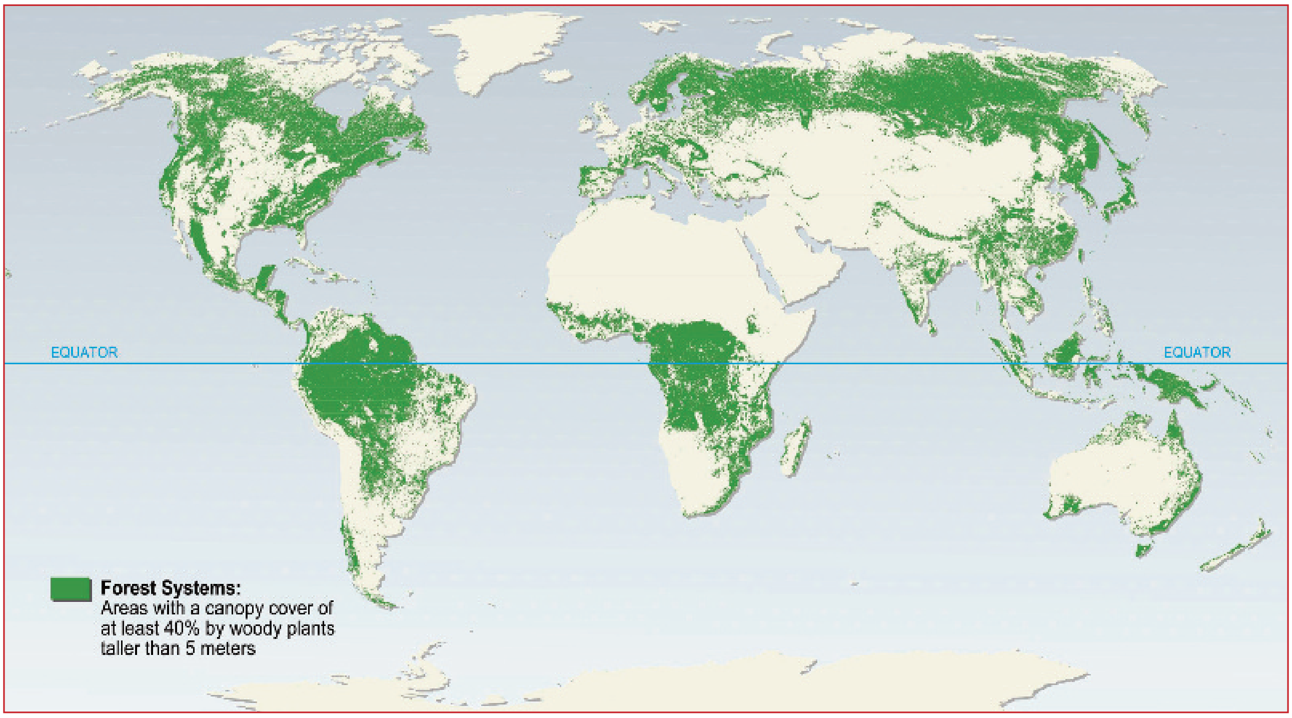
1.2.1 HOW MUCH OF OUR NATURAL CAPITAL IS BEING LOST?

This section provides an introduction to key facts about the planet's natural capital and how it is increasingly being lost. Information and examples are grouped by ecosystem types for ease of reference. The implications of species and genetic diversity loss are treated separately at the end of this section.

FORESTS

Forests in different forms cover an area of around 4 billion hectares (30.3% of total global land area) (Figure 1.1). The world's forests contain 80-90% of the world's remaining terrestrial biodiversity (Costanza et al 1997, see also FAO 2000). Forests provide many valuable goods and services, including timber, food, fodder, medicines, climate regulation, provision of fresh water, soil protection, carbon sequestration, cultural heritage values and tourism opportunities (Shvidenko et al. 2005).

Figure 1.1: Map of Forest Areas



Source: Millennium Ecosystem Assessment (2005b): 28

The FAO Global *Forest Resources Assessment 2005* (2006) found that:

- forests have completely disappeared in 25 countries;
- about 12 million hectares are lost to deforestation each year, including 6 million hectares of primary forests particularly in Latin America, South-East Asia and Africa;
- however, some countries are seeing a net increase in forest coverage (e.g. countries in Europe, China, Costa Rica);
- global net loss of forest area between 2000-2005 was 7.3 million hectares/year (about the size of Sierra Leone or Panama and over twice the size of Belgium). This is down from an estimated 8.9 million ha/yr between 1990-2000 but still equivalent to a net annual loss of 0.18% of global forests.

Standing forests are an important net carbon sink. Old-growth tropical forests are estimated to absorb up to 4.8 Gt CO_2 per year, equivalent to around 0.67 t CO_2 per capita (IPPC 2007; Eliasch 2008; Lewis and White 2009); this is assumed to amount to approximately 15% of annual human induced CO_2 emissions. **Deforestation** releases CO_2, into the atmosphere and at current rates, **may account for 18-25% of global CO_2 emissions.**

NATURAL AND SEMI-NATURAL GRASSLANDS

Grasslands (land used for grazing) cover an estimated 52.5 million km2. This is about 40.5% of terrestrial land cover, which breaks down into wooded savannah and savannah (13.8%), open and closed shrub (12.7%), non-woody grassland (8.3%) and tundra (5.7%) (FAO 2005b).

The biggest change to ecosystem structure has been the **transformation of nearly a quarter (24%) of the Earth's terrestrial surface to cultivated systems** (Millennium Ecosystem Assessment 2005a, see Figure 1.2). Since 1945, 680 million hectares out of 3.4 billion hectares of rangelands have been affected, while 3.2 million hectares are currently degraded every year (FAO 2005b)..Over 50% of flooded grasslands and savannahs and tropical and sub-tropical grasslands and savannahs, and nearly 30% of montane grasslands and shrublands, have been destroyed. Cultivation of grassland has led to problems of access to water for livestock and wildlife, loss of lean season grazing, obstruction of migration routes and loss and fragmentation of wildlife habitat. **Soil degradation has damaged the productive capacity** of both cultivated lands and natural rangelands (FAO 2005b).

This is a global problem with **serious implications for food security** but it also has a significant local dimension. In Africa 40% of farmland suffers from nutrient depletion rates greater than 60 kg/hectare/year. The highest rates are in Guinea, Congo, Angola, Rwanda, Burundi and Uganda (Henao & Baanante 2006).

AGRICULTURAL LAND

Of the world's 13.5 billion hectares of total land surface area, about 8.3 billion hectares are currently in grassland or forest and 1.6 billion hectares in cropland (Fischer 2008):

- An additional 2 billion hectares are considered potentially suitable for rain-fed crop production, but a 2008 FAO study suggests prudent use of this figure, as it also includes forests and wetlands which are extremely important for climate changes and for the provision of ecological services (FAO 2008).
- Additional demand for agriculture production has been created from biofuels production request. The experienced and foreseen increase in biofuel production and recent food shortages due to adverse climatic conditions have had a very sharp impact on the price of agricultural commodities, an effect that is expected to continue. A push in commodity prices of 12–15 percent above the levels that would have prevailed in 2017 is projected, even if biofuels were held at 2007 levels (OECD–FAO 2008).
- FAO estimates that 1.02 billion people are undernourished people in 2009, the vast majority in Asia and Pacific, as well as Sub-Saharan Africa (907 million in total). Agriculture production and yields is not the real issue here; poor people can not really face the globally increasing food prices, a situation aggravated by the current economic crisis (FAO 2009c).

- Enough food could be produced on currently cultivated land for the projected global population of 9 billion, provided that adequate investment was made in sustainable management (including intensification of agriculture and innovation) and further land conversion (i.e. forestry loss) could be avoided.

Significant local risks are generated by loss of agricultural production or productivity. This can happen where over-abstraction reduces groundwater aquifer levels to a point where they either pass a critical threshold and salt water intrusion occurs or where levels are too low for access to agriculture, compromising yields, activities and livelihoods. The result may be social tension and even conflict (see Box 1.3).

FRESHWATER SYSTEMS

Freshwater systems are aquatic systems which contain water of almost no salt content and include lakes and ponds, rivers and streams, reservoirs, wetlands (see below and groundwater. At global level:

- they provide most global drinking water resources, water resources for agriculture, industry and sanitation, and food such as fish and shellfish;
- they also provide recreational opportunities and a means of transportation;
- they cover 0.8% of the Earth's surface and contain 0.009% of its total water (Daley et al 1997);
- they house 40% of all known fish species on Earth (Master et al. 1998).

