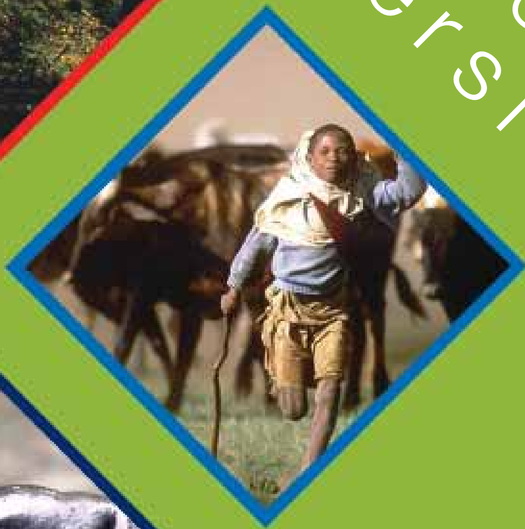
The Economics of Ecosystems & Biodiversity



MAINSTREAMING THE ECONOMICS OF NATURE

A SYNTHESIS OF THE APPROACH, CONCLUSIONS AND RECOMMENDATIONS OF TEEB

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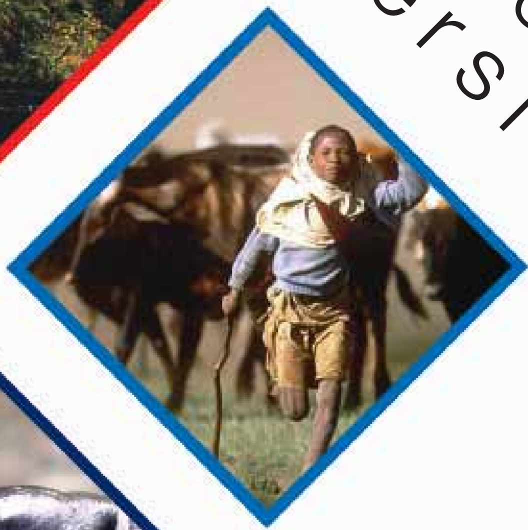

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A SYNTHESIS OF THE APPROACH, CONCLUSIONS AND RECOMMENDATIONS OF TEEB

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PREFACE

Pavan Sukhdev and the TEEB team

In 2007, environment ministers from the governments of the G8+5 countries[1], meeting in Potsdam, Germany, agreed to "initiate the process of analysing the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation."

The Economics of Ecosystems and Biodiversity (TEEB) study, which emerged from that decision, has delivered a series of reports (see insert) addressing the needs of major user groups: national and local decision makers, business and the wider public.

This synthesis complements, but does not attempt to summarize, the other products of TEEB (see insert, section 4 and Annex 1). The aim of this synthesis is to highlight and illustrate the approach adopted by TEEB: namely to show how economic concepts and tools can help equip society with the means to incorporate the values of nature into decision making at all levels.

Applying economic thinking to the use of biodiversity and ecosystem services can help clarify two critical points: why prosperity and poverty reduction depend on maintaining the flow of benefits from ecosystems; and why successful environmental protection needs to be grounded in sound economics, including explicit recognition, efficient allocation, and fair distribution of the costs and benefits of conservation and sustainable use of natural resources.

The analysis of TEEB builds on extensive work in this field over the last decades. TEEB presents an approach that can help decision makers recognize, demonstrate and, where appropriate, capture the values of ecosystems and biodiversity (see section 2). TEEB also acknowledges the plurality of values which people hold for nature, as well as the multitude of techniques available for their assessment.

The values of nature vary according to local biophysical and ecological circumstances and the social, economic and cultural context. Intangible values, which may be reflected in society's willingness to pay to conserve particular species or landscapes, or to protect common resources, must be considered alongside more tangible values like food or timber to provide a complete economic picture.

Valuation is seen not as a panacea, but rather as a tool to help recalibrate the faulty economic compass that has led us to decisions that are prejudicial to both current well-being and that of future generations. The invisibility of biodiversity values has often encouraged inefficient use or even destruction of the natural capital that is the foundation of our economies.

The aim of TEEB is to provide a bridge between the multi-disciplinary science of biodiversity and the arena of international and national policy as well as local government and business practices. The scope of TEEB is intentionally broad and it should therefore be seen as an inspiration and as an invitation for others to deepen its findings and to develop more context-specific recommendations. Ideally, TEEB will act as a catalyst to help accelerate the development of a new economy: one in which the values of natural capital, and the ecosystem services which this capital supplies, are fully reflected in the mainstream of public and private decision-making.

The completion of the study and the publication of this synthesis come at a time when the global community has an unprecedented opportunity to rethink and reconfigure the way people manage biological resources. A new vision for biodiversity, with proposals for time-bound targets and clear indicators, is being drawn up by the Convention on Biological Diversity (CBD), in this International Year of Biodiversity. TEEB's approach to incorporating nature's values into economic decision making can help turn that vision into reality.

Crucially, TEEB's recommendations are aimed far beyond the remit of most environment ministries and environmental institutions. TEEB seeks to inform and trigger numerous initiatives and processes at national and international levels, including:

- the deliberations of the G8+5 and the G20 groups of nations, which have committed to move toward greener, more sustainable growth;
- the Millennium Development Goals, to which all nations subscribed and pledged to achieve by 2015;
- the United Nations Conference on Sustainable Development, also referred to as the 'Rio + 20' Earth Summit, planned for 2012;
- efforts to mainstream the environment in financial services, spearheaded by the United Nations;
- the on-going review and update of Guidelines for Multinational Enterprises, which seek to promote responsible business conduct, by the OECD and several developing countries; and
- various voluntary declarations, codes and guidelines related to biodiversity and ecosystem services drawn up by, and for, industry.

In the following pages, we make the case for systematic appraisal of the economic contribution of biodiversity and ecosystem services to human well-being; and for routine steps to prevent that contribution being lost or diminished through neglect or mismanagement. It is an appeal to each of us, whether a citizen, policy maker, local administrator, investor, entrepreneur or academics, to reflect both on the value of nature, and on the nature of value.

Note to the reader

This synthesis builds on the results of **six TEEB reports** over the last 3 years. To make referencing easy, **we refer to these reports in the text with single letters** followed by the corresponding chapter number:

I	TEEB Interim Report
C	TEEB Climate Issues Update
F	TEEB Ecological and Economic Foundations
N	TEEB for National and International Policy Makers
L	TEEB for Regional and Local Policymakers
B	TEEB for Business

Example: (F5) refers to: TEEB Ecological and Economics Foundations, Chapter 5

Short summaries of all reports are provided in the insert.
Information on contributors can be found in Annex 3.
Glossary terms: The terms indicated with an → are further defined in the glossary in Annex 1.
TEEBcases: Examples from across the globe that illustrate how ecosystem services have already been taken into account in local/regional policy making. TEEBcases were reviewed by independent experts and are being uploaded to **TEEBweb.org** upon completion.

TABLE OF CONTENTS

This report includes an insert providing an overview of all TEEB reports.

1 INTRODUCTION

Biodiversity is defined by the CBD as "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" (CBD 1992). In other words, biodiversity includes diversity within species populations (genetic variation); the number of species, and the diversity of ecosystems.

Both quantity and quality attributes of biodiversity are important when considering the links between nature, economic activity and →*human well-being*. In addition to the diversity of species, genes and ecosystems, the sheer abundance of individual animals and plants, as well as the extent of ecosystems such as forests or living coral reefs, are critical components of →*natural capital* and key determinants of the benefits delivered.

In recent literature, the links between nature and the economy are often described using the **concept of →*ecosystem services***, or flows of value to human societies as a result of the state and quantity of natural capital. The Millennium Ecosystem Assessment defined four categories of ecosystem services that contribute to human well-being, each underpinned by biodiversity (MA 2005; for a more detailed description, see Annex 2):

- **Provisioning services** – for example wild foods, crops, fresh water and plant-derived medicines;
- **Regulating services** – for example filtration of pollutants by wetlands, climate regulation through carbon storage and water cycling, pollination and protection from disasters;
- **Cultural services** – for example recreation, spiritual and aesthetic values, education;
- **Supporting services** – for example soil formation, photosynthesis and nutrient cycling.

The concepts of ecosystem services and natural capital can help us recognize the many benefits that nature provides [F1]. From an economic point of view, the flows of ecosystem services can be seen as the 'dividend' that society receives from natural capital. **Maintaining stocks of natural capital allow the sustained provision of future flows of ecosystem services**, and thereby help to ensure enduring human well-being.

Sustaining these flows also requires a good understanding of how ecosystems function and provide services, and how they are likely to be affected by various pressures. Insights from the natural sciences are essential to understanding the links between biodiversity and the supply of ecosystem services, including ecosystem →*resilience* – i.e. their capacity to continue to provide services under changing conditions, notably climate change [F2].

There is growing evidence that many ecosystems have been degraded to such an extent that they are nearing **critical →*thresholds*** or tipping points, beyond which their capacity to provide useful services may be drastically reduced. However, there is **considerable uncertainty** about how much use or disturbance different ecosystems can withstand before irreversible harm is caused. Hence **precaution** is needed in order to maintain 'healthy' ecosystems and the continued flow of ecosystem services over the long-term. [F2]

Few ecosystem services have explicit prices or are traded in an open market. Those ecosystem services most likely to be priced in markets are the consumptive, →*direct use* ***values*** of 'provisioning services,' such as crops or livestock, fish or water, which are directly consumed by people (see box far left in Figure 1). Non-consumptive use values, such as recreation, or →*non-use values*, which may include the spiritual or cultural importance of a landscape or species, have often been influential in decision making but these benefits are rarely valued in monetary terms.

Box 1: The Economics of Ecosystem Services: some numbers

Conserving forests avoids greenhouse gas emissions worth US$ 3.7 trillion

Halving deforestation rates by 2030 would reduce global greenhouse gas emissions by 1.5 to 2.7 GT CO_2 per year, thereby avoiding damages from climate change estimated at more than US$ 3.7 trillion in NPV terms. This figure does not include the many co-benefits of forest ecosystems (Eliasch 2008).

