THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY

TEEB for National and International Policy Makers

Chapter 3: Strengthening indicators and accounting systems for natural capital

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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY
TEEB for National and International Policy Makers

Chapter 3

Strengthening indicators and accounting systems for natural capital

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Key Messages of Chapter 3

Ecosystems and biodiversity are our stock of 'Natural Capital' – they lead to a flow of benefits that support societal and individual well-being and economic prosperity. We do not measure this capital effectively enough to ensure its proper management and stewardship. Without effective monitoring we will not understand the scale of the challenge or the nature of the response. Indicators feed into aggregate measures and are an integral component of accounting systems. Without suitable indicators or accounting, we lack a solid evidence base for informed policy decisions.

We already have a large amount of existing data, indicators and methods for accounting; there is huge potential for progress. What we lack is an implementation mechanism that makes best use of and produces maximum results from available information to feed into global discussions. A science-policy interface is essential for such implementation and could be provided through the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). In support of this process, the following improvements are urgently needed:

Improving the measurement and monitoring of biodiversity and ecosystem services

Headline indicators are needed now to set and monitor specific, measurable, achievable, realistic and time-specific (SMART) biodiversity and ecosystem services targets. These indicators should address the status of phylogenetic diversity (genetic diversity between species), species' populations, species' extinction risk, the quantity and ecological condition of ecosystems/biotopes and flows in related benefits. The status indicators should be part of an interlinked framework of driver, pressure, state, impact and response indicators.

More field data are required from biodiversity-rich countries. Some monitoring can be carried out by remote sensing (e.g. for deforestation) but more ground surveys are required (e.g. for degradation). Data are vital not just for monitoring but also for economic evaluation and designing effective policy instruments, particularly for defining 'baselines' and taking informed decisions. A select dashboard of indicators needs to be developed for policy makers and the public that takes biodiversity into account.

More effort is needed especially to develop indicators of ecosystem services. Further research is urgently required to improve understanding of and develop better indicators on the link between biodiversity and ecosystem condition and the provision of ecosystems services. However, the need for research should not prevent the selection and use in the short term of headline indicators for biodiversity and ecosystem services targets that can be refined later.

Better macro-economic and societal indicators

More effort is needed to use macro-indicators that take natural capital into account. The ecological footprint is a valuable concept for policy objectives and communication. The EU's Beyond GDP process is piloting an environmental index for use alongside GDP and launching macro indicators to communicate key issues on sustainable development. The Stiglitz-Sen-Fitoussi Commission on the Measurement of Economic Performance and Social Progress supports indicators and the need for well-being measurement in macro-economic policy and sustainable development.

Adjusted Income and Consumption aggregates reflecting **under-investment** in ecosystem maintenance and **over-consumption** of natural resource and ecosystem services should be introduced as international standards in the core set of headline macro-economic aggregates, alongside conventional GDP, National Income and Final Consumption. To be effective and efficient in budgetary and public debates, these need to be computed and published at the same date as conventional indicators, i.e. in relation to fiscal year deadlines.

More Comprehensive National Income Accounting

National accounts need to take the wider issues of natural capital into account, including well-being and sustainability dimensions. The 2003 UN System of Economic Environmental Accounting (SEEA) manual upgrade needs to be completed rapidly to include physical accounts for ecosystem stocks, degradation and services as well as valuation rules. Natural capital accounts should be developed to take the full set of ecosystem services (private or common-pool economic resources as well as public goods) into account.

Towards GDP of the Poor

The rural poor are the most vulnerable to loss of biodiversity and ecosystem services. Appropriate policies require an understanding of this link and ways to measure the importance of such services to incomes and livelihoods. Measuring the GDP of the Poor can clarify current dependence and risks to poverty, development and MDGs from losses of natural capital.

3 Strengthening indicators and accounting systems for natural capital

"The welfare of a nation can scarcely be inferred from a measurement of national income".

Simon Kuznets, principle architect of the GDP concept, in 1934.

In 1962, he added

"Distinctions must be kept in mind between quantity and quality of growth, between its costs and return, and between the short and the long term. Goals for more growth should specify more growth of what and for what."

Chapter 3 highlights the importance of measurement of ecosystems and biodiversity for the proper stewardship of our 'natural capital'. **3.1** introduces the key issues, underlining the predominance of GDP and economic measurement in political decisions, and argues that this needs to be complemented by other measures. **3.2** looks at useful types of measurement – e.g. in the policy cycle, where they help develop and communicate an understanding of the relationship between drivers and effect – and then in more depth at the role of biodiversity indicators and tools for measuring ecosystem services. **3.3** shows how such indicators feed into mainstream economic aggregates: it focuses on macro and societal indicators and indices to 'measure the true wealth of nations', comparing traditional tools with available equivalent indicators that take nature into account. **3.4** presents indicators and aggregate measures as an integral component of accounts: it explains the current System of National Accounts and shows what can usefully be done to improve its ability to measure nature systematically in a national framework. **3.5** completes the picture by discussing ways to better measure the social dimension – by looking at 'GDP of the Poor'.