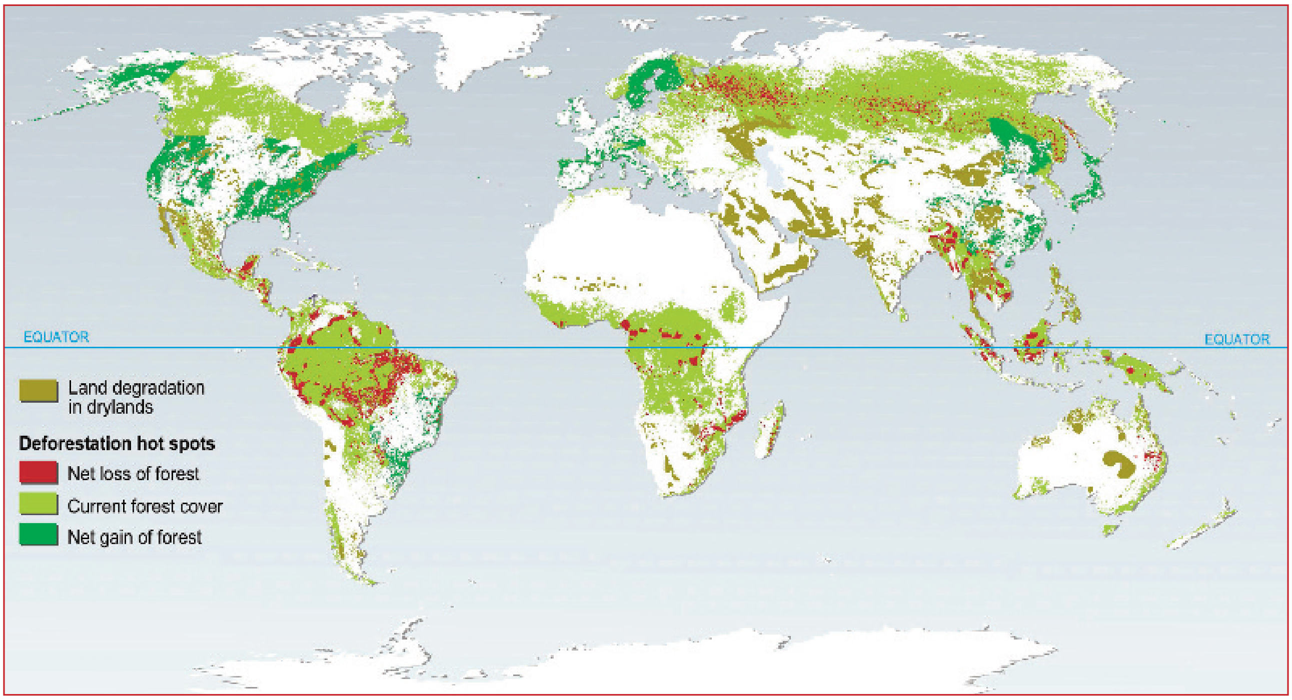
Box 1.3: In India, the spectre of 'water wars' arrives

The subcontinent is extracting water from its groundwater at a rate that will compromise the sustainability of the resource.

Key extracts translated: India is caught in a trap between consumption that does not stop rising, and groundwater stocks that are falling by 4 cm/year. There is an increasing risk of salination in certain regions, and access to water for some of the farming community is being compromised - the viability of farming in some areas and the viability of ecosystems are under increasing risk. While some farmers can dig deeper wells and afford more powerful pumps to access the resource, others cannot afford to. Furthermore, city dwellers extract water that should 'belong' to locals. Tensions over water scarcity are rising. Groundwater is free and 19 million wells were dug in the absence of laws and control.

Source: Le Monde Friday 14th August 2009

Figure 1.2: Areas of rapid land cover change



Source: Millennium Ecosystem Assessment (2005b): 3

All continents unsustainably exploit freshwater resources. 5-25% of global freshwater use exceeds long-term accessible supply (Vorosmarty et al. 2005). Water withdrawals from rivers and lakes for irrigation, urban uses, and industrial applications doubled between 1960 and 2000. The construction of dams and other structures along rivers has moderately or strongly affected flows in 60% of the world's large river systems, fragmenting the ecosystems. Water removal for human uses has reduced the flow of several major rivers, including the Nile, Yellow, and Colorado Rivers, to the extent that they do not always flow to the sea (Millennium Ecosystem Assessment 2005a). Forest loss, watershed degradation, wetland drainage and infrastructure that accelerates water run-off all reduce the potential for this 'natural infrastructure' to store, purify and provide water.

Risks arising from loss of clean water provision occur both at the local level (loss of forests, degradation of watersheds) and at international level. The possible future loss of the 'Amazon water pump' is an example of potentially dramatic international impact (see Chapter 5).

WETLANDS

Wetlands include swamps, marshes, mangrove forests and wet prairies and cover 6% of the Earth's land surface. Another 2% is covered by valuable **coastal ecosystems** such as estuaries, dunes, seagrass beds and lagoons. Wetlands help maintain the water cycle by capturing and holding rainfall and snowmelt, retaining sediments and purifying water. They are important biodiversity areas and provide breeding grounds for fish, grazing lands and the source of staple food plants. Wetlands can also act as water recyclers and carbon sinks, provide protection from floods and storms, control soil erosion and even serve as a natural wastewater treatment system for some cities. Coastal ecosystems are highly productive and have been estimated to account for up to 40% of the total value of global ecosystem services (Valiela et al 2001).

Since 1900, the world has lost around 50% of its wetlands (UNWWAP 2003). Since 1980, 20% of mangrove area (3.6 million hectares) has been lost (FAO 2007) but some countries have lost up to 80% through conversion for aquaculture, overexploitation and storms. Coastal wetland loss in some places has reached 20% annually (Agardy et al 2005).

A range of ecosystems act as important buffers for natural hazards: wetlands for flood control, mangroves against sea surges and tsunamis forests against landslides and mudslides and mixed forests for reduced fire risk. The risks of such hazards thus increases along with the conversion of mangroves, deforestation and drainage of wetlands, For example, during typhoon Wukong in 2000, areas planted with mangroves in Vietnam remained relatively unharmed while neighbouring provinces suffered significant losses of life and property (Brown et al. 2006).

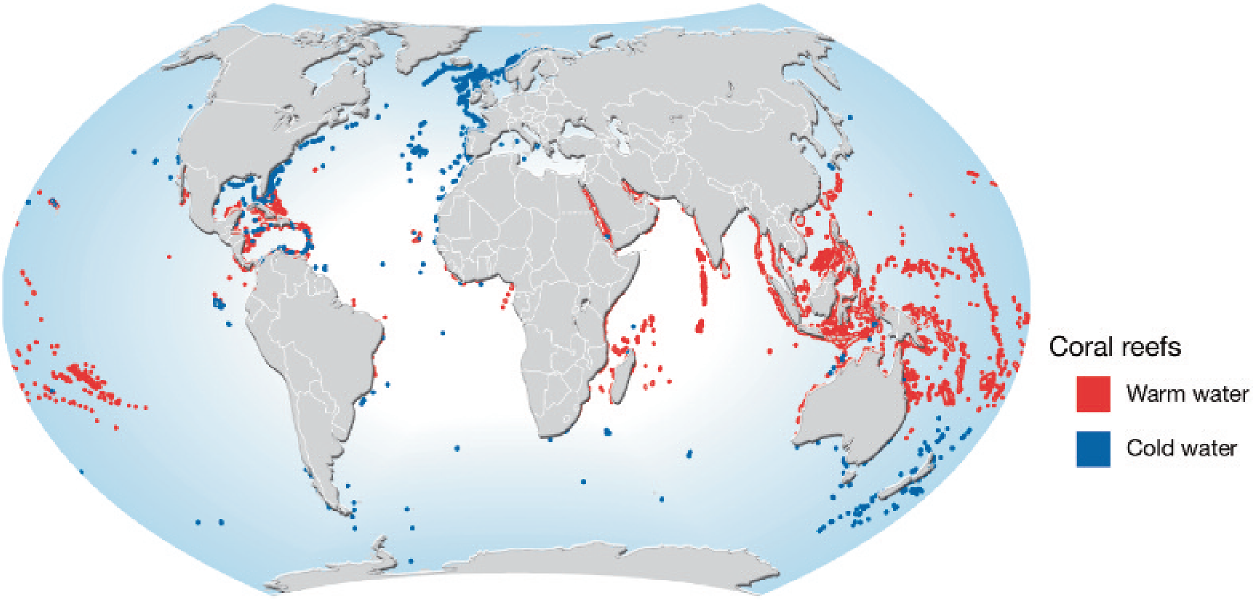
TROPICAL CORAL REEFS

Tropical coral reefs cover just 1.2% of the world's continental shelves but they are the most diverse marine ecosystems. They are often likened to 'oases' within marine nutrient deserts (see Figure 1.3) as they **have a crucial role in shaping tropical marine systems** which, are highly productive despite surviving in very low nutrient condition (Odum and Odum 1955):

- coral reefs harbour an estimated 1-3 million species, including over a quarter of all marine fish species (Allsopp et al. 2009), and often have even higher levels of biodiversity than tropical forests;
- 20% of reefs have been destroyed (Millennium Ecosystem Assessment 2005a, Wilkinson 2008);
- 30% have been seriously damaged through destructive fishing practices, pollution, disease, coral bleaching (Wilkinson 2008), invasive alien species and tourism;
- 58% of the world's reefs are potentially threatened by human activities at the global scale (Bryant et al 1998).

The risks of climate change for coral reef biodiversity and ecosystems now look greater than initial forecasts. Temperature rise is expected to make major (further) loss of warm water coral reefs inevitable. New scientific evidence points to the fact that coral reef recovery is seriously hampered by CO_2 concentrations above 350 ppm (see TEEB Climate Issues Update 2009).