Global fisheries underperform by US$ 50 billion annually

Competition between highly subsidized industrial fishing fleets coupled with poor regulation and weak enforcement of existing rules has led to over-exploitation of most commercially valuable fish stocks, reducing the income from global marine fisheries by US$ 50 billion annually, compared to a more sustainable fishing scenario (World Bank and FAO 2009).

The importance of coral reef ecosystem services

Although just covering 1.2% of the world's continent shelves, coral reefs are home to an estimated 1-3 million species, including more than a quarter of all marine fish species (Allsopp et al. 2009). Some 30 million people in coastal and island communities are totally reliant on reef-based resources as their primary means of food production, income and livelihood (Gomez et al. 1994, Wilkinson 2004).

Green products and services represent a new market opportunity

Global sales of organic food and drink have recently been increasing by over US$ 5 billion a year, reaching US $46 billion in 2007 (Organic Monitor 2009); the global market for eco-labelled fish products grew by over 50% between 2008 and 2009 (MSC 2009); and ecotourism is the fastest-growing area of the tourism industry with an estimated increase of global spending of 20% annually (TIES 2006).

Bee keeping generates US$ 213 million annually in Switzerland

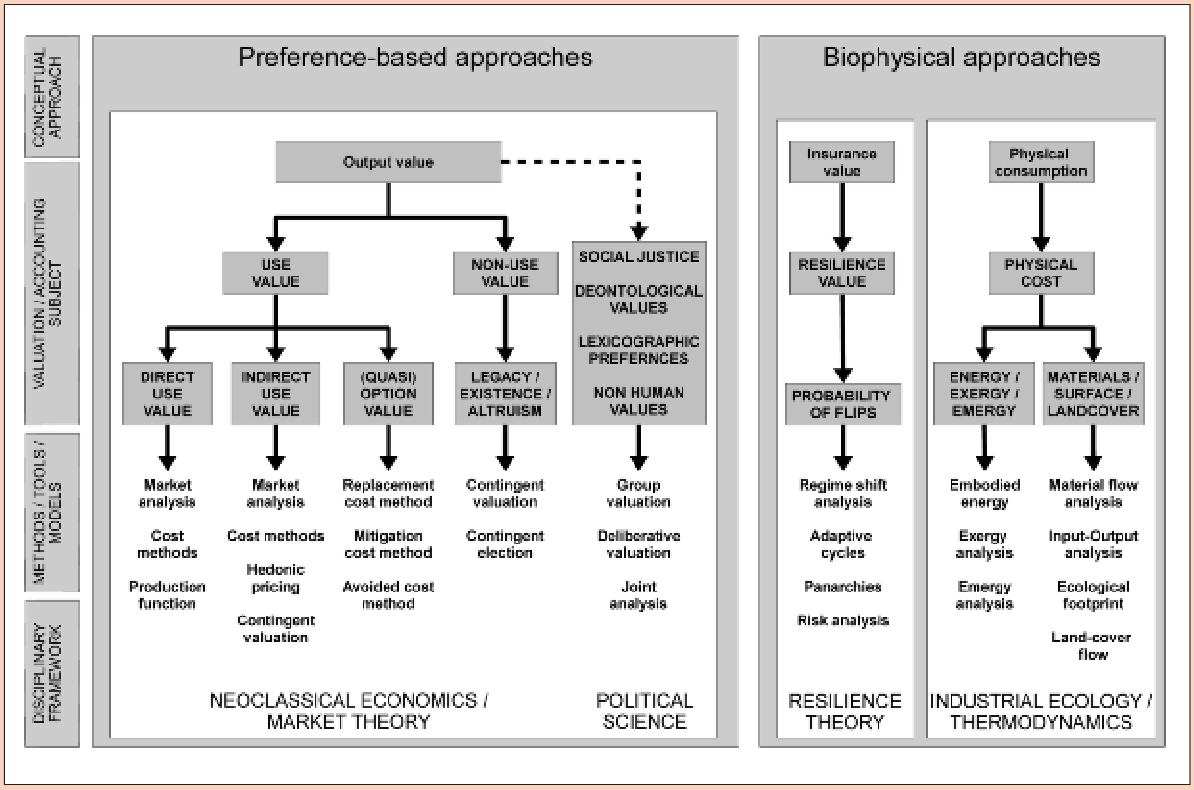
A single bee colony ensured a yearly agricultural production worth (US$ 1,050) in pollinated fruits and berries in the year 2002, compared to just US$ 215 for direct products from beekeeping (e.g. honey, beeswax, pollen) (Fluri and Fricke 2005). On average, Swiss bee colonies ensured a yearly agricultural production worth about US$ 213 million by providing pollination, about five times value of the production of honey (TEEBcase: Valuation of pollination spurs support for bee keepers, Switzerland). The →*total economic value* of insect pollination worldwide is estimated at €153 billion, representing 9.5% of world agricultural output in 2005 (Gallai et al. 2009).

Tree planting enhances urban life quality in Canberra, Australia

Local authorities in Canberra have planted 400,000 trees to regulate microclimate, reduce pollution and thereby improve urban air quality, reduce energy costs for air conditioning as well as store and sequester carbon. These benefits are expected to amount to some US$ 20-67 million over the period 2008-2012, in terms of the value generated or savings realized for the city (Brack 2002).

Some other ecosystem benefits, especially **regulating services** such as water purification, climate regulation (e.g. carbon sequestration), and pollination, have only recently begun to be assigned an economic value, referred to as →*indirect use values* in Figure 1. Although the latter values, when calculated, commonly form the majority of the →*Total Economic Value* of an ecosystem, they **remain largely invisible** in the day-to-day accounts of society [F1, F5].

Figure 1: Approaches for the estimation of nature's values



Source: TEEB Foundations, Chapter 5

The results of this economic invisibility are illustrated by the challenge of large-scale commercial deforestation. Companies do not clear-cut forests out of wanton destructiveness or stupidity. On the whole, they do so because **market signals** – influenced by subsidies, taxation, pricing and state regulation, as well as land tenure and use rights – make it a logical and profitable thing to do. It is often profitable and logical because the costs of deforestation are generally not borne by companies clearing the land for agriculture or by companies logging and selling the timber. Rather, these **costs tend to fall on society**, on future generations, and often, on poor households in rural areas who frequently depend on the resources and services of the forest for their daily survival and security.

The most recent assessments of global biodiversity find that species are continuing to decline and that the **risk of extinction is growing**; that natural habitats are continuing to be lost and becoming increasingly degraded and fragmented; and that the principal direct →***drivers*** of biodiversity loss (habitat disturbance, pollution especially nutrient load, invasive alien species, over-exploitation and, increasingly, climate change) are either constant or intensifying (Butchart et al. 2010, GBO3 2010). Further driving forces include economic and human population growth. Finally, the **failure to account for the full economic values** of ecosystems and biodiversity has been a significant factor in their continuing loss and degradation (GBO3 2010, MA 2005).

The same assessments warn of serious consequences for human societies as ecosystems become incapable of providing the goods and services, on which hundreds of millions of people depend (Rockstrom et al. 2009). Such →*thresholds* have already been passed in certain coastal areas where 'dead zones' now exist, for a range of coral reefs and lakes that are no longer able to sustain aquatic species, and for some dryland areas that have been effectively transformed into deserts. Similarly thresholds have been passed for some fish stocks [F5, N1, B2].

The **TEEB Interim Report** [I], published in 2008, provided some initial estimates of the **economic impacts of biodiversity loss at a global scale**. Although such large-scale assessments may be helpful to outline the economic importance of natural capital, estimating the costs of biodiversity loss at a global scale remains a controversial and complex undertaking, and the resulting numbers should be used with care.

Apart from exploring such 'big numbers', and perhaps more usefully, the TEEB reports offer **numerous case studies** of the economic impacts of biodiversity loss, and the economic opportunities from recognizing and responding better to the economic values of biological resources. These case studies are explored from several important perspectives, including those of:

- **National and sub-national policy and management:** ignoring or undervaluing natural capital in economic forecasting, modelling and assessments can lead to public policy and government investment decisions that exacerbate the degradation of soils, air, water and biological resources and thereby negatively impact a range of economic and social objectives. Conversely, investment in natural capital can create and safeguard jobs and underpin economic development, as well as secure untapped economic opportunities from natural processes and genetic resources. [N1, L1]
- **Poverty reduction:** poorer households, in particular in rural areas, face disproportionate losses from the depletion of natural capital due to their relatively high dependence on certain ecosystem services for income and insurance against hard times. Biodiversity conservation and sustainable management of ecosystems should be key elements in strategies to eliminate poverty, contribute to internationally-agreed objectives, such as the Millennium Development Goals, as well as a target for poverty reduction policies at national and local levels [I2, L1].
- **Businesses:** the private sector both impacts and depends to varying degrees on ecosystem services and therefore on the stock of natural capital. Businesses must manage risks to reputation and the bottom line posed by environmental damage – an issue highlighted with unprecedented force by the recent oil spill in the Gulf of Mexico. At the same time, promising new opportunities are offered by green innovation, environmental efficiencies and early entry into technologies and practices that are increasingly demanded by consumers or required by regulation. [B1]
- **Individuals and communities:** biodiversity loss imposes personal and collective costs to health, income, security and many other aspects of well-being. Conversely, conservation opportunities include individual action to improve the quality of life; as well as exercising the right of citizens to hold governments and companies accountable for managing the 'public wealth' of which natural capital is a major part, and in which citizens and communities hold the ultimate stake.

Assessing the costs and benefits of conserving and sustainably using biodiversity and ecosystems is only the first step. Knowing that overfishing is jeopardizing the integrity of a coral reef, and with it the benefits that local communities derive from the reef, **will not by itself lead to changes** in fishing methods, so long as short-term profits and government incentives continue to promote destructive practices.

Recognizing that biodiversity underpins human well-being is one thing; **translating that knowledge into incentives** which influence behaviour for the better is another. It is a challenge – both in political and technical terms – that must be met if the failures of the recent past are not to be repeated and compounded.

The approach promoted by TEEB is based on work carried out by economists over several decades. **Economic assessment** should be seen **as a tool to guide** biodiversity management, not as a precondition for taking action. However, the framework of economic analysis and decision making described in the TEEB reports, if widely implemented, could go a long way towards making **pro-biodiversity investment the logical choice** for a much wider range of actors in the future.