3.1 WHAT MEASUREMENT PROBLEMS DO WE FACE?

"No one would look just at a firm's revenues to assess how well it was doing. Far more relevant is the balance sheet, which shows assets and liability. That is also true for a country."

Joseph Stiglitz, 2005 in Foreign Affairs

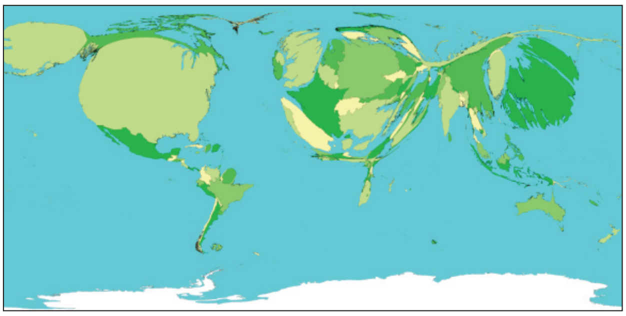
Newspapers, political speeches and policy decisions have until recently tended to focus on GDP growth, job losses/unemployment, trade issues and financial markets. Reporting on these issues is helped by the existence of accepted, timely and aggregated data. Despite their importance, it is increasingly recognised that such issues are only part of the picture. We also need to take account of our 'ecological footprint' – to measure how human demands on natural capital stocks (including ecosystems and biodiversity) affect the flows of ecosystem services which contribute to human well-being at all levels.

We measure economic transactions and assets through the System of National Accounts (SNA) which provides much used aggregated indicators such as GDP (United Nations 1968; United Nations et al. 2003). The SNA has evolved over time and is well respected for its core purposes. However, our valued **natural capital is almost totally excluded from these accounts and its depreciation is not reflected in the macro-economic aggregates used by policy makers or discussed in the press**. This means that fish stock losses, forest degradation, pollution and overuse of aquifers and species/habitat losses have little or no visibility in national accounting systems.

This lack of measurement and lack of reporting undermines efforts to ensure the future availability of resources. In particular, it means that public and political awareness of the status of and threats to ecosystem services is relatively poor. **This feeds into a lack of informed public discussion on what to do, where and by whom.**

If we don't know what we have, how can policy hope to manage it? Changes in our natural capital stock are important to understand because they affect the flow of goods and services from nature. Taking fisheries as an example, the catch that can be landed in a year is not just a function of effort and fishing fleet capacity, but also depends on the size of available fish stocks and on the status of each level of the fisheries' food chain. This information is increasingly understood for fish as a resource but still tends to be only half taken into account in fisheries quotas, subsidies, monitoring and enforcement. The same applies to genetic diversity of crops which is critical to long-term food security. In situations where there is low understanding even of basic information on natural capital stock and its changes (e.g. for functions of some marine ecosystems), the chance of an appropriate policy response is slighter still.

The current emphasis on 'evidence-based policy making' will be held back if we lack information on what is happening to our natural capital stock (see 3.2). TEEB therefore aims to offer new information on measuring the value of the nature we manage in order to help policy makers.



Map of the world according to the nations GDP

Copyright: Mark Newman, Department of Physics and Center for the Study of Complex Systems, University of Michigan. URL: http://www-personal.umich.edu/~mejn/cartograms/gdp1024x512.png

3.2 IMPROVING MEASUREMENT OF BIO-DIVERSITY AND ECOSYSTEM SERVICES

3.2.1 WHAT ROLE DO INDICATORS PLAY?

"Indicators arise from values (we measure what we care about) and they create values (we care about what we measure)"