Figure 1.3: Map of Coral Reefs



Source: Nellemann et al 2008: 22

MARINE SYSTEMS

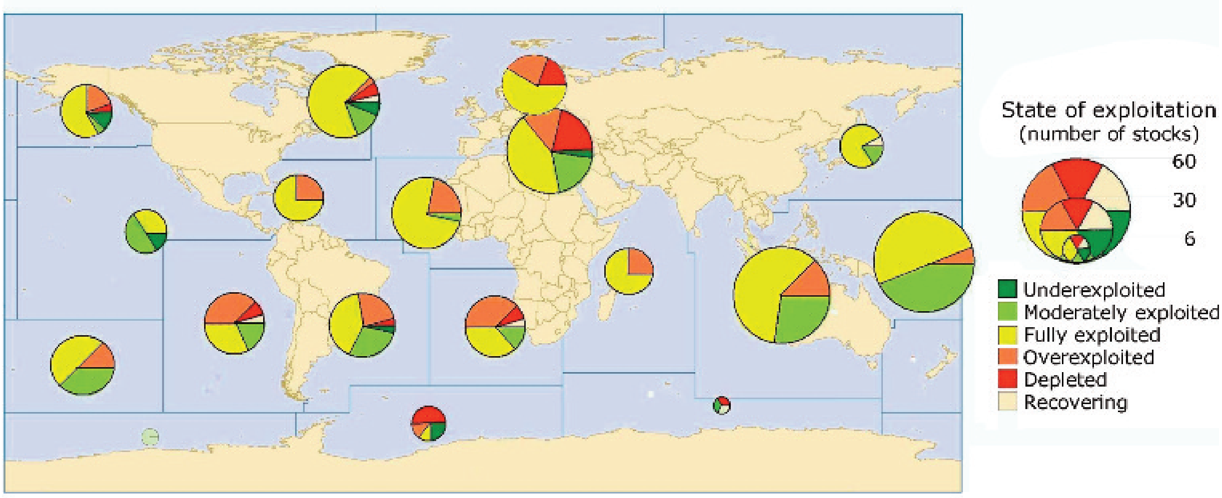
Oceans account for 90% of the habitable volume for life on earth and contain 90% of Earth's biomass (Rogers 2009). Recent statistics (FAO 2009a) demonstrate their importance as a provider of food and other goods:

- in 2006, global capture fisheries represented 92 million tonnes of fish, of which nearly 90% was from the marine environment;
- since industrial fishing began, the total mass of commercially exploited marine species has been reduced by 90% in much of the world;
- 52% of marine fisheries are fully exploited (at or near maximum sustainable yields), 17% over exploited, 7% depleted and 1% recovering; 18% are moderately exploited, with only 2% 'underexploited' (see Figure 1.4).

Lowered biomass and habitat fragmentation resulting from fisheries impacts have led to local extinctions, especially among large, long-lived, slow-growing species with narrow geographical ranges (Pauly et al. 2005). Yields from global marine capture fisheries are lower than maximum potential owing to excess fishing pressure in the past, with no possibilities in the short or medium term of further expansion and with an increased risk of further declines and a need for rebuilding (FAO 2009a).

Improved governance could greatly increase economic benefit from existing fisheries. **The difference between the potential and actual net economic benefits from marine fisheries is in the order of $50 billion/year** in an industry with an annual landed catch value of $86 billion. The cumulative economic loss to the global economy over the last three decades is estimated to be in the order of US$2 trillion (FAO 2009a). There is also enormous waste: by-catch (unused catch) amounts to 38 million tonnes/year or 40% of total catch (Davies et al 2009).

Figure 1.4: State of exploitation of selected stock or species groups for which assessment information is available, by major marine fishing areas, 2004



Source: adapted from FAO 2005a: 7

Under current policies, there is an increased risk of a series of collapses in fish stocks, with impacts on target stocks, entire marine ecosystems, food security, protein input and economies. In the near future, global fleets have potential for substitution but local fleets will not always be able to find alternative sources of fish which has knock-on implications for food supply and local and livelihoods. At the global level, fishery substitution potential will decrease with time.

SPECIES AND GENETIC DIVERSITY

Historically, natural loss of biodiversity occurred at far slower rates and was countered by origination of new species (Millennium Ecosystem Assessment 2005a). Today, current extinction rates are estimated to be 100 to 1,000 times faster than those in geological times. Recent tracking of losses by the Living Planet Index (trend) and IUCN Red List (rarity) offer similarly bleak pictures of the situation. A number of terrestrial, marine and freshwater species are in steady decline (see Living Planet Report 2008) and the number of globally threatened species has been steadily increasing for the past ten years. Latest estimates in the Red List (IUCN 2009) indicate that:

- nearly a quarter (22%) of the world's mammal species and a third (32%) of amphibian species are known to be globally threatened or extinct;
- over a third i.e. 3,481 species out of the 30,700 estimated described species are endangered;
- 12% of the world's bird species are under threat;
- the highest levels of threat are found in island nations: 39-64% of mammals are threatened in Mauritius, Reunion and The Seychelles and 80–90% of amphibian species are endangered or extinct in the Caribbean.

Globalisation has also contributed to species populations and ecosystems becoming increasingly dominated by a few widespread species. The spread of invasive alien species (IAS) is known to increase the similarity between habitats and ecosystems around the globe, with isolated islands rich in endemic species particularly hard hit by biological invasions. This 'biotic homogenisation' represents further ongoing losses in biodiversity (Millennium Ecosystem Assessment 2005a).

Species extinction and population loss in different ecosystems has also reduced global genetic diversity. Such losses reduce the fitness and adaptive potential of both species and ecosystems, thus limiting the prospects for recovery after possible disturbance. More specifically, agricultural intensification - coupled with selective breeding and the harmonising effects of globalisation - has significantly reduced the genetic diversity of cultivated plants and domesticated animals in agricultural systems. A third of the 6,500 breeds of domesticated animals are estimated to be threatened or already extinct due to their very small population sizes (Millennium Ecosystem Assessment 2005a; FAO 2009b).

1.2.2 GLOBAL PROJECTIONS OF FUTURE LOSS

Under current policies, the losses outlined above are expected to continue, leading to an increasingly acute global biodiversity crisis. Recent global environmental assessments provide specific projections on the scale of likely changes in biodiversity, based on potential scenarios and policies (see Box 1.4).

The assessments are unanimous that **significant biodiversity loss will continue under all considered policy scenarios**, with the rate of loss projected to accelerate and exceed that of the last century. Predictions for the period 2000-2050 include:

- **terrestrial biodiversity:** Under business-as-usual scenarios, a further 11% of biodiversity would be lost, with higher rates of loss in Africa and Latin America (OECD 2008). Even under global sustainability policies, 7.5% would be lost, with higher rates of 10.5% and 9% for Africa and Latin America/Caribbean respectively (UNEP 2007);

- **forest cover** would decrease under all scenarios, with the highest predicted losses (16%) occurring under sustainability scenarios due to an increased land demand for biofuels to combat climate change (UNEP 2007);

Box 1.4: Global Assessments and the use of scenarios to make future projections

In 2005, the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005a) assessed the consequences of ecosystem change for human well-being, establishing the scientific basis for actions to enhance their conservation and sustainable use. It was followed by the Global Biodiversity Outlook 2 (GBO-2, see SCBD 2006), the Global Environmental Outlook-4 (GEO-4, see UNEP 2007), the OECD Environmental Outlook (OECD 2008) and the International Assessment of Agricultural Science and Technology (IAASTD 2008).

Scenarios used in the assessments
Assessments typically use a set of different scenarios outlining likely global situations (the best-known is the IPCC's Special Report on Emissions Scenarios). The MEA and GEO-4 have developed broadly comparable sets, based on four categories:

- **conventional markets:** continued focus on liberalised markets, leading to rapid economic and technological growth with a reactionary approach to environmental protection;
- **global sustainable development:** a global response to sustainability issues, average economic and technological growth and proactive approach to environmental protection;
- **competition between regions:** countries shun global cooperation in favour in protectionist policies, leading to slower economic and technological growth, and a reactionary approach to environmental protection;
- **regional sustainable development:** sustainable development is prioritised at a regional level without cooperation at a global scale leading to average economic and technological growth.

Shortcomings in the models
The projections for biodiversity, though severe, are likely to be underestimates. None of the models consider Invasive Alien Species (IAS) impacts, considered one of the most serious threats to global biodiversity, or potential unpredictable shocks to the system, such as the reaching of tipping points or economic shocks,. The marine models are also hampered by a lack of information and are likely to underestimate the scale of fishing effort, particularly artisanal.

- **agriculture:** Poor agricultural practices associated with unfavourable socioeconomic conditions could create a vicious circle in which poor smallholder farmers are forced to use marginal lands, increasing deforestation and overall degradation. The assessments are unanimous that increased productivity is key to protecting terrestrial biodiversity (i.e. improved yield reduces the need to convert remaining natural areas to cultivation. If this does not occur, biodiversity loss would be even higher than the assessments project). IAASTD (2008) predicts that land demanded for agriculture will increase by 10% by 2050, even with high investment leading to substantial increases in yield (up to 300% in Sub-Saharan Africa and 200% in Latin America). GBO-2 predicts that poverty alleviation measures in Sub-Saharan Africa (e.g. sustainable meat consumption, increased protected area coverage) could reduce the rate of biodiversity loss, with little impact on global GDP. However, pressure for additional agricultural produce for bio-energy will put additional pressure;

- **energy demand** is projected globaly to almost double between 2000 and 2030 under businessasusual scenarios (IAASTD 2008). For biofuels, the International Energy Agency (IEA) in its World Energy Outlook 2006 presented various scenarios for the development of biofuel demand up to 2030. Its ‘Reference Scenarios’ project that around 4.2% of arable land will be needed to satisfy growing demand, assuming an increase in demand of 10% of global share of biofuels in transport. Even under a second-generation scenario, a hypothetical large-scale substitution of liquid biofuels for fossil-fuel-based petrol would require major conversion of land;

- **trade liberalisation** may stimulate more efficient use of resources (OECD 2008) but would be likely to shift agricultural production to Africa and South America where the land and labour costs are lower. This would have an unintended net negative impact on biodiversity due to impacts on grasslands and tropical forests;

- **fisheries:** One study predicts a global fish stock collapse by 2048 without major additional policy response, noting that 29% of edible fish stocks have already declined by 90% (Worm 2006). All the assessments predict improvements if ecosystem-based conservation policies are deployed (e.g. total catch limits, designated fishing seasons and zones, regulated fishing methods, elimination of capacity subsidies) although much depends on regional policy.

Source: André Künzelmann, UFZ

1.2.3 WHAT IS DRIVING THESE LOSSES?

The global assessments identify a range of direct causes and key underlying drivers for biodiversity and ecosystem losses.

DIRECT CAUSES

These can be grouped into five main categories and will vary between ecosystems and regions (as summarised in Figure 1.5 below).

Habitat loss results from land use change, mainly through conversion for agriculture as well as urban, industrial and infrastructure development, and has impacted over 2,000 mammal species (IUCN 2009).