For an overview of the different TEEB stakeholder reports, see insert.

2 RECOGNIZING, DEMONSTRATING AND CAPTURING VALUE: TEEB'S APPROACH

A basic premise of the TEEB study is that the valuation of biodiversity and →*ecosystem services* may be carried out in more or less explicit ways according to the situation at hand. The TEEB study follows a tiered approach in analyzing and structuring valuation.

RECOGNIZING VALUE

Recognizing value in ecosystems, landscapes, species and other aspects of biodiversity is a feature of all human societies and communities, and is sometimes sufficient to ensure conservation and sustainable use. This may be the case especially where the spiritual or **cultural values** of nature are strong. For example, the existence of sacred groves in some cultures has helped to protect natural areas and the biodiversity they contain, without the need to place a monetary value on the 'services' provided. Equally, protected areas such as national parks have historically been established in response to a sense of collective heritage or patrimony, a perception of shared cultural or social value being placed on treasured landscapes, charismatic species or natural wonders.

Protective legislation or voluntary agreements can be appropriate responses where biodiversity values are generally recognized and accepted. In such circumstances, **monetary valuation** of biodiversity and ecosystem services may be unnecessary, or even counterproductive if it is seen as contrary to cultural norms or **fails to reflect a plurality of values**. A more detailed view of the limitations of monetary valuation is provided in TEEB Foundations, Chapter 4 [F4].

DEMONSTRATING VALUE

Nevertheless, **demonstrating value** in economic terms is often useful for policymakers and others, such as businesses, in reaching decisions that consider the full costs and benefits of a proposed use of an ecosystem, rather than just those costs or values that enter markets in the form of private goods. →*Economic valuations* of natural areas are a case in point. Examples include **calculating the costs and benefits** of conserving the ecosystem services provided by wetlands in treating human wastes and controlling floods, compared to the cost of providing the same services by building water treatment facilities or concrete flood defences) (see for example the case of the Kampala wetland valuation in section 3.2.3 below).

A variety of economic valuation methods have been developed, refined, and applied to biodiversity and ecosystem services in a range of different contexts. **TEEB has reviewed the main methods**, which all have their advantages and disadvantages (F5). It first needs to be stressed that valuation is best applied for **assessing the consequences of changes** resulting from alternative management options, rather than for attempting to estimate the total value of ecosystems. In practice, most valuation studies do not assess the full range of ecosystem services but focus on just a few services. Moreover, not all biodiversity values can be reliably estimated using existing methods (see Figure 1). Nevertheless, as a first step, it is important to identify all significant changes in ecosystem services even if it is not possible or necessary to monetize all of these changes. Decision makers also need information about who is affected and where and when the changes will take place.

The demonstration of economic value, even if it does not result in specific measures that capture the value, can be an important **aid in achieving more efficient use** of natural resources. It can also highlight the costs of achieving environmental targets and help identify more efficient means of delivering ecosystem services. Valuation in these circumstances enables policy makers to **address →*trade-offs*** in a rational manner, correcting the bias typical of much decision making today, which tends to favour private wealth and physical capital above public wealth and →*natural capital*.

Some aspects of ecosystem functioning such as ecological →***resilience*** or the proximity of tipping points are **difficult to capture** in valuations. In such cases this information should rather be presented alongside the valuation calculation. The adoption of safe minimum standards or precautionary approaches for decisions about →*critical natural capital* is called for prior to any consideration of trade-offs. [F2, 5, N7, L2]

CAPTURING VALUE

Capturing value, the final tier of the economic approach, involves the introduction of mechanisms that **incorporate the values** of ecosystems into decision making, **through incentives and price signals**. This can include payments for ecosystem services, reforming environmentally harmful subsidies, introducing tax breaks for conservation, or creating new markets for sustainably produced goods and ecosystem services [N2,5-7; L8-9]. It needs to come along with **reinforcing rights** over natural resources and liability for environmental damage,

In many cases, explicit valuation of the ecosystem services targeted by such mechanisms can help to ensure they are economically efficient. However, calculating prices for natural assets and ecosystem services is not always necessary in order to set up market-based schemes. Moreover, such **valuation does not imply that all ecosystem services** must necessarily **be privatized** and traded in the market: that is a separate choice that involves a range of issues including **equity for the users** of common resources and future generations, as well as considerations of economic efficiency. The TEEB reports provide numerous examples that illustrate the use of market-based mechanisms for biodiversity conservation, which may be appropriate in certain circumstances. The challenge for decision makers is to **assess when market-based solutions** to biodiversity loss are likely to be culturally **acceptable**, as well as effective, efficient and equitable. [N5, 7,; L8]

In summary, TEEB's approach to valuing ecosystems and biodiversity is one that **acknowledges the limits, risks and complexities** involved, covers different types of value appreciation, and includes various categories of response at the level of public policies, voluntary mechanisms and markets. In situations where cultural consensus on the value of ecosystem services is strong and the science is clear, it may be relatively straightforward to **demonstrate values in monetary terms** and capture them in markets. This applies most obviously to commodity values such as the number of livestock or cubic meters of timber, but can equally be applied to amount of carbon storage or the supply of clean water. On the other hand, in more complex situations involving multiple ecosystems and services, and/or plurality of ethical or cultural convictions, monetary valuations may be less reliable or unsuitable. In such cases, simple recognition of value may be more appropriate.

In general, however, one should not shy away from providing **the best available estimates of value for a given context** and purpose and seeking ways to internalize that value in decision making. Indeed, the TEEB study calls for assessing and internalizing such values wherever and whenever it is practical and appropriate to do so. **A failure to do so is** unacceptable: namely, to permit the continued absence of value to seep further into human consciousness and behaviour, as **an effective 'zero' price**, thus continuing the distortions that drive false →*trade-offs* and the self-destructiveness that has traditionally marked our relationship with nature (for a detailed review of the economics of ecosystem valuation F5, N4, L3).

Valuation can act as **a powerful form of feedback**, a tool for self-reflection, which helps us rethink our relation to the natural environment and alerts us to the consequences of our choices and behaviour on distant places and people. It also acknowledges the costs of conservation and can promote more equitable, effective and efficient conservation practices.

3 PUTTING THE TIERED APPROACH INTO PRACTICE

For every decision the context is different; hence there is **no single valuation process** that can be prescribed **for every situation**. However, a broad framework or heuristic has emerged that may be useful as a first step towards a recalibrated economic compass. This approach can be adapted to fit individual needs and circumstances, using the three steps below as guideline. As suggested in the previous section, steps 2 and 3 will not be appropriate in all contexts.

Step 1: For each decision **IDENTIFY and ASSESS the full range of →*ecosystem services* affected and the implications for different groups in society**. Consider, and take steps to involve, the full range of stakeholders influencing and/or benefiting from the affected ecosystem services and biodiversity.

Step 2: ESTIMATE and DEMONSTRATE the value of ecosystem services, using appropriate methods. Analyze the linkages over scale and time that affect when and where the costs and benefits of particular uses of biodiversity and ecosystems are realized (e.g. local to global, current use versus future →*resilience*, 'upstream to downstream', urban to rural), to help frame the distributive impacts of decisions.

Step 3: CAPTURE the value of ecosystem services and seek SOLUTIONS to overcome their undervaluation, using economically informed policy instruments. Tools may include changes in subsidies and fiscal incentives, charging for access and use, payments for ecosystem services, targeting biodiversity in poverty reduction and climate adaptation/mitigation strategies, creation and strengthening of property rights and liability, voluntary eco-labelling and certification. The choice of tools will depend on context and take into account the costs of implementation.

Practical guidance and illustrations of these steps are provided in the reports (see insert), and are supported by a collection of case studies from the local and regional level (so-called 'TEEBcases', see Box 2), which are available online. The reader is encouraged to navigate through these resources to find aspects of the approach most relevant to her or his needs and interests – and indeed, to develop and share additional case studies and advice.

Here, the approach is illustrated by applying it to an ecosystem (forests), a unit of human settlement (cities) and a business sector (mining). In each case, the steps of recognizing, demonstrating and capturing value are illustrated.

Box 2: The challenge of application and the 'TEEBcase' collection: showcasing best practice examples from around the globe

As outlined in section 1 of this document, →*economic valuation* of ecosystem services is a challenging task which needs careful selection and application of methodologies, depending on the context and the needs of a given situation [F4, F5]. High levels of precision and reliability can be obtained using best practices and rigorous methods but this is often time and resource intensive.

The review of case studies undertaken by TEEB shows that, in many instances, more efficient but less precise methods have been used, hence the results must be interpreted with appropriate care. Nevertheless, even approximate estimates of the value of ecosystem services can help lead to better resource management and policy, especially where the alternative assumption is that nature has zero (or infinite) value.

The TEEBcase collection presents such examples and discusses the impact they have had in local and regional policy and resource management. The TEEBcases can be accessed via teebweb.org.

3.1 APPLYING THE APPROACH: ECOSYSTEMS

The value provided to human societies by ecosystems varies greatly between (and within) the various →*biomes* found on earth. Increasingly, the services provided by terrestrial, freshwater and marine ecosystems in various contexts are being assessed, and their role in supporting a wide range of economic activity is being appreciated.

For example, Hawaii's **coral reef ecosystems** provide many goods and services to coastal populations, such as fisheries and tourism, and also form a natural protection against wave erosion. In addition, they represent a unique natural ecosystem. The net benefits of the State's 166,000 hectares of reefs off the Main Hawaiian Islands are estimated at US$ 360 million per year (Cesar and van Beukering 2004). The study thus highlights that coral reefs, if properly managed, contribute enormously to the welfare of Hawaii through a variety of quantifiable benefits. It covers only values currently captured including recreation, amenity (real estate), research and fishery, the public benefits referring to protection against natural hazards, climate regulation or potential future benefits from species living in the reef are not included (TEEBcase: Recreational value of coral reefs, Hawaii). The threats to coral reefs due to climate change and ocean acidification, as well as local pressures such as pollution and overfishing, therefore have major economic implications. When considering non-marginal values or the value of a →*biome* as a whole, monetary values are less meaningful and other indicators may be more revealing, such as the fact that half a billion people depend on coral reefs for their livelihoods [N Summary, C].