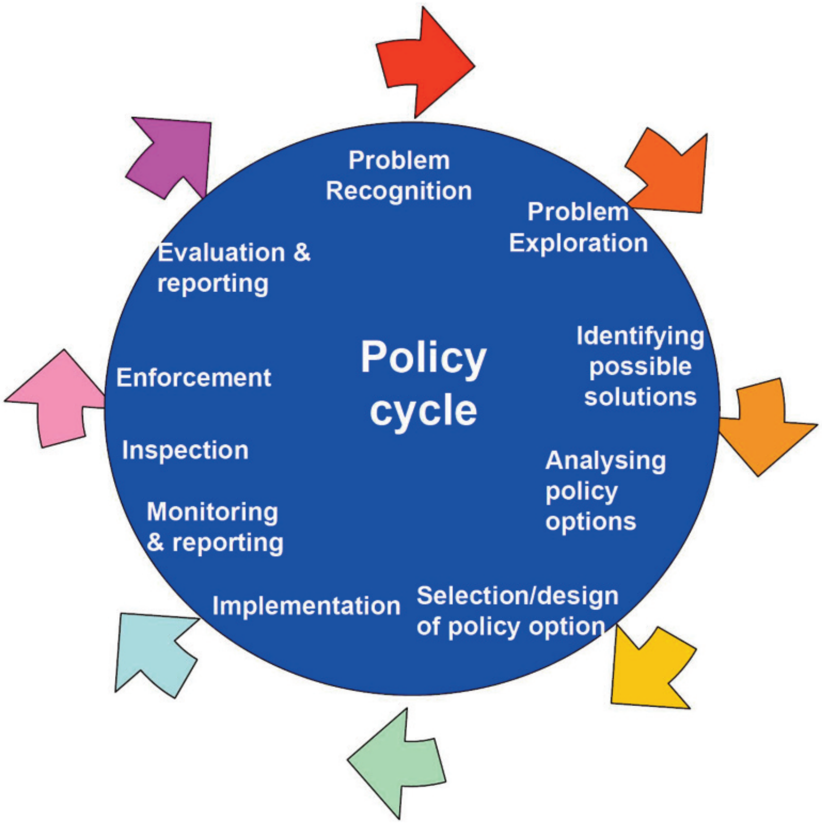
Meadows D. 1998

'Indicators'[1] **produce a manageable amount of meaningful information by summarising, focusing and condensing it** (Godfrey and Todd 2001).

Considering the huge complexity of biodiversity, its multi-faceted benefits for human well-being and the complicated interlinkages between the two, it is not an easy task to develop a commonly agreed set of indicators. Nevertheless, this task is vital because relevant indicators can play a decisive role in:

- helping decision makers and the public at large to understand status/condition and trends related to biodiversity and the ecosystem services it provides (e.g. which habitats/species and ecosystem services are in danger of being lost or damaged);

Figure 3.1: The policy cycle



Source: own representation, Patrick ten Brink

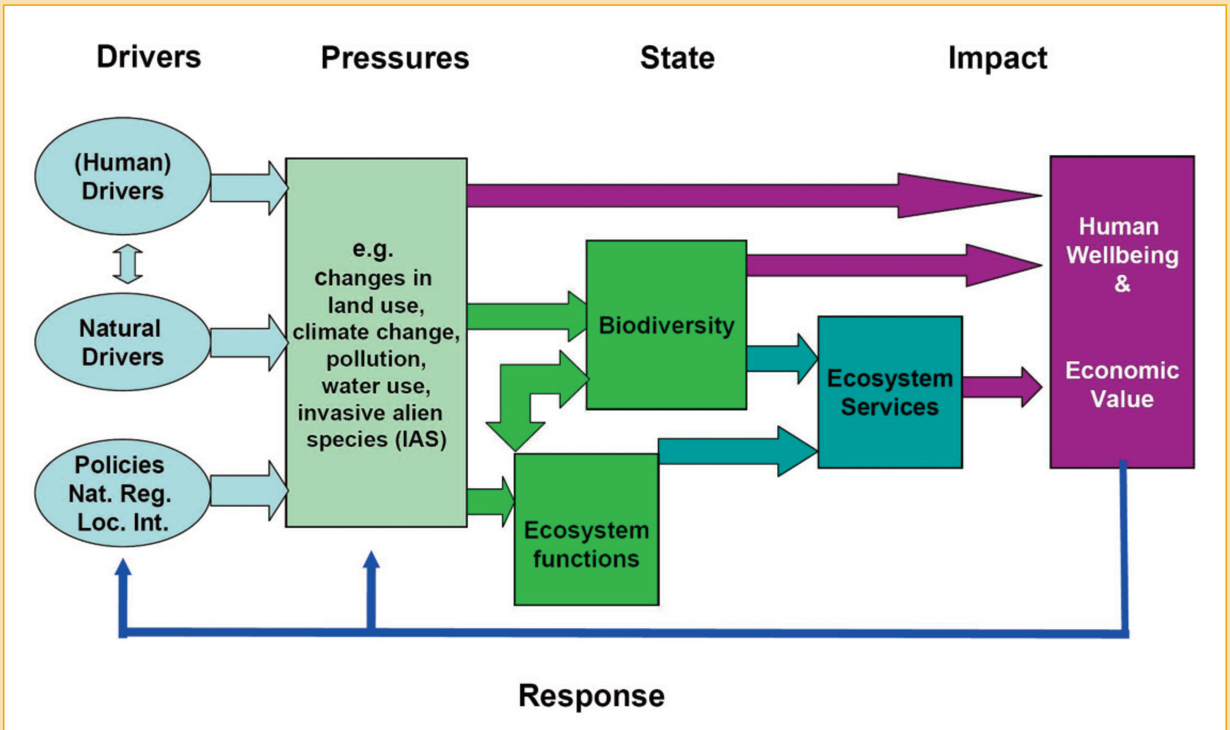
- clarifying the consequences of action or inaction for human well-being by measuring our progress and the efficiency of measures we take (e.g. whether a subsidy actually helps fish stocks to recover; and
- benchmarking and monitoring performance in relation to defined targets and communicating whether, when and by whom targets are met (e.g. whether deforestation rates are slowed by the use of the instrument REDD, see Chapter 5).