Over-exploitation of resources, such as fish, energy, mining and soil, reflects increased prosperity as well as poverty (see Box 1.5). Use of species for their (perceived) medicinal properties affects over 900 mammal species, mainly in Asia (IUCN Red List 2009).

Box 1.5: How human demand can affect biodiversity

- global meat, fish, and dairy consumption is now causing around 30% of biodiversity loss;
- 80% of agricultural area is currently devoted to meat and dairy production;
- on average, a world citizen consumes 39 kg of meat per year. In the US, this figure is 121kg, in EU-15 91kg, in China 54kg and in Africa 14 kg;
- 10% of the world's population consumes 25% of animal protein (fish, meat, and dairy) and world consumption has doubled since 1970;
- in sub-Saharan Africa, 71% of World Heritage Sites are affected by over-extraction of resources (illegal hunting or fishing, fuelwood collection, etc.) and 38% by encroachment for agriculture.

Source: PBL 2009

Pollution from multiple sources contributes to cumulative impacts on natural capital and results from a wide range of mainstream economic sector activities.

Climate change impacts on biodiversity and ecosystems are now considered likely to be greater than initial forecasts. Although scientists indicate that ecosystems will be able to adapt to a certain extent to rising temperatures, changes in evapotranspiration and rising sea levels, the combination of human-induced pressures and climate change will increase the risk of losing numerous systems. Coral reefs are a well documented example (see TEEB Climate Issues Update 2009).

Invasive alien species (IAS) have wide-ranging impacts on species types and levels, the food web and habitat structure and functions. An estimated 480,000 IAS have been introduced around the world, invading virtually every ecosystem type , with potential estimated costs of damage and control reaching almost 5 per cent of global GDP (US$ 1.4 trillion/year) (Pimentel et al. 2001, 2005). Environmental degradation already creates favourable conditions for some introduced species to establish and spread. Climate change may in turn modify the whole process of an invasion, increase ecosystem vulnerability and alter species' distributions (Capdevila-Argüelles and Zilletti 2008).

Figure 1.5: Main direct drivers of change in biodiversity and ecosystems

Source: Millennium Ecosystem Assessment 2005b: 16

UNDERLYING DRIVERS

The assessments identify **growing demand for goods and services** from an increasingly wealthy and expanding population as the main underlying cause of biodiversity loss and ecosystem conversion or degradation. This type of consumption is based on choice, not survival.

In contrast, those living below the poverty line are more likely to directly depend for their livelihood and possibly their survival on local resources or land. Short term needs will take precedence over long term considerations particularly where there is no clear and immediate incentive to preserve under-valued ecosystems.

At a deeper level, economic signals from policy and market prices rarely reflect the true value of biodiversity, including the social costs and benefits of ecosystem services. Most ecosystem services are unpriced or underpriced (see also chapters 5 and 7), such as:

- **water:** extraction from groundwater aquifers rarely faces resource extraction cost;
- **fish in the high seas:** no-one pays for exploitation rights for this common resource and there are as yet few mechanisms for payments in territorial waters (see Chapter 7);
- **forests:** these are often de facto 'commons', exploited by the few. Where payment systems exist for the resource extracted (e.g. stumpage fees, concessions) or land conversion fees, these are generally too low to reinvest in future forests;
- **regulating services provided by ecosystems.** As land managers rarely receive income for carbon storage, water regulation, maintenance of air quality or protection against natural hazards, they have little incentive to conserve or manage ecosystems to maintain these services. In general, providing marketable commodities (often through the modification, simplification and degradation of ecosystems) will take precedence.

Many ecosystem services are difficult or impossible to price or trade in conventional markets. There is a clear **rationale for public intervention to protect services with the following characteristics:**

- **public goods:** services such as maintenance of air quality and climate regulation are *non-excludable* (i.e. people cannot be excluded from consuming them) and *non-rival* (one person consuming them does not prevent another from doing so);
- **services with strong externality effects:** for a range of regulating services (e.g. water supply, pollination, erosion control), the actions of some landowners and managers generate benefits to neighbouring landowners and communities which tend to be difficult to capture in market transactions;
- **services for which markets are hard to design:** e.g. fisheries are not pure public goods, but are rarely priced because organising and policing markets in fishing rights is complex.

More often than not, negative impacts generated by the primary production, transport, mining and energy sectors are not monetised. No compensation for damage is paid. There is an imbalance between rewards from providing marketable goods and services and rewards from providing services that benefit the wider population, including future generations.

Responding to these drivers will be critical to address the biodiversity challenge. Current losses reflect multiple failures of public policy and, too often, the lack of high-level political backing for conservation. We can turn the situation around by better appreciating the value of ecosystems and biodiversity and integrating such values into all areas of policy making (see Chapters 2 and 4).

1.3 ECONOMIC DIMENSIONS OF THE BIODIVERSITY CRISIS

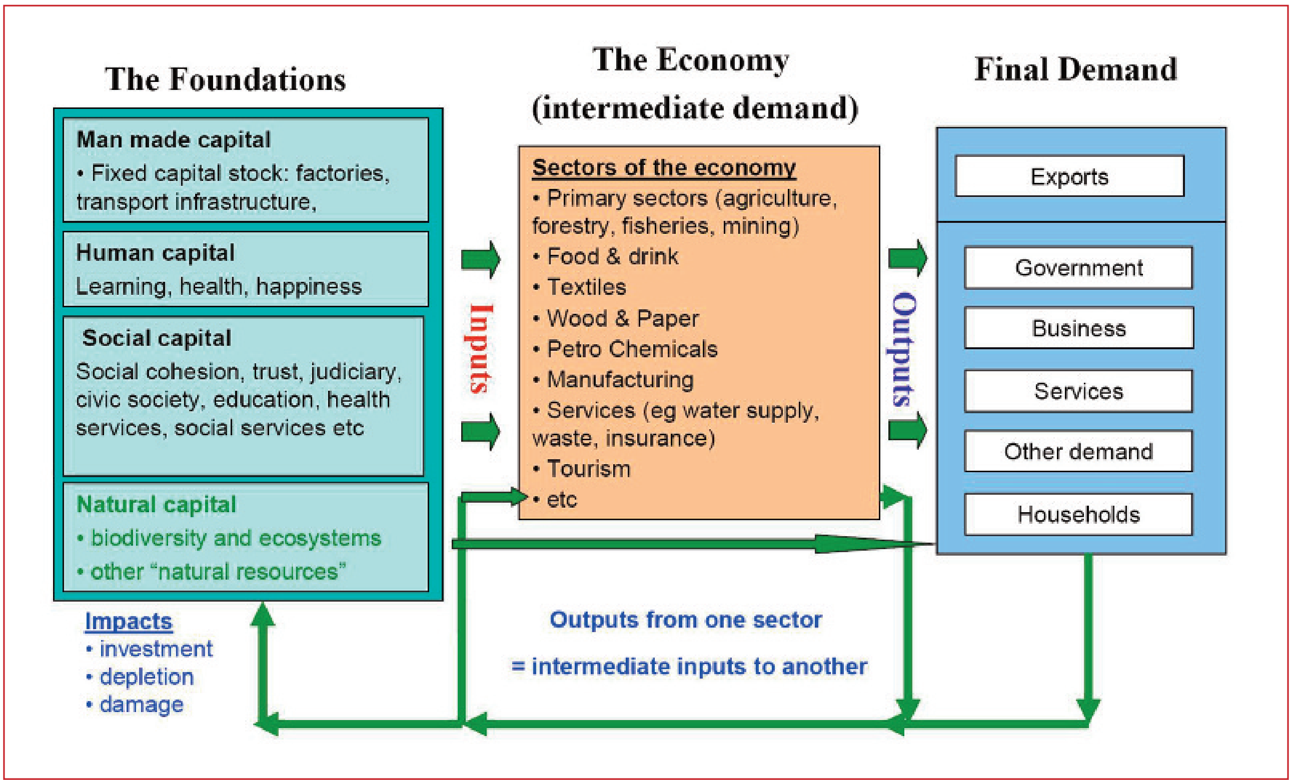
We need to understand the value of what we have today in terms of natural capital wealth, the value of what will be lost if biodiversity and ecosystem loss is not halted and share insights on the potential added value of investing in natural capital.

1.3.1 HOW DO ECOSYSTEM SERVICES UNDERPIN THE ECONOMY?

Economic prosperity depends on the flow of services from at least four types of capital: natural capital (level of reliance depends on the sector and country), man-made capital (buildings, machines and infrastructure), human capital (people and their education, skills and creativity) and social capital (the links between people and communities in terms of cooperation, trust and rule of law) (see Figure 1.6) [3].

Gross domestic product (GDP) therefore builds on natural capital. This can be done sustainably without loss or destruction of biodiversity (i.e. ecotourism that works within renewable limits of ecosystems). More often, GDP relies on extractive uses and either draws down natural capital (e.g. deforestation, overfishing) or replaces it with other forms of capital (e.g. replacement of natural habitats with built infrastructure). Box 1.6 puts this into economic context.

Figure 1.6: Natural capital: its contribution to the economy and livelihoods



Source: own representation, Patrick ten Brink

Box 1.6: Natural capital: its relationship to productivity

The growth rate of the economy is traditionally split into (i) weighted growth rates of the various factors of production and (ii) total factor productivity (TFP) covering growth that is not accounted for by productive inputs (e.g. resulting from technological progress). Environmental economists have long maintained that the importance of natural capital as a production factor is often overlooked and that many TFP estimates do not take adequate account of the draw-down of the stock of natural capital (Ayres and Warr 2006; Dasgupta and Mäler 2000; Repetto et al. 1989).