Wetlands, too, both inland freshwater and coastal, are being 're-valued' as providers of essential ecosystem services and not simply areas that require draining or conversion to make them economically viable. Flooded wetlands can also be highly effective in reducing pollution (Jeng and Hong 2005); e.g. in India, the East Kolkata wetlands facilitate bio-chemical processes for the natural treatment of an important share of the city's waste water – after this treatment process, the remaining nutrients in the water are an important input for local fish farms and vegetable cultivation (Raychaudhuri et al. 2008). The value of conserving wetlands for flood protection in the city of Vientiane (Lao PDR) has been estimated at just under US$ 5 million, based on the value of flood damages avoided (TEEBcase: Wetlands reduce damages to infrastructure, LAO PDR). Wetland protection in Hail Haor, Bangladesh, contributed to an increase in fish catch of over 80% (TEEBcase: Wetland protection and restoration increase yields, Bangladesh).

The 'TEEB approach' can be applied to any ecosystem in any biome, from drylands, grasslands and savannas to tundras, mountain ecosystems and island habitats. However, some of the most advanced economic evaluation efforts have been carried out for the world's forests, which are the focus of the remainder of this section.

FORESTS: IDENTIFYING ISSUES AND ASSESSING SERVICES

Forests currently occupy about one-third of the Earth's land surface and are estimated to contain more than half of all terrestrial species, mainly in the tropics. Moreover, forest ecosystems account for over two-thirds of net primary production on land – i.e. the conversion of solar energy into biomass through photosynthesis – making them a key component of the global carbon cycle and climate (MA 2005).

The UN Food and Agriculture Organisation (FAO) reports that net deforestation slowed in recent years from around 83,000 square kilometres per year, in the 1990s, to just over 50,000 square kilometres per year between 2000 and 2010. This is mainly attributed to replanting of forests in temperate regions, especially in China, and to natural re-growth. Tropical deforestation, while slowing in several countries, nevertheless continues at a high rate. The first decade of the millennium saw the global extent of primary or natural forest reduced by over 400,000 square kilometres, an area larger than Japan (FAO 2010; GBO3 2010).

The issue of tropical deforestation illustrates vividly the economics of biodiversity loss. By far the greatest use of deforested land is for agriculture, a sector that generates substantial income which shows up clearly in national accounts and trade balances. By contrast, the **multiple flows of value generated by standing**

Figure 2: 'GDP of the poor': estimates for ecosystem service dependence

Source: TEEB for National Policy, Chapter 3 [N3]

forests tend to be in the form of →***public goods*** that in the past **have not been valued in monetary terms** or priced in markets. Techniques for calculating and capturing a wider range of forest values are however increasingly employed, as described below.

An important finding of many studies reviewed by TEEB is the **contribution of forests** and other ecosystems **to the livelihoods of poor rural households**, and therefore the significant potential for conservation efforts to contribute to poverty reduction. For example, it has been estimated that ecosystem services and other non-marketed goods account for between 47% and 89% of the so-called 'GDP of the poor' (i.e. the effective GDP or total source of livelihood of rural and forest-dwelling poor households), whereas in national GDP agriculture, forestry and fisheries account for only 6% to 17% (Figure 2). [N3]

FORESTS: DEMONSTRATING VALUES

Table 1 below summarizes studies that estimate the value of ecosystem services provided by tropical forests. Values vary according to the methods used, the size and type of forests considered, the local ecological conditions as well as social and economic variables, such as population density or food prices. For example, one study estimated the pollination service provided by patches of forest adjacent to coffee plantations in Costa Rica to be worth US$ 395 per hectare per year, or about 7% of the farm income (Ricketts et al. 2004), far more than the average value attributed to forests for the same service in Indonesia, as shown in Table 1.

A large portion of the value of tropical forests arises from so-called regulating services, such as carbon storage, erosion prevention, pollution control, and water purification. In many valuation studies, these regulating services account for around two-thirds of →*total economic value*. In contrast, the supply of food, timber, genetic and other materials typically accounts for a relatively small share of forest value, although these are the benefits on which perceptions of the economic importance of forests are often based.

TEEB reviewed research into the benefits and costs of designating forests as protected areas [N8]. The precise values vary depending on local conditions and context. These studies, however, suggest that the **benefits of protecting tropical forest ecosystems often outweigh the costs**. While forest conservation may be a good deal for society, the question remains how to make it a good deal for the people who actually live there [N8, L7].

FORESTS: CAPTURING VALUES AND FINDING SOLUTIONS

Forests have been the focus of recent efforts to correct the failure of markets to value biodiversity and ecosystems, using **payments for ecosystem services** (PES) [N5, L8]. While still relatively rare and involving modest sums compared with commercial uses of forests and alternative uses of forest lands, PES

Table 1: Some estimated values of ecosystem services from tropical forests	
Ecosystem Service	**Value**
Food, fibre and fuel	Lescuyer (2007) values the provisioning services of Cameroon's forests at US$ 560 for timber, US$ 61 for fuelwood, and US$ 41-70 for non-timber forest products (all values per hectare per year).
Climate regulation	Lescuyer (2007) values climate regulation by tropical forests in Cameroon at US$ 842-2265 per hectare per year.
Water regulation	Yaron (2001) values flood protection by tropical forests in Cameroon at US$ 24 per hectare per year. Van Beukering et al. (2003) estimate the NPV of water supply from the Leuser Ecosystem (comprising approximately 25,000 km^2 of tropical forest) at US$ 2,42 billion.
Groundwater recharge	Kaiser and Roumasset (2002) value the indirect watershed benefits of the 40,000 hectare Ko'olau watershed, in Hawaii, at US$ 1.42-2.63 billion.
Pollination	Priess et al. (2007) value pollination services provided by forests in Sulawesi, Indonesia, at 46 Euros per hectare. Ongoing forest conversion is expected to reduce pollination services and thus coffee yields by up to 18% and net revenues per hectare by up to 14% over the next two decades.
→*Existence values*	Horton et al. (2003) use contingent valuation to estimate the →*willingness to pay* of UK and Italian households for protected areas in the Brazilian Amazon at US$ 46 per hectare per year. Mallawaarachchi et al. (2001) use choice modelling to value natural forests in the Herbert river District of North Queensland at AU$ 18 per hectare per year.

schemes are nevertheless growing in number and scale. The basic idea is that landowners or communities should be rewarded for practices that keep forests intact and maintain their services. This can be accomplished by using money and other incentives provided by the users of those services, be it society as a whole, through general taxation, downstream water users, through water tariffs, or distant emitters of greenhouse gases, through the carbon market or grants based on the role of forests in climate mitigation.

One country that has established a **forest PES scheme at a national scale** is **Mexico** (TEEBcase: Hydrological Services, Mexico). Since 2003, following a change in federal law to allow a portion of water charges to be earmarked for conservation, landowners may apply for public payments in exchange for commitments to preserve forest land and forgo certain uses, such as agriculture and cattle raising. The scheme focuses on areas that are important for the recharge of Mexico's aquifers, maintaining surface water quality, and reducing the frequency and scale of damage from flooding. A points system is used to prioritise areas according to the value of environmental service, as well as the level of poverty and risk of deforestation (Muñoz-Piña et al. 2008).

During the first seven years of its operation, Mexico's PES scheme enrolled more than 3,000 forest owners (collectives and individuals), covering an area of 2,365 square kilometres and involving payments of over US$ 300 million. The scheme is estimated to have reduced deforestation by some 1,800 square kilo-metres, i.e. more than halved the annual rate of deforestation from 1.6% to 0.6%. It has effectively contributed to protecting water catchments and biodiverse cloud forests, in addition to cutting emissions of about 3.2 million tonnes of carbon dioxide equivalent (Muñoz et al. 2010).
Another approach to capture the value of forest ecosystems is to require compensation from landowners who convert forests to other uses, based on the value of the services lost. In 2006, the Indian Supreme Court

drew up a scale of compensatory payments for converting different types of forested land to other uses. Their regulations drew from a report led by the Institute for Economic Growth and estimates made by Green Indian States Trust (GIST 2005). The amounts of compensatory payments are distinguished for six classes of forest types, and based on estimated values for timber, fuel wood, non-timber forest products, ecotourism, bioprospecting, flood prevention and soil erosion, carbon sequestration, biodiversity values, as well as values attached to conserving charismatic species such as the Royal Bengal Tiger and Asian Lion. Payments for the permits to convert forest lands go into a public fund to improve India's forest cover (CEC 2007). In 2009, the Supreme Court directed Rs. 10 billion (around EUR 220 million) to be released every year for afforestation, wildlife conservation and the creation of rural jobs (Surpreme Court of India 2009).

A new international payment mechanism under development has the potential to significantly scale-up the capture of certain forest ecosystem values. Initiatives to **Reduce Emissions from Deforestation and Forest Degradation (REDD-Plus)**, currently being negotiated under the UN Framework Convention on Climate Change, could, if successful, generate substantial revenues for the conservation and sustainable use of forests. Studies suggest that REDD would compete favourably with other land uses (Olsen and Bishop 2009), while at the same time potentially bringing much-needed income to remote rural communities [C2, N5].

Human-induced deforestation, which accounts for about 12 per cent of global greenhouse gas emissions, is an issue that must be addressed as part of the international response to climate change (van der Werf et al. 2009). Avoiding deforestation is an economically attractive option due to the fact that it is among the cheapest ways of reducing emissions, in terms of dollars per tonne of carbon (McKinsey 2009; Eliasch 2009), and also because it secures further ecosystem and biodiversity benefits.

There are a number of considerations before a REDD-Plus scheme becomes a working mechanism with real impacts on forest decisions. For instance, key choices need to be made on how funds will be allocated among landowners and local and national governments; how the rights of local and indigenous groups will be acknowledged; and whether investors and/or governments will be able to use the carbon credits generated by REDD-Plus to help meet emission reduction targets or obligations in their own countries. Before REDD-Plus proceeds beyond the pilot phase, major investments will be needed to build capacity in developing countries in order to make the mechanism credible.