Biodiversity and ecosystem service indicators can be useful for these purposes across different sectors and at different stages of the policy cycle. They can be applied to: problem recognition (e.g. endangered habitats and loss of ecosystem services); identification of solutions (e.g. favourable conservation status and necessary management activities); assessing and identifying linkages between policy options (e.g. investment in protected areas, green infrastructure); the implementation process (e.g. reforming subsidies, payment for ecosystem services); and ongoing monitoring and evaluation (e.g. status and trends). Figure 3.1 shows how indicators feed into the iterative policy cycle.

To make full use of their potential, indicators need to be part of an analysis framework that addresses functional relationships between nature and human well-being. The DPSIR approach (see Figure 3.2 below) can be a useful basis for such a framework, making it possible to characterise/measure driving forces (e.g. population growth, consumption and production patterns), pressures (e.g. intensive agriculture, climate change) on biodiversity state and ecosystem functions, their impact on the delivery of related ecosystem services and subsequently on human well-being and, finally, the (policy) response.

We also need indicators to consider 'tipping points' or 'critical thresholds' i.e. the point at which a habitat or a species is lost and the provision of an ecosystem service is therefore compromised. Used in this way, indicators can function as an early warning system to effectively communicate the urgency of targeted action. Table 3.1 demonstrates how indicators can be applied to the fisheries sector to reveal the link between sustainable catch, stock resilience and minimum viable stock thresholds.

Figure 3.2: Drivers, Pressures, Status, Impact and Responses (DPSIR)



Source: adapted by Chapter 3 authors from Braat and ten Brink 2008

Table 3.1: Thresholds and responses in the fisheries sector

Thresholds	**Examples**
Natural critical thresholds	• Minimum population levels for stock viability (e.g. fish) • Salination of water bodies (freshwaters becoming salty) • Minimum oxygen levels in water for species viability • Minimum habitat area for species survival • Ocean acidity levels and species viability • Absorptive capacity of ecosystem (beyond which damage occurs)
Scientifically-established critical thresholds	*Scientific assessment of the above, and* • Maximum sustainable yield (MSY) • Maximum fleet capacity
Responses	**Examples**
Political responses	• Commitment to significantly reducing the rate of biodiversity loss • Commitment to sustainable use of marine ecosystems • Commitment to achieving good ecological status of ecosystem
Legal responses *(creating legal thresholds) Stakeholder responses*	• Catch quotas, catch sizes e.g. Total Allowable Catch (TAC) • Emission limit values: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), SO_2 • Designation of marine protected areas and no-take zones
Stakeholder responses	• Protection of the value of the marine environment i.e. natural and cultural resource protection • Agreed management practices to work within sustainable take levels

Source: adapted from ten Brink et al. 2008

The effectiveness of indicators is influenced by the presentation of the information they generate. Maps can be critical tools – not only for communication with the public but also to identify problems and solutions. They provide a powerful instrument to communicate information spatially and can thus form the basis for targeting policy measures. For example, information contained in and shared through a map can help identify:

- who creates benefits associated with biodiversity and should therefore be eligible to receive a Payment for Ecosystem Services;
- who benefits from these ecosystem services and should therefore contribute to payments to secure the future provision of such services (see Chapter 5 on PES).

However, indicators are not a panacea – whether for biodiversity and ecosystem services or in any other field. They have to be used bearing in mind their limitations and risks (see Box 3.1). These include the risk of misinterpretation due to condensing of information, the challenge of data quality and limitations in clearly capturing causality.

Box 3.1: Keeping indicators in perspective

"Indicators only indicate; they do not explain. Determining that change has occurred does not [always] tell the story of why it has occurred. Indicators constitute only one part of the logical and substantive analysis needed […]. The use of indicators can be made into an elaborate science. Using a large number of different indicators, however, has no merit in itself. The key to good indicators is credibility – not volume of data or precision in measurement. A quantitative observation is no more inherently objective than a qualitative observation. Large volumes of data can confuse rather than bring focus. It is more helpful to have approximate answers to a few important questions than to have exact answers to many unimportant questions."

Source: UNDP 2002

3.2.2 WHAT SHOULD BIODIVERSITY INDICATORS MEASURE?

It is becoming obvious that we urgently need to better understand what is happening to biodiversity in order to conserve and manage ecosystem services effectively. All ecosystem services are underpinned by biodiversity and there is good evidence that biodiversity losses can have substantial impacts on such services. For example, the loss of functional groups of species can negatively affect overall ecosystem resilience (see also TEEB D0 Chapter 2, Folke et al. 2004), restoration of biodiversity can greatly enhance ecosystem productivity (Worm et al. 2008) and regions of high priority for biodiversity conservation can also provide valuable ecosystem services (Turner et al. 2007).