One study found that when the environment is not considered as a factor of production, TFP estimates are biased upward. This means that part of the economy's productivity growth can be specifically attributed to natural capital and conversely, that loss of natural capital has a negative impact on productivity. Failing to internalise the cost of an environmental externality is equivalent to using an unpaid factor of production. Continued reduction in natural capital will thus compromise the potential for economic growth (Vouvaki and Xeapapadeas (2008) (see further TEEB D0, Chapter 6).

The number of sectors benefiting from natural capital represents a far larger share of the economy than many policy-makers appreciate. In some cases, their dependence on ecosystem services is obvious e.g. the primary production sectors, water supply and growing parts of the tourism sector. In others, the relationship is less obvious but the economic benefits derived from biodiversity are still huge e.g. pharmaceuticals and cosmetics, chemicals, plastics, food, drink and ornamental fish. Data for 2006 shows how widely products derived from genetic resources contributed to the economy, including:

- 25-50% of pharmaceutical turnover (total US$ 640 billion);
- many products (e.g. enzymes, microorganisms) used in biotechnology (total US$ 70 billion);
- all agricultural seeds (US$ 30 billion) (SCBD 2008, see further TEEB D3 Report for Business forthcoming).

1.3.2 UNDERSTANDING THE VALUE OF ECOSYSTEM SERVICES

Appreciating value - to understand what is being lost and the value of what is being lost - **is the first step towards changing the way in which policy trade-offs and investment decisions are made** (see 1.3.3 and 1.3.4).

The **first step** is to understand the whole set of services - what they are, what helps create them, how they link to activities on the site, who benefits and the spatial relationship between service provision and the beneficiary. Section 1.1 outlined the scientific relationship between ecosystems, their services and benefits to users, and showed how change in the ecosystem could trigger changes to such services and benefits. In practice, there is rarely a simple linear relationship between ecosystem damage and a loss of service that applies to all services: the reality is usually more complex (see Balmford et al. 2008 and TEEB D0).

The **second step** is to express the changes in ecosystem services in monetary terms. Their value per hectare depends on the nature of the land, its use, proximity to population groups making use of the service and the wealth of these groups. Actual values will obviously vary from place to place and between different land uses. Table 1.1 presents some examples to illustrate the range of potential values for selected ecosystem services of tropical forests (see further Chapter 4 on valuation and assessment frameworks and more detailed discussion of methodologies in TEEB D0).

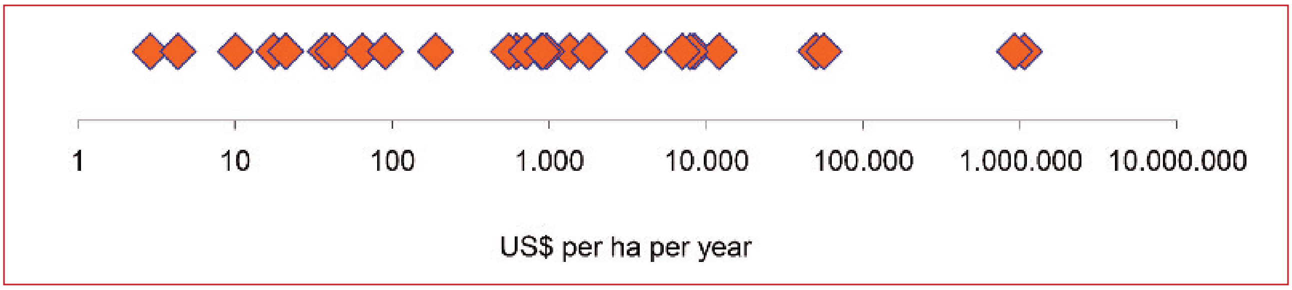
Table 1.1 shows that forests can have significant values in a range of regulating services – carbon storage, erosion prevision, pollution control, water purification - when their economic importance is often currently only perceived in terms of timber and non-timber products. As a rough proxy, it is not atypical to find that two thirds of the value of tropical forests derives from regulating services whereas only one third comes from provisioning food, raw material and genetic material for pharmaceuticals (see TEEB D0, Chapter 7).

Table 1.1: Examples of ecosystem service values from tropical forests

Service	Value
Food, Fibre and Fuel	Lescuyer (2007), based on a review of previous studies, estimated the annual per hectare average values of provisioning services for Cameroon's forests at US$ 560 for timber, US$ 61 for fuelwood and US$ 41-70 for non-timber forest products.
Climate Regulation	Lescuyer (2007), based on a review of previous studies, estimated the value of climate regulation by tropical forests in Cameroon at US$ 842-2265 per hectare per year.
Water Regulation	Yaron (2001) estimated the value of flood protection by tropical forests in Cameroon at US$ 24 per hectare per year. Van Beukering et al. (2003), estimate the NPV for water supply from 2000 to 2030 of the Leuser Ecosystem comprising approx. 25,000 km^2 of tropical forest at 2,419 Bio US$.
Groundwater recharge	Kaiser and Roumasset (2002) valued the indirect watershed benefits of tropical forests in the Ko'olau watershed, Hawaii, using shadow prices. The net present value of the contribution to groundwater recharge of the 40,000 hectare watershed was estimated at US$ 1.42 billion to US$ 2.63 billion.
Pollination	Priess et al (2007) estimated the average value of pollination services provided by forests in Sulawesi, Indonesia, at 46 Euros per hectare. As a result of ongoing forest conversion, pollination services are expected to decline continuously and directly reduce coffee yields by up to 18% and net revenues per hectare up to 14% within the next two decades.
Existence Values	Horton et al (2003) reported the results of a Contingent Valuation study in the UK and Italy, which evaluated non-users' willingness to pay for the implementation of a proposed programme of protected areas in Brazilian Amazonia. Estimated willingness to pay for forest conservation was $US 43 per hectare per year. Mallawaarachchi et al. (2001) used choice modelling to estimate the value of natural forest in the Herbert River District of North Queensland at AUS$ 18 per hectare per year.

Actual values are naturally site specific. This can be best exemplified by coral reefs. The value of coral reefs for tourism can range from low values (eg where fewer tourists for lesser known sites) to extremely high values, where tourism associated with the reef a key source of income and economic development of the areas (see Figure 1.7). In some tourist destinations the value of coral reefs can be up to US$ 1 million per hectare and year, as it is the case for Hawaii (Cesar et al 2002; Ruitenbeek and Cartier 1999). This is certainly an exceptional value, due to Hawaii's accessibility to high-income markets. However, even when these extreme values are put aside, the economic potential of coral reefs for tourism is considerable and highlights the potential that intact scenic and unique ecosystems can offer. At the same time it reflects the economic risk of a loss of these natural assets.

Figure 1.7: The range of the value of coral reefs for tourism



Source: TEEB D0, Chapter 7

As noted, benefits can arise at different geographic scales (global, national, subnational and/or local), depending on the ecosystem service provided. Some have global benefit, such as carbon storage and medicines, whilst others are mainly national (e.g. education, art and research) or local (e.g. pollination, water purification). Many services have the potential to deliver benefits at several levels e.g. ecotourism and recreation. Figure 1.8 illustrates this spread of benefits in a generic way: in practice, actual benefits will obviously vary on a case-by-case basis and also over time.

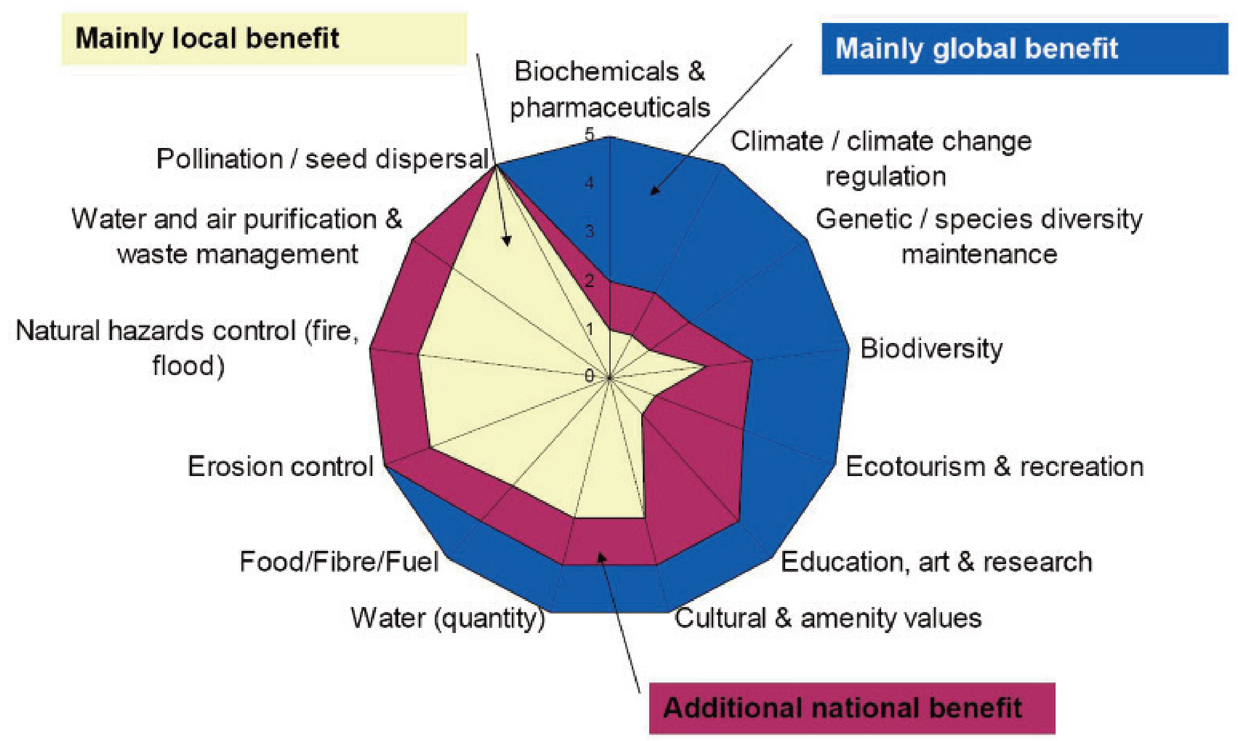
Any given area provides multiple services and thus offers a unique set of benefits. Focusing on a single service from an area risks ignoring the wide range of other services and can lead to potentially important losses, in terms both of cost and of opportunities foregone (see discussion on trade-offs below).