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3.2 APPLYING THE APPROACH: HUMAN SETTLEMENTS

All forms of human settlement involve a combination of dependence on the current availability of →*natural capital*, both local and remote, and the impact of the settlement on the future availability of the natural capital. As noted in the previous section, the poor households in rural areas are often disproportionately dependent on biodiversity for their daily needs; agriculture remains the dominant activity for some 37% of the world's labour force, or 1.2 billion people (CIA 2010) [L1]. An assessment of ecosystem services and natural resource management in rural areas is provided in the TEEB for Local and Regional Policymakers report [L5]. This section focuses on what has become the dominant form of human settlement, urban living, and its economic relationship with nature.

CITIES: IDENTIFYING ISSUES AND ASSESSING SERVICES

For the first time in history, **more than half of the human population lives in cities**. China already has 100 cities with a population of over one million and India has 35 and by 2050, the UN predicts that up to 80% of the global population could be based in urban areas (UNDESA 2010). Moreover, most of the world's cities are situated on the coasts, making them particularly vulnerable to climate change effects and more dependent on well-functioning coastal ecosystems.

This demographic shift has **profound implications for** the relationship between our species and the rest of **nature**. The fast-moving, mechanized lifestyle of today's urban centres presents an illusion of distance and disconnection from the natural world. Yet every activity in our towns and cities depends in some way on the Earth's ecosystems and their functions, and imposes pressures upon them. The energy for our transport, raw materials for our gadgets, food in our homes and restaurants, convenient disposal of our wastes, all depend on biological resources but this pressure and impact on the resources is often economically invisible [L4].

The paradox of city living is that while it appears to be an efficient use of the Earth's land space (50 per cent of the population crammed into two per cent of its land surface), the 'ecological space' required to serve urban needs is enormous. For example, the ecological footprint of Greater London in 2000 was estimated to be nearly three hundred times its geographical area, and twice the size of the United Kingdom (Best Foot Forward 2002).

The **impact of cities on the world's resources** is, in fact, **disproportionate** to their share of the population. Urban activities are estimated to account for some 67% of total energy consumption, and 70% of greenhouse gas emissions (OECD/IEA 2008). Similar dominance of the global demand for resources can be observed in urban consumption of fresh water, wood and other raw materials.

Decision makers in cities have a responsibility to acknowledge the natural capital required to maintain and improve the well-being of their residents. The first step is one of discovery – an assessment of the relationship between city life and the environment. This assessment can be undertaken at various scales: the total footprint of a city, in terms of its use of resources and production of waste; the role and value of regional ecosystems in providing for the needs of city-dwellers; and the importance of the urban environment itself, including the amount of green space available to each resident, and its influence on quality of life [L4].

Even without formal →*economic valuation*, the **importance of green spaces in urban areas** to the quality of life of their residents has prompted city authorities to prioritize parks and the protection of biodiversity in development plans. For example, the Brazilian city of Curitiba recognized the importance of extending a network of urban parks to prevent flooding and provide recreation. With parks covering nearly one-fifth of the city, each citizen of **Curitiba** has an average of more than 50 square metres of green space, among the highest ratios in Latin America (ICLEI 2005).

Similarly, **Singapore** has for decades prided itself in being a **'garden city'**, with a model national parks service. Singapore today continues its experiment in 'greening' with rooftop gardens and well maintained wilderness areas open to the public, including Sungei Buloh (a mangrove park restored from disused shrimp farms), Bukit Timah Nature Reserve (a hilly area of primary and secondary tropical rainforest), and Mc Ritchie Reservoir (another natural area which serves as the catchment for the island city's main freshwater reservoir).

Singapore has also taken the lead in devising a 'City Biodiversity Index' which could be emulated more widely to help cities benchmark their efforts to enhance quality of life (TEEBcase: Singapore city biodiversity index). The Singapore index measures performance and assigns scores based on three categories:

1. the number of plant and animal species in a city;
2. the services that these plants and animals provide, such as pollination and carbon storage; and
3. how well the city manages its biodiversity – for instance, by setting up a conservation agency or a museum to document species and habitats [L4].

CITIES: DEMONSTRATING VALUES

Demonstrating the value of ecosystem services provided to cities by the surrounding countryside and urban green spaces can help decision makers maximize the efficient use of natural capital. For instance, a study undertaken for the David Suzuki Foundation of Canada sought to value the natural capital contained within the **'Greenbelt' of Ontario**, Canada, which adjoins the Greater Toronto area, three years after its designation as green area (TEEBcase: Economic value of Toronto's Greenbelt, Canada). The most valuable services identified by the study were habitat, flood control, climate regulation, pollination, waste treatment, and control of water runoff. The study estimated the total value of the region's measurable non-market ecosystem services at CA$ 2.6 billion annually (Wilson 2008).

The valuation of the natural capital protected by the Greenbelt can be compared with →*opportunity costs* associated with other uses of the land, and thus help inform future decisions, such as whether to expand the Greenbelt to areas currently outside the protected zone.

In other cases, valuation of the services provided to cities by surrounding ecosystems has been decisive in preventing the conversion of natural areas to other uses. For example, the Nakivubo **Swamp**, linking the **Ugandan capital Kampala** with Lake Victoria, was found in 1999 to have a value of between US$ 1 million

Rio de Janeiro, Brazil, a city shaped and defined by its natural landscape and US$ 1.75 million per year (depending on the valuation technique used) for the services it provided in **purifying the city's waste waters** and retaining nutrients (TEEBcase: Protected wetland for securing wastewater treatment, Uganda, Emerton 1999) [L4].

Based on this valuation and the importance of the wetland for local livelihoods, plans to drain it for development were abandoned, and Nakivubo was incorporated into Kampala's greenbelt zone. Nevertheless, the wetland has suffered significant modification in the past decade, compromising its ability to continue performing a water purification function, and a new plan for rehabilitation and restoration of Nakivubo was proposed in 2008. The Ugandan case emphasizes that while valuation of ecosystem services will often strengthen arguments for protecting natural capital, it will not of itself prevent decisions from being made that degrade those services.

CITIES: CAPTURING VALUES AND FINDING SOLUTIONS

In a number of cases around the world, the valuation of ecosystem services has stimulated the implementation of policies that reward those responsible for protecting the services.

One of the most celebrated examples was the decision by the **New York City** authorities to pay landowners in the Catskill mountains to improve farm management techniques and prevent run-off of waste and nutrients into nearby watercourses in order to **avoid building expensive new water treatment facilities**, which otherwise would have been required by federal regulations [N9].

The cost of this choice, between US$ 1 billion and US$ 1.5 billion, contrasts with the projected cost of a new water filtration plant at US$ 6 billion to US$ 8 billion, plus US$ 300 million to US$ 500 million in estimated annual operating costs. Water bills for New Yorkers went up by 9%, rather than doubling as they would have if a filtration plant had been built (Perrot-Maitre and Davis 2001; Elliman and Berry 2007).

In other cities, innovative economic instruments are being used to capture the value of highly-prized and increasingly scarce green spaces. An example is the Japanese city of Nagoya, which lost more than 16 square kilometres of green space between 1992 and 2005, and risks a continuing loss of its remaining Satoyama, Japan's traditional diverse agricultural landscape. Under a new system of tradable development rights implemented from 2010 onwards, developers who wish to exceed existing limits on high-rise buildings will be able to offset their impacts by buying and conserving Satoyama areas at risk of development. In addition, incentives are offered to developers in Nagoya to provide more green space within their projects, including discounts on bank loans for buildings that receive a higher 'star rating' based on a green certification system designed by the city authorities (Hayashi and Nishimiya 2010). These schemes are clearly in an early stage of development, however, there is ample experience with the use of tradable permits to preserve open space and to contain urban sprawl available, e.g. in the US (Pruetz 2003) [N7]. Other cities will wish to evaluate their progress when making decisions about similar instruments [L4].

Finding appropriate solutions that value and maintain the natural capital required for the well-being of urban residents can be greatly helped by a formal process of '**ecological budgeting**'. For example, a procedure known as ecoBudget has been used by the municipality of Tubigon in the **Philippines** since 2005, as a way of tackling major threats to environmental resources and evaluating the impact of existing environmental initiatives. Shadowing the sequence of the financial budget cycle, ecoBudget monitors the state of various elements of natural capital judged essential to the economy of the municipality and the surrounding province: fertile soil, clean water, high biodiversity, adequate forest cover, healthy mangroves, seagrass and coral reefs. After a wide consultation process involving members of the public and the private sector, a Master Budget was drawn up to target particular aspects of natural capital felt to be at risk. Among the resulting measures were the planting of timber and fruit trees, the reforestation of mangroves, establishment of a new marine protected area, and the implementation of an ecological solid waste management programme. [L4]

3.3 APPLYING THE APPROACH: BUSINESS

Business has much to gain from following the approach promoted by TEEB [B1]. If anyone doubted that, events in the Gulf of Mexico in April 2010 should have set off alarm bells in boardrooms all over the world. Here was an industry with relatively little direct dependence on ecosystem services (compared with agri-business, forestry or fisheries, for example) which nevertheless faced a major threat to its market value and bottom line as a direct result of the environmental impacts of offshore oil drilling. In this case, a major energy company was suddenly faced with society's valuations of marine and coastal ecosystems, and forced to internalize the costs of environmental damage resulting from a large oil spill.

At a global scale, the **potential ecological liabilities of business loom very large**. For example, a study for the United Nations Principles for Responsible Investment (UNPRI) estimated that 3,000 listed companies in the world were responsible for environmental 'externalities' (i.e. third-party costs, or 'social costs', of normal business transactions) amounting to over US$ 2 trillion in Net Present Value terms (based on 2008 data), or about 7% of their combined revenues and up to a third of their combined profits [B2]. The externalities valued in this study were greenhouse gas emissions (69% of the total), overuse and pollution of water, particulate air emissions, waste and unsustainable use of natural fish and timber (UNPRI forthcoming).

Businesses increasingly recognize the importance of biodiversity and ecosystem services for their operations, as well as the business opportunities provided by the conservation and sustainable use of biodiversity. In a 2009 survey of 1,200 business executives from around the world, 27% of respondents were either 'extremely' or 'somewhat' concerned about biodiversity loss, which was seen as a threat to business growth prospects (PricewaterhouseCoopers 2010). The figure was significantly higher for CEOs in Latin America (53%) and Africa (45%). More recently, a survey of over 1,500 business executives found that a majority of respondents (59%) see biodiversity as more of a business opportunity than a risk (McKinsey 2010).