More comprehensive and representative measures and monitoring are needed for biodiversity as a whole, without prejudice to current efforts to develop and monitor specific ecosystem service indicators (see 3.2.4 and TEEB D0 Chapter 3). It is critical that these cover the three principal components of biodiversity (genes, species and ecosystems) in terms of their quantity, diversity and ecological condition ('quality'). Concentrating only on selected components that we currently consider to be of particular value is risky: ecological processes are too complex and interlinked and present too many unknowns for us to do this without risking grave damage to ecosystem services and wider aspects of biodiversity. The big picture is vital to keeping future options open – and this clearly depends on maintaining the full range of biodiversity. "To keep every cog and wheel", wrote Aldo Leopold, "is the first precaution of intelligent tinkering" (Leopold 1953).

In practice, even if the importance of measuring and monitoring biodiversity has been long recognised, most effort has focused on species of high conservation concern to provide evidence of ongoing losses and thereby prompt actions by politicians and wider society. This approach has produced enough data to provide status assessments of some of the better-known taxa groups and led to regular publication of lists of globally threatened species according to standardised IUCN Red List criteria (IUCN 2001). It has also supported assessments of some species and habitats threatened at regional and national levels. However, we still have only an incomplete picture of the status of many taxa groups across the world.

Through various multilateral environmental agreements, including the Ramsar Convention on Wetlands, the CBD and the Convention on Migratory Species, targets have been agreed for conserving biodiversity. Most notably, CBD Parties committed themselves in April 2002 to achieve by 2010 a significant reduction in the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth. This target was endorsed by the World Summit on Sustainable Development (WSSD) and the United Nations General Assembly and incorporated within the Millennium Development Goals. Similar targets were adopted in other regions: the EU adopted a more ambitious target of halting the decline of biodiversity in the EU by 2010 and restoring habitats and natural systems.

Setting targets has been a bold and extremely important step towards halting biodiversity loss, but it is now clear that the CBD and EU targets will not be met (for the latter, see European Commission 2008a). These failures may be partly because the targets did not explicitly define measures of biodiversity by which they could be monitored, undermining their usefulness in terms of accountability. More broadly, biodiversity monitoring is insufficient in most parts of the world and for most taxa groups to reliably measure progress towards targets (or key pressures or effectiveness of responses). In practice, assessing biodiversity trends presents significant challenges as it needs to cover a wide variety of features. Given the complexity of biodiversity, targets need to relate to a set of inter-related indicators rather than individual indicators.

In 2004, the CBD Conference of the Parties agreed on a provisional list of global headline indicators to assess progress at the global level towards the 2010 target (Decision VII/30) and to effectively communicate trends in biodiversity related to the Convention's three objectives (see Table 3.2). The more recent Decision VIII/15 (2006) distinguished between indicators considered ready for immediate testing and use and those requiring more work. A similar and linked process of indicator development has also been undertaken in the EU (EEA 2007).

For reasons of necessity and practicality, the CBD indicators tend to rely on existing datasets rather than identifying future needs and devising appropriate monitoring programmes. This approach of adopting, adapting and supplementing existing data brings inevitable compromises (Balmford et al. 2005; Dobson 2005; Mace and Baillie 2007). As a result of these data constraints, and in the interests of balance, most indicators identified in the CBD process relate to pressures rather than to the actual status of biodiversity.

In July 2009, an International Expert Workshop on the 2010 Biodiversity Indicators and Post-2010 Indicator Development[2] concluded that "the current indicator set is incomplete in a number of areas; e.g. wild genetic resources, ecosystem quality, ecosystem services, sustainable use, human well-being, access and benefit sharing and indigenous local knowledge, and both threats and responses more broadly" (UNEP-WCMC 2009). Similar conclusions were reached in a review of the EU biodiversity indicator set (Mace and Baillie 2007).

From a TEEB perspective, the gaps relating to genetic diversity, the quality of ecosystems (i.e. their ecological condition) and ecosystem services are of particular concern (see also TEEB D0 Chapter 3). We outline requirements for the first two below and consider ecosystem service indicators in more detail in section 3.2.4.

Table 3.2: Indicators for assessing progress towards the 2010 biodiversity target

Indicators considered ready for immediate testing use **are bold**;
indicators confirmed as requiring more work are *in italic* and placed in parentheses.

Focal area	**Indicator**
Status and trends of the components of biological diversity	**Trends in extent of selected biomes, ecosystems, and habitats** **Trends in abundance and distribution of selected species** **Coverage of protected areas** **Change in status of threatened species** **Trends in genetic diversity of domesticated animals, cultivated plants and fish species of major socio-economic importance**
Sustainable use	**Area of forest, agricultural and aquaculture ecosystems under sustainable management** *(Proportion of products derived from sustainable sources)* *(Ecological footprint and related concepts)*
Threats to biodiversity	**Nitrogen deposition** **Trends in invasive alien species**
Ecosystem integrity and ecosystem goods and services	**Marine Trophic Index** **Water quality of freshwater ecosystems** *(Trophic integrity of other ecosystems)* **Connectivity/fragmentation of ecosystems** (Incidence of human-induced ecosystem failure) (Health and well-being of communities who depend directly on local ecosystem goods and services) (Biodiversity for food and medicine)
Status of traditional knowledge, innovations and Practices	**Status and trends of linguistic diversity and numbers of speakers of indigenous languages** *(Other indicators of status of indigenous and traditional knowledge)*
Status of access and benefit-sharing	*(Indicator of access and benefit-sharing)*
Status of resource transfers	**Official development assistance provided in support of the Convention** *(Indicator of technology transfer)*