1.3.3 USING VALUATION TO ASSESS TRADE-OFFS, COSTS AND BENEFITS

Distributional impacts - who are the winners and losers? - are a fundamental element of decision-making.

Where ecosystem services are concerned, this question has not only a geographic dimension (see Figure 1.8) but also a time dimension. Conversion of natural systems may create immediate wealth and short term employment, but often ecosystem services would provide wealth and jobs indefinitely, albeit at lower levels. This is why the issue of how we compare impacts now and in the future can change decisions (see Chapter 4 and TEEB D0 chapter 6 on use of the discount rate).

Figure 1.8: Distribution of benefits over different geographic scales



Source: own representation, Patrick ten Brink

COSTS AND BENEFITS OF LAND CONVERSION

Any land use choice involves trade-offs. Decisions to convert imply that someone decides that the benefits outweigh the costs of conversion. However, often these decisions are systematically biased because they do not take into account the value of all the ecosystem services affected by the decision.

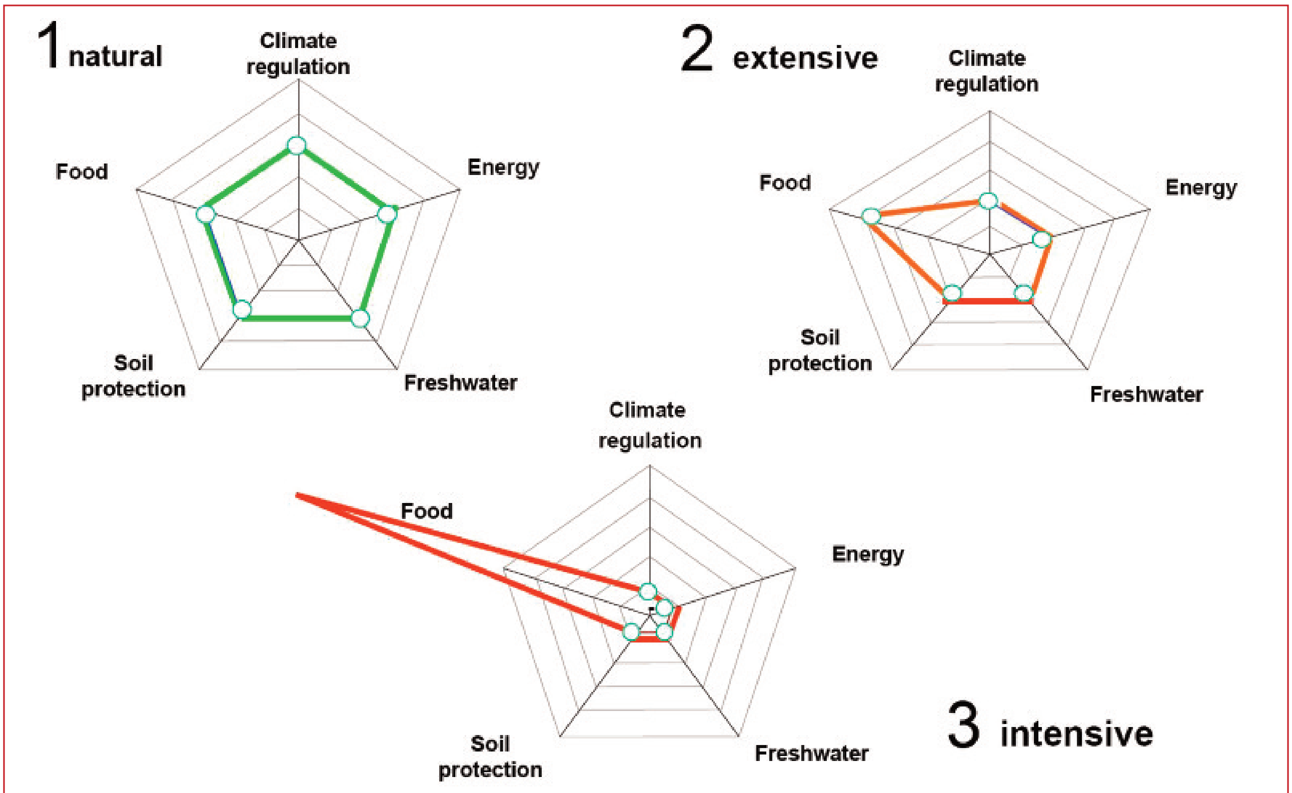
More specifically, the **choice of land use will affect the services produced and therefore who will benefit or lose and by how much**. Figure 1.9 gives a simplified example of the trade-offs involved in a decision to leave land in a natural state, convert it to extensive agriculture or convert it to intensive agriculture (excluding pollution issues). The example shows that the increasing focus on food provision entails greater loss of other services. In some cases, this may be essential and the benefits will outweigh the losses of other services. In others, the situation may be different and the main benefits from increased food provision may go to a different private interest than the former beneficiaries of the other services.

Land conversion decisions thus have important distributional impacts. Valuation helps to clarify the trade-offs between services provided and the associated trade-offs between beneficiaries of the different services. All evidence-based policy and decision-making (e.g. on spatial planning applications) should include an understanding of these implications.

Under current policy frameworks, most decisions consider trade-offs, either explicitly or implicitly e.g. for building roads and houses or designating areas as protected. However, the decision-making process does not generally see the whole picture and factor in all the benefits and costs. The loss of carbon stored in the soil when converting forests to biofuels production or the loss of species when fragmenting rivers by dams may remain invisible.

Where the value of ecosystem services are understood and included, what seemed an 'acceptable' trade-off may be found to have net costs (see site-specific example in Box 1.7). Conversely, including too little information in decision-making can lead to accidental 'lose-lose' decisions.

Figure 1.9: Land use choices and trade-offs of ecosystem service provision



Source: ten Brink, B. 2008

Box 1.7: To convert or not to convert - deciding between mangroves and a shrimp farm

Southern Thailand: Profits from commercial shrimp farming have been estimated at around US$ 9,632/ha* (Hanley and Barbier 2009). Returns to private investors in this case were particularly high not only because the farms receive subsidies but also because mangroves are an open-access resource (i.e. the investors do not have to bear the costs of mangrove rehabilitation after farm abandonment or the costs of property depreciation). For those making the private gain, the conversion decision is clearly an easy one.

However, the conclusion changes if the whole set of costs and benefits to society are considered. The shrimp farm benefits from subsidies and generates significant pollution. Adjusting for these factors, the economic return of the shrimp farm is reduced to a mere $1,220/ha* and turns negative if rehabilitation costs (around $9,318/ha*) are included. In contrast, the estimated benefits of retaining the mangroves (mostly to local communities) are around $584/ha* for collected wood and non-wood forest products, $987/ha* for fishery nursery and $10,821/ha* for coastal protection against storms (Barbier 2007). The total value of the mangrove is therefore around $12,392/ha*.

*All values are NPV over 9 years, with a productive life of 5 years of the shrimp farm, and a 10% discount rate. They are 1996 US$.

Putting private gain above public loss is a very common factor in decisions leading to loss of ecosystem services and biodiversity. As the example shows, a private investor, who receives public subsidies without having to pay for pollution or resource impacts of the activity has no incentive to avoid such damage. **The result is a potentially major public loss for a smaller private gain.** Only with a complete analysis and a due policy response (e.g. subsidy reform, payment of meaningful compensation, refusal of a permit) can cases like this be avoided.

This is a critical issue for policy-makers to address and indeed represents a fundamental argument for active public policy - to avoid global, national, or social losses that result from private gain.

COSTS AND BENEFITS OF PRO-CONSERVATION POLICIES

The issue of trade-offs is equally important for pro-conservation policies (see chapter 8). Choosing to protect a site has implications both for those already benefiting from the site and for those hoping to make use of the site by using it in another way:

- existing and potential beneficiaries include direct users (e.g. those harvesting timber) and indirect users (e.g. those dependent on filtration of water or maintenance of air quality):

- a site not under conservation will provide a range of benefits e.g. extractive benefits of timber for a private user plus other ecosystem services depending on the nature of the land, the links to population groups and the nature of the extractive activity;

- a move to conservation status is usually designed to reduce extractive use and pollution and increase provision of other ecosystem services. Conservation may therefore lead to a net benefit, although it will often be necessary to pay compensation to former users, address incentives for lost opportunity costs and pay for site management;

- there is a clear case for pro-conservation policies when the benefits of conservation (measured in terms of ecosystem services provided to wider society) outweigh the costs (including financial costs and opportunity costs). However, costs of implementing conservation are generally met lo cally whereas the benefits occur at multiple levels. This raises questions as to **who should pay for the conservation and what mechanisms are needed** (see in particular Chapters 5 and 8).