The relationship between business and biodiversity is explored comprehensively in TEEB for Business [B1-7]. Here, we highlight the TEEB approach, for illustration, with respect to the mining and quarrying sector.

MINING: IDENTIFYING ISSUES AND ASSESSING SERVICES

For mining and quarrying, failure to account for the values of natural capital can pose **significant business risks** and result in **missed business opportunities**. In the estimate of externalities associated with some of the world's leading companies, mentioned above,

Morenci Mine, largest copper mine in the United States: mining and quarrying may have considerable impact on landscapes.

over US$ 200 billion, or almost 10% of the total, is attributed to the industrial metals and mining sector. (UNPRI forthcoming)

The **direct use of ecosystem services** for mining and quarrying includes the need for freshwater supplies for mineral processing, which **can be very significant**. More often, the sector is associated with adverse impacts on biodiversity, due to habitat disturbance and conversion. The largest direct impacts result from surface mining, in which entire habitats and the geological features underlying them are removed during the period of extraction. In addition, the quarrying process can disturb plant and animal (and human) communities through noise, dust, pollution and the removal and storage of waste (tailings). Less direct but nonetheless significant impacts can come from the wider footprint of mining exploration, such as access roads that bring people into ecosystems where there has previously been little or no human presence, or the 'honey pot' effect of increased economic activity attracting large numbers of workers, who may engage in other environmentally damaging activities (e.g. farming to supplement mining wages). Finally, the use and disposal of some heavy metals can have significant negative impacts on soils, water resources, animal and human health.

However, the **ecological balance sheet of the sector is by no means all negative**. The margins of open mines and quarries are often kept forested to reduce the visibility and noise of the workings, creating buffer zones where wildlife is protected by default or design. Restored mines and quarries can create wildlife habitats such as wetlands, sometimes with greater biodiversity value than the land use that preceded the mining or quarrying activity. Although in some cases these ecosystem values can be captured through ecosystem markets generating additional revenue to support corporate conservation actions, in most cases companies treat expenditure for restoration as part of the cost of doing business.

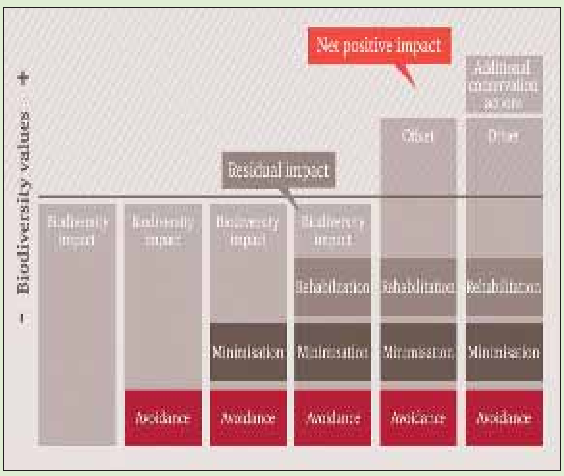
Increasingly, opportunities are available to, and taken up by, the mining and quarrying sector to **compensate for its ecological costs**. The intervention can be direct, through activities to enhance biodiversity in the regions where companies operate, and may include biodiversity offsets or other schemes to mitigate and/or compensate for unavoidable residual impacts (see below). Many environmental organizations are also beginning to see a common interest with the mining and quarrying sector, leading to some unexpected and productive partnerships. The self-interest of the sector is clear: mining and quarrying requires a licence to operate from society, both literally through planning and permitting processes, and in a wider sense through concepts of good corporate citizenship. In the long-term this necessitates giving back to society more than what is being taken in the form of natural capital.

On the conservation side, a profitable industry with the needs and impacts of the mining sector can represent an opportunity to leverage significant funds and human resources for biodiversity conservation. Even if it does not seem very dependent on ecosystem services, the sector has much to lose from the continued degradation of natural capital and the economic and social consequences that go with it.

MINING: DEMONSTRATING VALUES

Valuation of ecosystem services has been used by some mining and quarrying companies to support proposals for expanding production and to guide the rehabilitation of sites once production has finished. For example, in relation to an application to extend an existing quarry into agricultural land in North Yorkshire, **United Kingdom**, Aggregate Industries UK (a subsidiary of Holcim) proposed to create a mix of wetlands for

Figure 3: The concept of Net Positive Impact



Source: Rio Tinto 2008

wildlife habitat as well as a lake for recreational use once extraction is completed. In this case, an economic analysis using benefits transfer methods helped to value the expected changes in ecosystem services. The study concluded that, over 50 years and using a 3% →*discount rate*, the **restored wetland would deliver net benefits** to the community of some US$ 2 million in present value terms, after deducting the costs of restoration and →*opportunity costs*. The benefits were mainly accounted for by biodiversity (US$ 2.6 million), recreation (US$ 663,000) and increased flood storage capacity (US$ 417,000), and **far outweighed the current benefits** provided by agriculture (Olsen and Shannon 2010).

In other cases, **biodiversity valuations have provided arguments against mining**. In the early 1990s, Australia's Reserve Assessment Commission (RAC) investigated the options of either opening up the Kakadu Conservation zone for mining, or combining it with the adjoining Kakadu National Park. To help its deliberation, the commission conducted a contingent valuation study to estimate the economic value of the expected damage to the site should the mining go ahead. The result, based on an average →*willingness to pay* to avoid the damage, valued the area at AU$ 435 million, more than four times the net present value of the proposed mine, put at AU$ 102 million.

The **Australian government rejected the proposal to mine the conservation area** in 1990, although the valuation study was not used as part of the final report of the RAC – perhaps because at the time there was uncertainty about the validity of non-market valuation methods. Nevertheless, the example demonstrates the potential for intangible values of ecosystem services to be measured to some degree, and for such techniques to be used when appraising industrial projects. Such an approach can help firms establish the potential costs of damages, and therefore the risks, associated with their investments. This type of valuation has been used to calculate the level of fines imposed on some polluting companies.

MINING: CAPTURING VALUES AND FINDING SOLUTIONS

As noted above, some damage to ecosystems from mining and quarrying activities is inevitable. In recognition of this, a few companies are exploring concepts such as 'No Net Loss' and 'Net Positive Impact', in which unavoidable, residual biodiversity impacts are offset by conservation activities (usually very close to the impact site), with the aim of being at least equal in value to damages that cannot be avoided.

One business which has taken up **Net Positive Impact on biodiversity** as a long-term goal is the international mining company Rio Tinto, which announced the policy as a voluntary measure in 2004. As can be seen by Figure 3, the first steps in the process are to avoid and minimize negative impacts, and then to rehabilitate areas affected by the company's activities. Once the adverse impacts are reduced as far as possible using these steps, offsetting and additional conservation actions are undertaken as required to achieve a net positive result for biodiversity [B4].

A key step towards achieving Net Positive Impact is the **development of reliable tools to assess and verify the biodiversity impacts** of a company's activities, both positive and negative. In association with several conservation organizations, including the Earthwatch Institute and IUCN, Rio Tinto has begun to test Net Positive Impact in Madagascar, Australia and North America. Other efforts to develop indicators and verification processes to assess business impacts on, and investments in, biodiversity include the Business and Biodiversity Offset Program (BBOP) and the Green Development Mechanism (GDM) initiative[2].

Attempts to rehabilitate damaged sites or offset adverse impacts on biodiversity and ecosystems are sometimes undertaken by companies on a voluntary basis. In addition, **some governments** have introduced incentive mechanisms to **encourage or require mitigation and compensation** for adverse impacts. In a few cases, new markets for ecosystem services or biodiversity 'credits' have been established, in which extractive companies may be both significant buyers and sellers, due to their role as land managers as well as their responsibility for land disturbance.

Wetland Mitigation Banking in the United States was one of the first such systems to be established; it has accumulated considerable experience and has been refined over time. Under this scheme, developers are obliged to compensate for damage to wetlands, either directly or by purchasing credits from third parties, based on the restoration of wetlands in the same watershed. Although the approach is still evolving, the market for US wetland credits is currently estimated to be worth between US$ 1.1 and 1.8 billion annually (Madsen et al. 2010).

Several **Australian states** have introduced similar schemes, whereby disturbance of native vegetation and impacts on species habitats may be compensated by an appropriate offset, generated by active conservation or restoration projects. Examples include the Biobanking scheme introduced in New South Wales in 2008; and the Bushbroker scheme in Victoria, which has so far facilitated more than AU$ 4 million in trades [B5, L8].

Approaches such as Net Positive Impact, wetland mitigation and bio-banking can help **ensure that developers take responsibility** for their environmental footprint, while also seeking **to maintain natural capital**. At the same time, there may be ecological and social limitations to applying biodiversity offsets and other forms of compensatory mitigation, especially where impacts are very large, suitable land for offsets is scarce or mechanisms for community participation are weak.

Mining enterprises may also benefit from the market advantages available for products that can be certified under **social and environmental labelling schemes**. One example is the Chocó region of **Colombia**, a biologically and culturally rich area with soils containing gold and platinum. Fearful of the impact of large-scale mining on fishing, wood extraction and subsistence agriculture, local communities chose not to rent out their lands to mining companies, but instead introduced their own low-impact practices of mineral extraction that do not involve the use of toxic chemicals. The minerals are certified under the FAIRMINED label, giving the communities a premium and additional income while sustaining biodiversity and ecosystem services [L6]. At a larger scale, the Responsible Jewellery Council is working on standards and assurance processes to guarantee the social and environmental performance in the diamond and gold jewellery supply chain, based on third party audits and certification (Hidron 2009; Alliance for Responsible Mining 2010).