Source: CBD 2009

Monitoring of genetic diversity in wild species would be especially valuable with respect to its linkage to ecosystem services (such as the potential provision of new drugs). As genetic material is the raw material upon which natural selection and selective breeding acts, it is fundamental to enabling adaptation to environmental change (e.g. climate change) and longer-term evolution. However, information on **genetic diversity within species** is largely confined to cultivated crops and domesticated animals at the moment and would be extremely difficult, time-consuming and costly to gather and monitor more widely. For these reasons, its direct measurement and inclusion as a headline biodiversity indicator is currently impractical. However, a useful proxy indicator would be phylogenetic diversity – i.e. the **taxonomic difference between species** (which can be measured as an index of the length of evolutionary pathways that connect a given set of taxa).

The most important gap in the CBD indicator set that needs to and actually can be filled concerns the ecological condition of ecosystems (biotopes and habitats). Although existing indicators address some attributes of some habitats (e.g. marine habitats by the Marine Trophic Index), no habitats are adequately monitored with respect to all the key attributes that define their condition. This is a significant weakness for monitoring the overall status of biodiversity because many ecosystems can be degraded with little visible impact on the species that are most typically monitored (e.g. birds, which are often less sensitive to habitat degradation than other species groups). Monitoring ecosystem condition is particularly important with regard to provision of ecosystem services as it is often the most direct indicator of likely benefits. For example, some ecosystem services, such as climate regulation or water purification, tend to be related more to biomass than to biodiversity per se (i.e. quantity not diversity). Others relate more to diversity – e.g. bioprospecting and genetic diversity (see Chapter 5). Such attributes therefore need to be considered in assessments of ecosystem condition.

Establishing a global standardised system for measuring ecosystem condition indicators would be a major challenge and probably prohibitively time-consuming and not cost-effective. A possible solution would be to create a simple assessment approach that works with and supports the establishment of national biodiversity indicators that are compatible with a global reporting framework. This framework could be established by expert working groups that first identify a minimum set of attributes to define acceptable condition for each type of ecosystem. Generic standards could then be set for each attribute against which to judge the condition of the ecosystem.

This approach is illustrated in the hypothetical examples in Table 3.3, which draw on the concepts used to monitor protected area condition in the UK based on generic standards within a Common Standards Framework[3]. Specific standards could vary between countries/regions within agreed limits appropriate to local conditions, but would be published to enable scrutiny of how each country interprets the acceptable condition standards. This approach could lead to a subset of common indicators at global level, complemented by more and varied indicators at national, regional and local levels.

Although a very large set of indicators would be used to measure the quality (condition) of all ecosystems, the results could if necessary be combined into one simple index of overall ecosystem condition e.g. x% of ecosystems in acceptable condition.

3.2.3 TOWARDS A BIODIVERSITY MONITORING FRAMEWORK

Balmford et al. (2005) noted that a global biodiversity monitoring system should not focus on a few aspects of biodiversity but cover a wide range of natural attributes, including habitat extent and condition. Similarly, the 2009 biodiversity indicators workshop (see 3.2.2) recommended that "some additional measures on threats to biodiversity, status of diversity, ecosystem extent and condition, ecosystem services and policy responses should be developed in order to provide a more complete and flexible set of indicators to monitor progress towards a post-2010 target and to clearly link actions and biodiversity outcomes to benefits for people" (UNEP-WCMC 2009).

Table 3.3 Hypothetical examples of key attributes and generic limits that define acceptable condition in two habitat types

	Temperate forest		Blanket mire	
Attribute types	**Attribute (and ecosystem service relevance)**	**Acceptable limits**	**Attribute (and ecosystem service relevance)**	**Acceptable limits**
Size	Area of habitat patch (minimum area for key species & interior habitat)	>10ha	Area of habitat patch (maintenance of hydrology)	>100ha
Physical properties			Peat depth (maintenance of carbon) Water level (vegetation requirements and peat protection)	>10cm <10cm below soil surface & <20 cm above soil surface
Vegetation structure	Height/age classes (regeneration of habitat and underpins diverse community)	>20% mature trees, 2-5% seedlings		
Species composition	Native species (supports key species of biodiversity)	>90%	Sphagnum mosses (carbon sequestration depend on these species) Dwarf shrubs	>20% cover < 10%
Biomass	Tree density (timber production)	> 10 trees per ha <100 trees per ha	Not measurable in practice	
Productivity			Forage (for livestock and wild species)	>90% potential net primary production
Specific features	Dead wood (habitat for key species)	> 10 cubic foot per ha		

On the basis of these observations and the discussions in 3.2.2, we suggest that the status of biodiversity could be (i) measured according to an expanded CBD indicator set and the above framework, and (ii) summarised into the following five headline indicators:

- taxonomic difference between species – phylogenetic trends (indicators to be developed);
- population trends (e.g. based on a modified version of the Living Planet Index (Collen et al. 2009; Hails et al. 2008; Loh et al. 2005);
- species extinction risk trends (based on the Red List index: see Baillie et al. 2008; Butchart et al. 2007; Butchart et al. 2005);
- ecosystem extent (following CBD practice, with agreement on classes and definitions);
- the condition of ecosystems according to key attributes (CBD indicators to be extended).