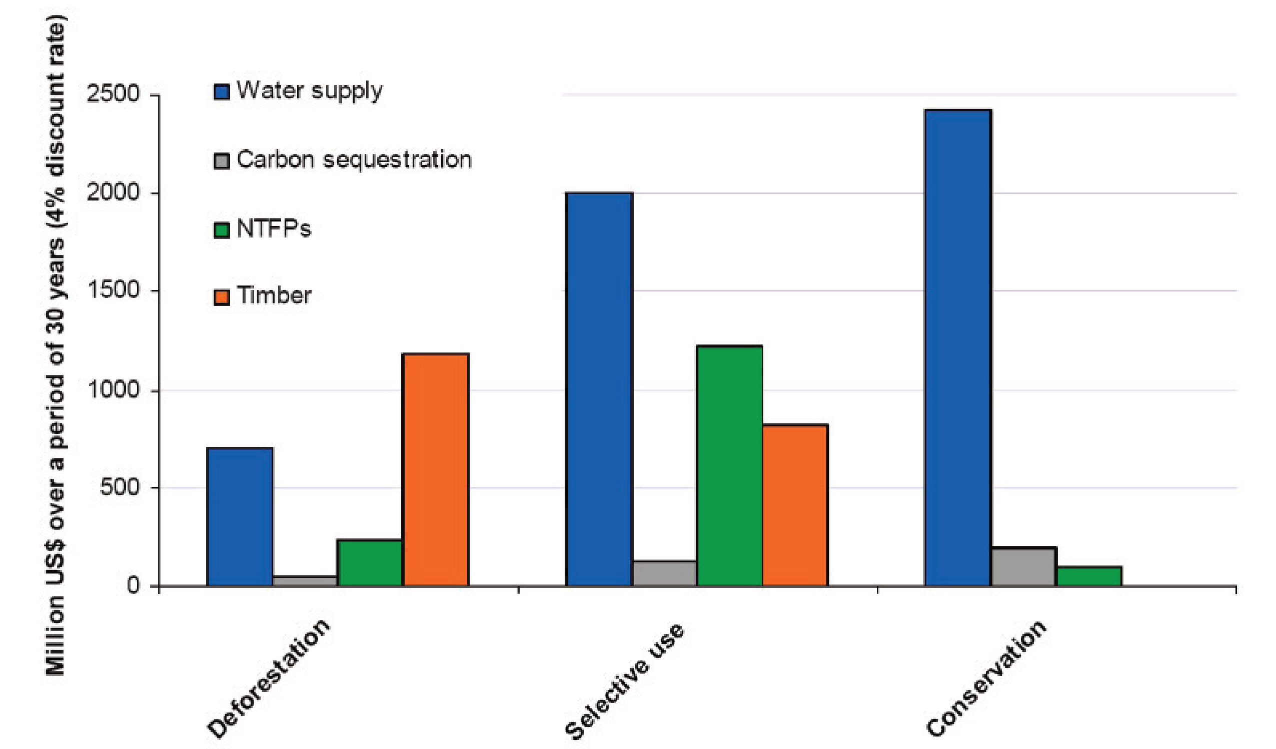
Trade-offs can be illustrated with the example of the Leuser National Park in Indonesia. Van Beukering et al. (2003) assessed the value of eleven ecosystem services of the Leuser Ecosystem in Indonesia under different land use scenarios (see Figure 1.10). Over a period of 30 years the total economic value of all eleven ecosystem services was estimated at US$ 9.5 billion for the conservation scenario and US$ 9.1 billion for the selective-use scenario, compared to an estimated income of US$ 7 billion under the deforestation scenario. The total value of four of the ecosystem services under the different land use scenarios over the period of 30 years, using a discount rate of 4%, is presented in the Figure 1.10. Deforestation is causing the degradation of important ecosystem services which leads to a decline in the overall benefit from the forest ecosystem. The conservation and selective use of the forest ecosystem allows using and maintaining a broad range of ecosystem services creating greater benefits for the local population.

1.3.4 RETURNS ON INVESTMENT IN ECOLOGICAL INFRASTRUCTURE

Avoiding unnecessary or excessive costs is in the interests of all policy-makers and economic sectors. Many services can usually be more efficiently provided by ecosystems than by artificial structures or processes. In addition to the examples below (including Box 1.8), these include fire protection by native vegetation, maintaining natural soil fertility and safeguarding genetic diversity (including crops and livestock breeds) as insurance for future food security. Investing in ecological infrastructure can be cheaper than investing in man-made technological solutions (see further Chapter 9).

Carbon capture and storage: Finding cost-effective means to mitigate climate change is essential given the scale of the challenge. Proposed man-made solutions include allocating substantial sums of money to artificial carbon capture and storage (CCS) e.g. by pumping CO_2 into the ground. Natural ecosystems (forests, agri-

Figure 1.10: Value of selected provisioning and regulating ecosystem services under different land use scenarios in the Leuser National Park, Indonesia



Source: van Beukering et al. 2003

cultural land and wetlands) already store vast quantities of carbon above the ground and in the ground, water or soil. They absorb additional amounts every year but, when lost to deforestation or degradation, lead to very significant emissions.

The proposed instrument REDD (Reducing Emissions from Deforestation and Forest Degradation), based on payment for carbon storage ecosystem services, could lead to an estimated halving of deforestation rates by 2030, cutting emissions by 1.5–2.7 Gt CO_2 per year. It has been estimated that this would require payments of $17.2 billion to $33 billion/year, but the estimated long-term net benefit of this action in terms of reduced climate change is assessed at $3.7 trillion in present value terms (Eliasch 2008). Delaying action on REDD would reduce the benefits of the instrument dramatically - delaying action on REDD by just 10 years could reduce the net benefit of halving deforestation by US$ 500 billion (see Eliasch 2008 and McKinsey 2008: see further Chapter 5 on the benefits of early action).

Box 1.8: Value for money: natural solutions for water filtration and treatment

Forests, wetlands and wetlands provide filtration for clean water at a much lower cost than man-made substitutes like water treatment plants:

- the catskills mountain case (US): $2 billion natural capital solution (restoration and maintenance of watershed) versus a $7 billion technological solution (pre-treatment plant), (Elliman and Berry 2007);
- New Zealand: in Te Papanui Catchment, the Central Otago conservation area is contributing to Dunedin's water supply, saving the city $93 million;
- Venezuela: the national protected area system prevents sedimentation that would reduce farm earnings by around $3.5 million/year (Pabon et al. 2009a);
- a third of the world's hundred largest cities draw a substantial proportion of their drinking water from forest protected areas (Dudley and Stolton 2003).

Flood control and coastline protection: Natural hazard control and mitigation can be provided by forests and wetlands (e.g. flood control) and on the coast by mangroves (e.g. reducing impacts from storms and tsunamis). Public expenditure dedicated to coastline protection against the risk of erosion and flooding reached an estimated EUR 3.2 billion in 2001, yet coastal ecological infrastructure can often do this more cheaply (see Box 1.9 and also Chapter 9).

Box 1.9: Forest investments to reduce flooding: experience from China

As a consequence of the severe floods of the Yangtse River in 1998, the Chinese government decided to invest over US$40 billion into the Sloping Land Conversion Programme. It intends to convert farmland along the river into forested area, by offering the farmers cash incentives to cede their land. This instrument aims to decrease soil erosion significantly, in order to mitigate the consequences of a flood (see further Chapter 9).

Source: Tallis et al. 2008

Fishstock regeneration in mangroves, coral reefs and inland waters: These habitats provide key fish nurseries. Protecting them from destruction and degradation can be a cost-effective means of supporting fishing whilst providing a range of other ecosystem services. In Cambodia, for example, the Ream National Park provides fish breeding grounds and other subsistence goods from mangroves worth an estimated $US 600,000 per year as well as an additional $300,000 in ecosystem services such as storm protection and erosion control (Emerton et al. 2002, see also Chapter 8).

1.3.5 IMPLICATIONS FOR POLICY-MAKERS

New public policy solutions are urgently needed to enhance the benefit that society as a whole obtains from ecosystems. This will require us to level the tilted playing field that currently favours private production over conservation of natural resources and ecosystems. Improved decision-making should take full account of the wider social benefits they provide for current and future generations and encourage markets and prices to reflect the true value of ecosystems, biodiversity and other natural resources.

Better measurement is required with regard to the role of ecosystems and biodiversity in providing services and of the value of these services, alongside improved policy assessment and tools to help make use of natural assets more efficiently.

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The tools and approaches presented in this report will therefore be relevant not only to central administrators but also to:

- statistical officers (given importance of measurement);
- planning administrators (given spatial planning needs and also permit issues);
- monitoring, permitting and inspection officers (for implementation and compliance);
- judges (for compliance and enforcement); and
- state auditors (to assess value for money on government spending).

1.4 HUMAN DIMENSIONS OF THE BIODIVERSITY CRISIS

1.4.1 ECOSYSTEM SERVICES: A LIFELINE FOR THE POOR, A NECESSITY FOR EVERYONE

It is not just wealth that is in danger, but also 'well-being' – both individual well-being and health (human capital) and social well-being and stability (social capital). The poor are often much more directly dependent on ecosystems for basic provisioning services but ultimately we all depend on nature and healthy natural systems. It is not all about dependency and negative impacts; the engagement of local communities is also a key part of the solution.

Poor populations are often the first to suffer the impact of degraded or lost biodiversity because the connection between their livelihoods and biodiversity is direct. Natural resources are a basic source of their income generation (see the discussion on 'GDP of the Poor' in Chapter 3). One less well-known aspect is that healthcare needs for the world's poor are mostly met by traditional medicines and treatments extracted from natural sources. They suffer directly from the loss of biodiversity as the cost of 'formal' healthcare medicines is often prohibitive. The TEEB Interim Report (TEEB 2008) demonstrated that there are critically important links between ecosystem services (loss) and the feasibility of achieving the Millennium Development Goals (see also Chapter 5).

Beyond material dependency, biodiversity often plays an important role in religious beliefs, traditional knowledge and social institutions. Many communities are enmeshed with the ecosystems within which they live and this connection often forms the basis of their collective identity and culture (see Box 1.10).

Box 1.10: Forests are essential for the well-being of the poor… and rural communities are often essential for the well-being of the forests

Over 90% of the world's poorest people depend on forests for their livelihoods. Some populations are entirely dependent on forests (e.g. indigenous forest peoples) and for a wide range of others, their livelihoods are fundamentally linked.