3.4 SUMMING UP THE 'TEEB APPROACH'

As illustrated by the examples, the **approach** summarized by TEEB **can be applied in a wide variety of contexts**, with a number of common threads. Using an economic approach to environmental issues can help decision makers to determine the best use of scarce ecological resources at all levels (global, national, regional, local, public, community, private) by:

- **providing information** about benefits (monetary or otherwise, including monetary estimates of non-tangible cultural values) and costs (including →*opportunity costs*);
- **creating a common language** for policymakers, business and society that enables the real value of natural capital, and the flows of services it provides, to become visible and be mainstreamed in decision making;
- **revealing the opportunities to work with nature** by demonstrating where it offers a cost effective means of providing valuable services (e.g. water supply, carbon storage or reduced flood risk);
- **emphasizing the urgency of action** through demonstrating where and when the prevention of biodiversity loss is cheaper than restoration or replacement;
- **generating information about value** for designing policy incentives (to reward the provision of ecosystem services and activities beneficial to the environment, to create markets or level the playing field in existing markets, and to ensure that polluters and resource users pay for their environmental impacts).

This synthesis has emphasized the approach which TEEB hopes to encourage for better management of natural capital. It concludes with a summary of the principle conclusions and recommendations that have emerged from the study.

4 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are directed at a wide range of decision makers and stakeholders, including inter-governmental and other international bodies, national governments, local and regional authorities, business, civil society organizations and the scientific community. For details, please refer to the TEEB report chapters given at the end of each section.

MAKE NATURE'S VALUES VISIBLE

- **Conclusions:** The invisibility of many of nature's services to the economy results in widespread neglect of →*natural capital*, leading to decisions that degrade →*ecosystem services* and →*biodiversity*. The destruction of nature has now reached levels where serious social and economic costs are being felt and will be felt at an accelerating pace if we continue with 'business as usual' [I1-2, N1, B1-2].
- **Recommendations:** Decision makers at all levels should take steps to assess and communicate the role of biodiversity and ecosystem services in economic activity, and for →*human well-being*. Such assessments should include analysis of how the costs and benefits of ecosystem services are spread across different sections of society, across localities, and over time. Public disclosure of and accountability for impacts on nature should be essential outcomes of biodiversity assessment [N1, N3-4, L1, B2-3].

PRICING THE PRICELESS?

- **Conclusions:** Valuing ecosystem services and biodiversity in monetary terms can be complex and controversial [F4-5]. Biodiversity delivers multiple services from local to global levels, while responses to biodiversity loss range from emotional to utilitarian. At the same time, the natural science underpinning many →*economic valuations* remains poorly understood. Nevertheless, both economics and ethics demand more systematic attention to the values of biodiversity and ecosystem services. Substantial progress has been made in valuation methodology and the process should be uncontroversial for many ecosystem services, especially at the local scale. Further guidance is needed on how, in what context, and for what purpose to use which kind of valuation method, illustrated with quality examples, which are increasingly available [F5, N1, L3, B3].
- **Recommendations:** An ecosystem service perspective should inform economic valuations of biodiversity, focusing on how decision makers can include the benefits and costs of conserving or restoring nature in their considerations. Once the relevant ecosystem services have been identified, the context of the decision will determine which methods and what degree of quantification and monetary valuation is appropriate. Drawing on work by TEEB and others, the standards of valuation representing best practice can increasingly be specified for different contexts and applications [F5, N4, L3].

ACCOUNTING FOR RISK AND UNCERTAINTY

- **Conclusions:** While an ecosystem services approach can help to recognize values and may guide management, it does not explain how ecosystems function. There is mounting evidence of the key role of biodiversity in delivering some – but not all – ecosystem services. Biodiversity also contributes to ecosystem →*resilience* – i.e. their ability to continue providing services under changing environmental conditions. Ecosystem resilience provides a kind of 'natural insurance' against potential shocks and losses of ecosystem services. Although difficult to measure, the insurance value of well-functioning ecosystems should be regarded as integral part of their total economic value. A precautionary approach to conserving biodiversity can be very effective in maintaining resilient ecosystems, capable of delivering multiple services on a sustainable basis [F2].

- **Recommendations:** →*Economic valuation* is less useful in situations characterized by non-marginal change, →*radical uncertainty* or ignorance about potential →*tipping points*. In such circumstances, prudent policy should invoke complementary approaches such as the 'safe minimum standard' or the 'precautionary principle' [F5]. Under conditions of uncertainty it is generally advisable to err on the side of caution and conservation [N7, L6].

VALUING THE FUTURE

- **Conclusions:** There is no simple rule for choosing a →*discount rate* to compare present and future costs and benefits. Discount rates reflect our responsibility to future generations and are a matter of ethical choice, our best estimates about technological change and the well-being of people in the future. For example, a 4% discount rate implies that biodiversity loss 50 years from now will be valued at only 1/7 of the same amount of biodiversity loss today. Furthermore, care is needed in the choice of discount rates for different asset classes; reflecting whether they are public or private goods and whether they are manufactured or ecological assets[3]. A strong case can be made for using lower discount rates for →*public goods* and natural/ecological assets. [I, F6]
- **Recommendations:** A variety of →*discount rates*, including zero and negative rates, may be used depending on the nature of the assets being valued, the time period involved, the degree of uncertainty, and the scope of the project or policy being evaluated. Uncertainty does not necessarily justify a higher discount rate. Different discount rates should be used for different types of assets and services, factoring in their nature as public goods or private assets, and also whether they are capable of being manufactured or not (i.e. social discount rates for public goods and natural assets versus market discount rates for private goods and manufactured assets). Presenting a sensitivity analysis of benefit-cost-ratios using a range of different discount rates is always recommended, in order to highlight different ethical perspectives and their implications for future generations. [I, F6]

MEASURING BETTER TO MANAGE BETTER

- **Conclusions:** Natural resources are economic assets, whether or not they enter the marketplace. However, conventional measures of national economic performance and wealth, such as GDP and Standard National Accounts, fail to reflect →*natural capital* stocks or flows of ecosystem services, contributing to the economic invisibility of nature [N3].
- **Recommendations:** The present system of national accounts should be rapidly upgraded to include the value of changes in natural capital stocks and ecosystem services. Such a shift could be supported, in part, through amendments to the UN manual on Integrated Environmental and Economic Accounting. Governments should also develop a 'dashboard' of indicators to monitor changes to physical, natural, human, and social capital as an ongoing effort [F3, N3]. Moreover, an urgent priority is to draw up consistent physical accounts for forest stocks and ecosystem services, both of which are required, e.g. for the development of new forest carbon mechanisms and →*incentives* [N5].

NATURAL CAPITAL AND POVERTY REDUCTION

- **Conclusions:** Poverty is a complex phenomenon and the relationship between poverty and biodiversity is not always clear-cut. In many countries poor households rely on →*natural capital* for a disproportionately large fraction of their income (e.g. in agriculture, forestry, fisheries) [N3]. Moreover these households have few means to cope with losses of critical ecosystem services, such as drinking water purification or protection from natural hazards. Sustainable management of natural capital is thus a key element to achieving poverty reduction objectives as reflected in the Millennium Development Goals [I2, L1].
- **Recommendations:** Human dependence on ecosystem services and particularly their role as a lifeline for many poor households needs to be more

fully integrated into policy. This applies both to targeting development interventions as well as to evaluating the social impacts of policies that affect the environment. How do policies directly and indirectly influence future availability and distribution of ecosystem services? This is not only a matter of applying appropriate indicators and analytical tools it also requires acting upon these insights [N2,3, L1,10]. In order to secure equitable access and maintain the flow of →*public goods* provided by nature, private, public and common property rights need to be carefully balanced [L10]. Given this, public investment as well as development aid targeted at maintaining or rebuilding →*ecological infrastructure* can make significant contributions to poverty reduction [N9, L5].

BEYOND THE BOTTOM LINE – DISCLOSURE AND COMPENSATION

- **Conclusions:** Better accounting of business impacts and dependence on biodiversity and ecosystem services – direct and indirect, positive and negative – is essential to spur needed change in business investment and operations [B2]. Current accountancy rules, purchasing policies and reporting standards do not consistently require attention to environmental externalities – including social costs due to impacts on ecosystems and biodiversity. Integrating biodiversity and ecosystem services into product value chains can, however, generate significant cost savings and new revenues, as well as improved business reputation and licence to operate [B3-5].
- **Recommendations:** The annual reports and accounts of business and other organizations should disclose all major externalities, including environmental liabilities and changes in natural assets not currently included in the statutory accounts [B3]. Methodologies, metrics and standards for sustainable management and integrated accounting of biodiversity and ecosystem services should be developed as a priority by national and international accounting bodies, working in cooperation with the conservation community and other stakeholders. The principles of 'No Net Loss' or 'Net Positive Impact' should be considered as normal business practice, using robust biodiversity performance benchmarks and assurance processes to avoid and mitigate damage, together with pro-biodiversity investment to compensate for adverse impacts that cannot be avoided [B4].

CHANGING THE INCENTIVES

- **Conclusions:** →*Economic incentives* including market prices, taxes, subsidies and other signals play a major role in influencing the use of →*natural capital* [N5-7]. In most countries, these market signals do not take account of the full value of ecosystem services; moreover, some of them unintentionally have negative side effects on natural capital. Reforming and redirecting environmentally harmful subsidies in such areas as fossil fuels, agriculture, fisheries, transport and water could provide significant benefits for nature as well as for government budgets [N6].
- **Recommendations:** The principles of 'polluter pays' and 'full-cost-recovery' are powerful guidelines for the realignment of →*incentive* structures and fiscal reform. In some contexts, the principle of 'beneficiary pays' can be invoked to support new positive incentives such as payments for ecosystem services, tax breaks and other fiscal transfers that aim to encourage private and public sector actors to provide ecosystem services [N5, N7, L8]. Reform of property rights, liability regimes, consumer information and other measures can also stimulate private investment in conservation and sustainable use [N2,7, L9]. As a first step, all governments should aim for full disclosure of subsidies, measuring and reporting them annually in order that their perverse components may be recognized, tracked and eventually phased out [N6].

PROTECTED AREAS OFFER VALUE FOR MONEY

- **Conclusions:** Some 12% of the Earth's land surface is covered by protected areas; however, marine protected areas are still relatively rare. Moreover, a significant proportion of terrestrial protected areas are not managed effectively. According to a range of studies, the costs of setting up and managing protected areas, including the →*opportunity costs* incurred by foregoing economic activity, are commonly far outweighed by the value of ecosystem services provided by such areas. However, many of the benefits of protected areas are enjoyed far away or far into the future (e.g. carbon storage), while costs tend to be local and immediate [N8, L7].

