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.

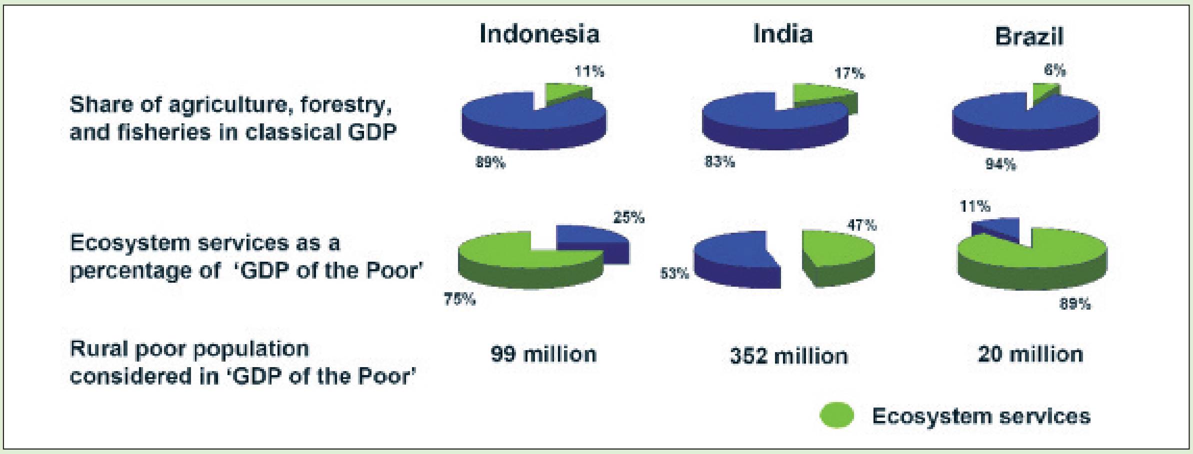
FORESTS: IDENTIFYING ISSUES AND ASSESSING SERVICES

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

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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.

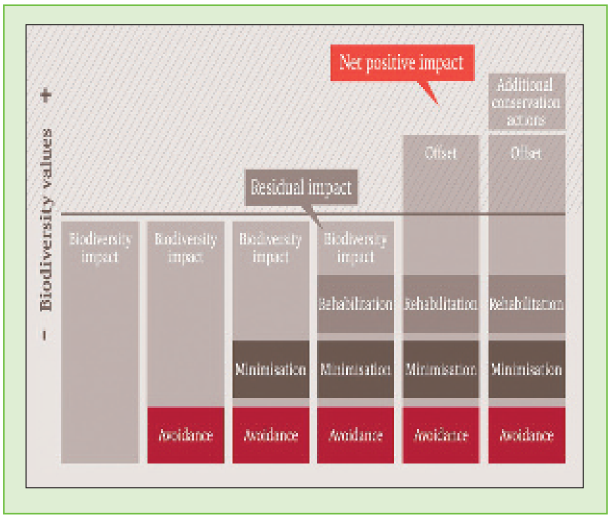
Increasingly, opportunities are available to, and taken up by, the mining and quarrying sector to **compensate for its ecological costs**. The intervention can be direct, through activities to enhance biodiversity in the regions where companies operate, and may include biodiversity offsets or other schemes 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.