The value of non-timber forest products (NTFPs) is variously estimated at between $1/ha and $100/ha (SCBD 2001). However, in certain countries, the share of NTFP of household income as massively higher e.g. 40-60% in Chivi (Zimbabwe) (Lynam et al. 1994), 47% in Mantandia (Madagascar) (Kramer et al. 1995) and 49% in Madhya Pradesh, Orissa and Gujarat (India) (Bahuguna 2000). A loss of forest can represent a fundamental loss of income/ well-being for population groups that often have no easy substitute for the loss.

At the same time, the communities can and do play an important role in the well-being of forests and there are strong arguments for making communities part of the solution to deforestation and forest degradation. 22% of all developing country forests are owned by communities. Community tenure is expected to double again by 2020 to more than 700 million hectares. In some countries the benefits communities bring is rewarded financially, for example in:

- **Ecuador:** municipal government pays communities $11-16 per hectare/year for maintaining natural forest cover and ensuring clean water supplies in the Pisque watershed;
- **Uganda:** ECOTRUST pays villagers $45.60 per hectare/year ($8 per tonne of carbon sequestered) for reforestation with native trees.

Source: Borges 2007

Vulnerability to climate shocks is unequally distributed. Hurricane Katrina provided a potent reminder of human frailty in the face of climate change, even in the richest countries – especially when the impacts are aggravated with institutionalised social inequality. Across the developed world, public concern over exposure to extreme climate risks is mounting with every flood, storm and heat wave.

Yet **climate disasters are heavily concentrated in poor countries**. Some 262 million people were affected by climate disasters annually from 2000 to 2004, over 98% of them in the developing world. In richer countries forming part of the Organisation for Economic Co-operation and Development (OECD), one in 1,500 people was affected by climate disaster over this period. The comparable figure for developing countries was one in 19 (UNDP 2007).

1.4.2 SUBSTITUTION POTENTIAL: LIMITS AND IMPLICATIONS

Typically, if we lose or damage something, we ask ourselves where to find a replacement. When a natural resource is depleted, we look for ways to acquire a substitute e.g. another fishing ground, another forest for fuel wood, another aquifer for water. In some cases, substitution of ecosystem services can happen by natural means: the services lost from the original ecosystem may be (partly) substituted for by exploiting another, similar ecosystem in some other location. In other cases, substitution of ecosystem services can be by artificial means: their loss may be substituted by technical solutions (artificial substitutes) – e.g. desalinated water or bottled water.

However, **there are limits to substitution potential** and this has very important human implications. For some services and groups of society, there are:

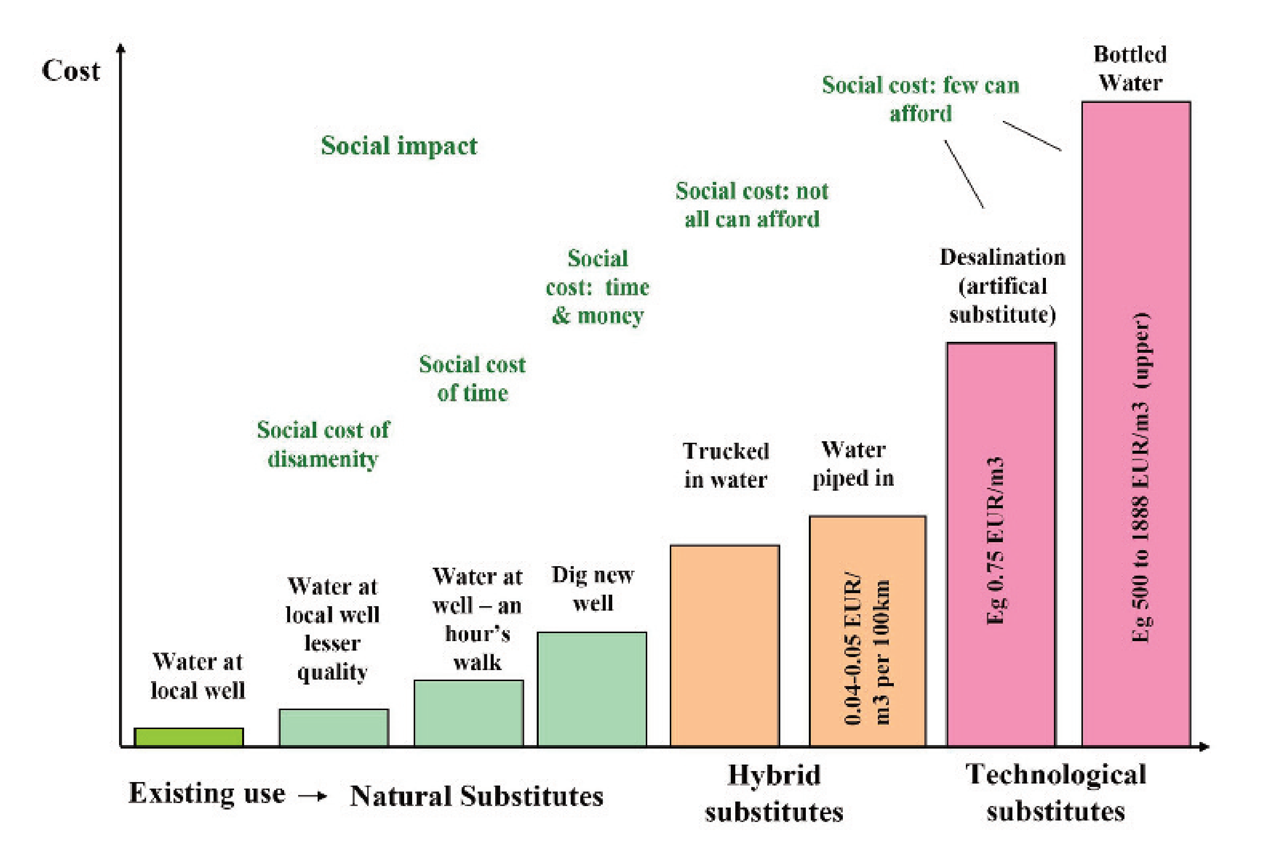
- no alternatives;
- only degraded alternatives; or
- much more costly – even unaffordable – alternatives.

Resource depletion has direct social impacts in such cases. Take fuelwood as an example. More and more time must be spent on collecting fuel or on earning money to pay for it, so less energy is available for cooking and heating. In some countries, women and children may spend 100-300 work days a year gathering wood: in Mali, some fuel wood collecting trips require walking 15 km one way and in urban areas, an average of 20-40% of cash income must be set aside to buy wood or charcoal. Fuelwood is thus a dwindling resource that is becoming more costly in every sense: deforestation can thus be a four fold loss (FAO 2006).

Figure 1.11 shows the social and cost implications of seeking substitutes. The values are illustrative as they are case specific: actual costs will obviously depend on location.

Source: André Künzelmann, UFZ

Figure 1.11: Substitution potential for ecosystem services



Source: ten Brink et al 2009

Other limits on substitution potential depend on timescale and geography as well as wealth. For example, global fishing fleets can move from one fishery to the next so for the short and probably also medium term, there is substitution potential. In the long term, however, without proper fisheries management/governance this will also hit a threshold. For local fishermen a local fish stock collapse may lead them to having no substitute to fish. The global incentives and local incentives can therefore be fundamentally different.

The situation is similar for fish protein – rich urban populations will hardly be affected by a loss of a fishery in one part of the world as there will still be fish in the supermarket. For local populations dependent on artisanal fishing, there may be no immediate substitute to loss of fish protein in their diet. This will either have health implications or knock-on effects in terms of them searching for protein elsewhere.

Substitution is of course more complex than simply finding other sources of the ecosystem service. Ecosystems are often interdependent on each other, and individual components cannot just be extracted and replaced without impacting on other associated ecosystems.

1.4.3 ENGAGING COMMUNITIES TO DEFINE POLICY SOLUTIONS

Engaging communities to be part of the process and part of the solution is invaluable. Local knowledge of ecosystems and biodiversity can reveal many opportunities (medicines, pharmaceuticals, other uses of biomimicry). Without local input, implementation may be inefficient or ineffective. Without changing the incentives people now have to convert forests or hunt for bush meat or rare species, any solution that looks good on paper is likely to fail.

This report provides many concrete examples of success stories for which local engagement has proven critical. For payments for environmental services (PES) or carbon storage programmes supported through REDD, it is generally local people who are paid for the maintenance or restoration of watersheds, forests and wetlands. Local knowledge of medicinal properties of plants makes bioprospecting more cost effective, and due sharing of the benefits can facilitate cooperation (see generally Chapter 5 on rewarding benefits).

In many southern African countries, community-based natural resource management is considered a good strategy not only to develop multi-resource livelihood activities, but also to stimulate local self-reliance and poverty alleviation (Wily 2000; Benjaminsen et al. 2002).

These types of approaches link natural capital and creation of social capital. Typically, attention is focused on restructuring the rights of access to and use of communal and/or state lands. For these programmes to be successful, the role of farmers in conserving biodiversity on their farmlands needs to be recognised, particularly the fact that rural communities through different uses have created a diversified landscape. For example, in Tanzania local communities often consciously preserve and cultivate endemic species on their village lands, because of their role to fulfil household needs, but also of wider value for crop diversity.

A country or region where the natural capital – its forests, watersheds, soil and crop varieties - is acutely run down will find it particularly difficult to meet the Millennium Development Goals (UN 2000). A concerted effort to restore natural capital will therefore be an essential part of a strategy to address the social challenges and improve community health and livelihoods.

Chapter 1 has highlighted the main issues for policy-makers raised by the **global biodiversity crisis** and outlined the economic and social case for integrating valuation across relevant policy areas. **Chapter 2** describes the **framework for the policy response** and shows how and when the benefits of biodiversity and ecosystems can be linked to policy process, opportunities and instruments.

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