- **Recommendations:** The establishment of comprehensive, representative, effective and equitably managed systems of national and regional protected areas should be pursued (especially in the high-seas) in order to conserve biodiversity and maintain a wide range of ecosystem services. Ecosystem →*valuation* can help to justify protected areas policy, identify funding and investment opportunities, and inform conservation priorities. [N8, L7].

ECOLOGICAL INFRASTRUCTURE AND CLIMATE CHANGE

- **Conclusions:** Investing in →*ecological infrastructure* often makes economic sense when the full range of benefits is taken into account. Maintaining, restoring or enhancing services provided by ecosystems, such as mangroves, other wetlands and forest watersheds often compare very favourably with alternative man-made infrastructure, such as wastewater treatment plants or dykes. While it is usually cheaper to avoid degradation than to pay for ecological restoration, there are, nonetheless, many cases in which the benefits from restoring degraded ecosystems far outweigh the costs. Such restoration projects could become increasingly important as a means of adapting to climate change [C, N9, L5]. Likewise, reducing emissions from deforestation and forest degradation (REDD-Plus) represents an important opportunity to limit the scale and impacts of climate change, with a wide range of additional benefits for biodiversity and people [N5].
- **Recommendations:** Ecosystem conservation and restoration should be regarded as a viable investment option in support of a range of policy goals including food security, urban development, water purification and wastewater treatment, regional development, as well as climate change mitigation and adaptation [N9]. Within the UNFCCC process, REDD-Plus should be prioritized for accelerated implementation, beginning with pilot projects and efforts to strengthen capacity in developing countries to help them establish credible systems of monitoring and verification that will allow for the full deployment of the instrument [C, N5].

MAINSTREAMING THE ECONOMICS OF NATURE

- **Conclusions:** Failure to incorporate the values of ecosystem services and biodiversity into economic decision making has resulted in the perpetuation of investments and activities that degrade →*natural capital*. Including the full value of biodiversity and ecosystem services in decision making can be achieved if their sustainable management is recognized as an economic opportunity rather than as a constraint on development [N2, L1,10, B5].
- **Recommendations:** Demonstrating the full range of ecosystem service values can help to increase awareness and commitment to sustainable management of biodiversity. Mainstreaming these values requires that →*natural capital* is considered routinely in:
  - economic, trade and development policies, for example by integrating biodiversity and ecosystem services in the impact assessments for new legislation, agreements and investment [N3,4],
  - transport, energy and mining activities, for examle by taking account of the value of nature in legislation, infrastructure investments and in permitting, inspection and enforcement [N4, L6, B4],
  - agriculture, fisheries, forestry practices, for example by integrating the value of biodiversity (or the costs of its loss) into reviews and reform of existing policies and instruments [N5-7, L5]
  - corporate strategies and operations, for example in business financial and Corporate-Social-Responsibility management and reporting [B3, B6],
  - development policies and planning at local, regional and national levels [N4, L4-6], and
  - public procurement and private consumption, for example via further developing certification and eco-labelling approaches [N5, L9]

The TEEB study makes the case for significant changes in the way we manage nature, based on economic concepts and tools. It calls for wider recognition of nature's contribution to human livelihoods, health, security, and culture by decision makers at all levels (national and local policy makers, administrators, businesses and citizens). It promotes the demonstration and (where appropriate) the capture of the economic values of nature's services through an array of policy instruments and mechanisms, some of which are market-based.

The issue facing us is how to ensure nature's capacity to continue providing these benefits in the face of widespread pressures. Ignoring biodiversity and persisting with conventional approaches to wealth creation and development is a risky strategy and ultimately self-defeating if it means losing the benefits that biodiversity provides, including most critically to the livelihoods of poor people.

National policy makers, local administrators, businesses and consumers each have an important role to play in responding to the recommendations set out in the TEEB reports. Taking the steps outlined in TEEB will help ensure that the economics of nature and its valuable services become more visible. By making this transformative journey, a compelling and successful rationale will emerge for the conservation and sustainable use of the living fabric of this planet – its ecosystems, its biodiversity.

Vision: Making Nature Economically Visible

Biodiversity in all its dimensions – the quality, quantity and diversity of ecosystems, species and genes – needs to be preserved not only for societal, ethical or religious reasons but also for the economic benefits it provides to present and future generations. We should aim to become a society that recognizes, measures, manages and economically rewards responsible stewardship of its natural capital.

"Another world is not only possible, she is on her way. On a quiet day, I can hear her breathing"

(Arundhati Roy, author of The God of Small Things, at the World Social Forum 2003)

Photographs by NASA and André Künzelmann, UFZ, composition by Susan Walter, UFZ

ENDNOTES

[1] The G8+5 includes the heads of government from the G8 nations (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States), plus the heads of government of five emerging economies (Brazil, China, India, Mexico and South Africa).

[2] For more information see: http://bbop.forest-trends.org/ and http://gdm.earthmind.net

[3] It has long been argued (e.g. Krutilla 1967) that when evaluating trade-offs between natural and man-made assets, it is acceptable to use different discount rates, on the grounds that technological advances may not enable us to 'manufacture' ecosystems and their services, unlike industrial goods.

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ANNEX 1: GLOSSARY

Biodiversity: the variability among living organisms, including terrestrial, marine, and other aquatic ecosystems. Biodiversity includes diversity within species, between species, and between ecosystems.

Biome: a large geographic region, characterized by life forms that develop in response to relatively uniform climatic conditions. Examples are tropical rain forest, savannah, desert, tundra.

Critical natural capital: describes the part of the natural capital that is irreplaceable for the functioning of the ecosystem, and hence for the provision of its services.

Discount rate: a rate used to determine the present value of future benefits.

Direct-use value (of ecosystems): the benefits derived from the services provided by an ecosystem that are used directly by an economic agent. These include consumptive uses (e.g. harvesting goods) and non-consumptive uses (e.g. enjoyment of scenic beauty).

Driver (direct or indirect): any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.

Ecological infrastructure: a concept referring to both services by natural ecosystems (e.g. storm protection by mangroves and coral reefs or water purification by forests and wetlands), and to nature within man-made ecosystems (e.g. microclimate regulation by urban parks).

Ecosystem services: the direct and indirect contributions of ecosystems to human well-being. The concept 'ecosystem goods and services' is synonymous with ecosystem services.

Existence value: the value that individuals place on knowing that a resource exists, even if they never use that resource (also sometimes known as conservation value or passive use value).

Human well-being: concept prominently used in the Millennium Ecosystem Assessment – it describes elements largely agreed to constitute 'a good life', including basic material goods, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience.

Incentives (disincentives), economic: a material reward (or punishment) in return for acting in a particular way which is beneficial (or harmful) to a set goal.

Indirect-use value (of ecosystems): the benefits derived from the goods and services provided by an ecosystem that are used indirectly by an economic agent. For example, the purification of drinking water filtered by soils.

Natural capital: an economic metaphor for the limited stocks of physical and biological resources found on earth, and of the limited capacity of ecosystems to provide ecosystem services.

Non-use value: benefits which do not arise from direct or indirect use.

Opportunity costs: foregone benefits of not using land/ecosystems in a different way, e.g. the potential income from agriculture when conserving a forest.

Public goods: a good or service in which the benefit received by any one party does not diminish the availability of the benefits to others, and where access to the good cannot be restricted.

Radical uncertainty: describes situations where the range of potential consequences of an action is unknown, as opposed to the uncertainty about whether a known (possible) consequence will happen.

Resilience (of ecosystems): their ability to function and provide critical ecosystem services under changing conditions.

Threshold/tipping point: a point or level at which ecosystems change, sometimes irreversibly, to a significantly different state, seriously affecting their capacity to deliver certain ecosystem services.

Total economic value (TEV): a framework for considering various constituents of value, including direct use value, indirect use value, option value, quasi-option value, and existence value.

Trade-offs: a choice that involves losing one quality or service (of an ecosystem) in return for gaining another quality or service. Many decisions affecting ecosystems involve trade-offs, sometimes mainly in the long term.

Valuation, economic: the process of estimating a value for a particular good or service in a certain context in monetary terms.

Willingness-to-pay (WTP): estimate of the amount people are prepared to pay in exchange for a certain state or good for which there is normally no market price (e.g. WTP for protection of an endangered species).

ANNEX 2: WHAT ARE ECOSYSTEM SERVICES

Provisioning Services are ecosystem services that describe the material outputs from ecosystems. They include food, water and other resources.

Food: Ecosystems provide the conditions for growing food – in wild habitats and in managed agro-ecosystems.
Raw materials: Ecosystems provide a great diversity of materials for construction and fuel.
Fresh water: Ecosystems provide surface and groundwater.
Medicinal resources: Many plants are used as traditional medicines and as input for the pharmaceutical industry.

Regulating Services are the services that ecosystems provide by acting as regulators eg regulating the quality of air and soil or by providing flood and disease control.

Local climate and air quality regulation: Trees provide shade and remove pollutants from the atmosphere. Forests influence rainfall.
Carbon sequestration and storage: As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.
Moderation of extreme events: Ecosystems and living organisms create buffers against natural hazards such as floods, storms, and landslides.
Waste-water treatment: Micro-organisms in soil and in wetlands decompose human and animal waste, as well as many pollutants.
Erosion prevention and maintenance of soil fertility: Soil erosion is a key factor in the process of land degradation and desertification.
Pollination: Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee.
Biological control: Ecosystems are important for regulating pests and vector borne diseases.

Habitat or Supporting Services underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.

Habitats for species: Habitats provide everything that an individual plant or animal needs to survive. Migratory species need habitats along their migrating routes.
Maintenance of genetic diversity: Genetic diversity distinguishes different breeds or races, providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock.

Cultural Services include the non-material benefits people obtain from contact with ecosystems. They´include aesthetic, spiritual and psychological benefits.

Recreation and mental and physical health: The role of natural landscapes and urban green space for maintaining mental and physical health is increasingly being recognized.
Tourism: Nature tourism provides considerable economic benefits and is a vital source of income for many countries.
Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and appreciation of the natural environment have been intimately related throughout human history.
Spiritual experience and sense of place: Nature is a common element of all major religions; natural landscapes also form local identity and sense of belonging.

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