These five headline indicators could form the basis of SMART (specific, measurable, achievable, realistic and time-specific) targets for the status of biodiversity. Like their constituent indicators (e.g. for each habitat type), they are scalable and could therefore be used for targets and monitoring from local to global scales, subject to agreement on standards. Monitoring data could also be differentiated according to sample locations (e.g. to report on the condition and effectiveness of protected areas) or applied to the land holdings of corporations to assess their impacts on biodiversity and ecosystems.

However, as noted in 3.2.1 above, the value of indicators increases considerably if they are integrated within a DPSIR framework. Including indicators of drivers and pressures can warn of impending impacts, whilst monitoring responses can help to assess the effectiveness of conservation measures: these facilitate the adoption of adaptive management practices (Salafsky et al. 2001). Creating a framework that complements state indicators with indicators of related pressures and drivers would therefore provide a comprehensive measurement and monitoring system to enable effective management of biodiversity and many key ecosystem services at a global level. Specific ecosystem service indicators would also be required for certain circumstances and locations (see 3.2.4 below).

We already have sufficient species monitoring data to provide headline indicators of species population trends and threat status trends, although representation of some taxa groups and regions needs to be improved. We can also assess ecosystem extent through remote sensing data: existing datasets could be used more effectively by developing software to create long time series and near-real-time data on land use, land cover and landscape fragmentation in collaboration with e.g. GMES and NASA.

The main gap in available data therefore concerns ecosystem condition. This requires major investment in monitoring. Some monitoring can be done using existing and new remote sensing data (e.g. habitat fragmentation, vegetation cover and landscape diversity) but more on-the-ground sample surveys of key attributes will be

needed in utilised ecosystems as well as more field data from countries with the highest levels of biodiversity and threatened biodiversity (c.f. in richer western countries as is now the case). With appropriate training and capacity building, such surveys could be carried out by local communities and other stakeholders using simple but robust and consistent participatory methods (Danielsen et al. 2005; Tucker et al. 2005). This type of monitoring approach would also engage local people in biodiversity issues and provide employment benefits. It is essential to ensure that indicator development supports local and national needs as much as top-down international institutional needs.

Biodiversity monitoring is currently inadequate mainly because funding is insufficient. Although creating a comprehensive biodiversity monitoring framework would require significant resources, this would almost certainly be a small fraction of the value of the ecosystem services currently lost through ineffective monitoring and management. Increasing funding for biodiversity monitoring would be highly cost-effective.

At present, responsibility for and funding of monitoring and measurement is not fully shared with those who use and benefit from biodiversity or with those who damage it. At the moment, a significant proportion of biodiversity monitoring costs are met by NGOs and their volunteers or from public sources. A strong case can be made for more use of approaches based on the polluter pays principle to contribute to better monitoring of biodiversity pressures and state. Shifting more responsibility for monitoring to the private sector can reduce the cost burden on public authorities.

More generally, the private sector's impacts on biodiversity need to be better monitored and reported on. Although indicators of such impacts have been developed, these tend to be too general and inconsistently applied to be of great value. We need to agree on approaches and standards that provide more meaningful and robust indicators of biodiversity impacts and are linked to SMART business targets (e.g. no net loss of biodiversity). Top-down generic indicators need to be completed by bottom-up approaches where local stakeholders report on impacts of relevance to them.

3.2.4 MEASURING ECOSYSTEM SERVICES

Policy makers need information from measurement of ecosystem services for integrated decision-making that responds to environmental, social and economic needs. If wisely used and well researched, ecosystem services (ESS) indicators can reflect the impacts of biodiversity and ecosystem loss and degradation on livelihoods and the economy. This move from measurement of biophysical capacities to measurement of benefit flows and economic values of ecosystem services can provide an effective tool that takes the whole value of our natural capital into account.

ECOSYSTEM SERVICE INDICATORS

Ecosystem service indicators make it possible to describe the flow of benefits provided by biodiversity. They contribute to better measurement and communication of the impacts that change an ecosystem's capacity to provide services supporting human well-being and development. Within the analytical DPSIR framework (see Figure 3.2 above), they can complement other indicators by focusing on the social impact of loss of natural capital and thus describe and communicate interactions between nature and society.

Compared to 'traditional' biodiversity indicators on status and trends in species diversity and richness, long recognised as important, ecosystem services indicators are a relatively new tool. The publication of the Millennium Ecosystem Assessment (MA) catalysed increased attention to ecosystem services in the political arena.

This shift also led to increased development and use of related indicators, very often derived from other sectors e.g. for timber production and the forestry sector. Because these were often available immediately, initial indicators mostly focused on provisioning services. However, the MA's final report in 2005 noted that "there are at this time no widely accepted indicators to measure trends in supporting, regulating or cultural ecosystem services, much less indicators that measure the effect of changes in these services on human well-being". Some years on, despite ongoing efforts, this statement remains largely valid. This is mostly due to the complexity of functional relationships between ecosystem components and how they affect the provision of services, and the multi-dimensional character of these services. It is essential to continue efforts to develop reliable indicators of the provision of the main types of ecosystem services, including regulating, supporting and cultural services. The technical difficulties reflect to a large extent the relatively recent focus on ecosystem services. They are no reason to stop exploring and promoting the potential use of existing indicators – what we have is already useful for policy discussions and instrument choice and design, even if much remains to be done.

VALUING WHAT ECOSYSTEM SERVICES INDICATORS MEASURE

Table 3.4 offers a useful, but far from extensive, first set of ecosystem services indicators, based on the MA framework, that are already in use or being developed. It includes a wide range of quantitative (e.g. timber, crop and fish production) and some qualitative indicators (e.g. probability of natural hazards) which well reflect the value of some ecosystem services.

However, for some services and some audiences, economic valuation is seen as essential. When considering potential trade-offs between provisioning services (usually captured by market prices) and regulating services (often non-marketed services), the absence of monetary values for regulating services can create a bias towards provisioning services. The approach, importance and examples of monetising ecosystem services indicators are explored in Chapter 4 below.

Each type of information is important. **Although qualitative indicators do not quantify and monetise benefits arising from ecosystem services, they are an important tool to underpin quantitative and monetary information and help to close gaps where no such information exists.** It is possible to develop widely-recognised qualitative indicators, if based on sound judgment, experience and knowledge. This is particularly true for supporting ecosystem services which, in the MA framework, include all natural processes that maintain other ecosystem services (e.g. nutrient cycling, soil formation, ecological interactions) and whose benefits

Table 3.4 Examples of ecosystem service indicators

Ecosystem service	Ecosystem Service Indicator
Provisioning Services	
Food Sustainably produced/harvested crops, fruit, wild berries, fungi, nuts, livestock, semi-domestic animals, game, fish and other aquatic resources etc.	• Crop production from sustainable [organic] sources in tonnes and/or hectares • Livestock from sustainable [organic] sources in tonnes and/or hectares • Fish production from sustainable [organic] sources in tonnes live weight (e.g., proportion of fish stocks caught within safe biological limits) • Number of wild species used as food • Wild animal/plant production from sustainable sources in tonnes
Water quantity	• Total freshwater resources in million m^3
Raw materials Sustainably produced/harvested wool, skins, leather, plant fibre (cotton, straw etc.), timber, cork etc; sustainably produced/ harvested firewood, biomass etc.	• Forest growing stock, increment and fallings • Industrial roundwood in million m^3 from natural and/or sustainable managed forests • Pulp and paper production in million tonnes from natural and/or sustainable managed forests • Cotton production from sustainable [organic] resources in tonnes and/or hectares • Forest biomass for bioenergy in million tonnes of oil equivalent (Mtoe) from different resources (e.g. wood, residues) from natural and/or sustainable managed forests
Genetic resources Protection of local and endemic breeds and varieties, maintenance of game species gene pool etc.	• Number of crop varieties for production • Livestock breed variety • Number of fish varieties for production
Medicinal resources Sustainably produced/harvested medical natural products (flowers, roots, leaves, seeds, sap, animal products etc.); ingredients / components of biochemical or pharmaceutical products	• Number of species from which natural medicines have been derived • Number of drugs using natural compounds
Ornamental resources Sustainably produced/harvested ornamental wild plants, wood for handcraft, seashells etc.	• Number of species used for handcraft work • Amount of ornamental plant species used for gardening from sustainable sources
Regulating services	
Air purification	• Atmospheric cleansing capacity in tonnes of pollutants removed per hectare
Climate/climate change regulation Carbon sequestration, maintaining and controlling temperature and precipitation	• Total amount of carbon sequestered / stored = sequestration / storage capacity per hectare x total area (Gt CO_2)
Moderation of extreme events Avalanche control, storm damage control, fire regulation (i.e. preventing fires and regulating fire intensity)	• Trends in number of damaging natural disasters • Probability of incident
Regulation of water flows Regulating surface water run off, aquifer recharge etc.	• Infiltration capacity/rate of an ecosystem (e.g. amount of water/ surface area) - volume through unit area/per time • Soil water storage capacity in mm/m • Floodplain water storage capacity in mm/m
Waste treatment & water purification Decomposition/capture of nutrients and contaminants, prevention of eutrophication of water bodies etc.	• Removal of nutrients by wetlands (tonnes or percentage) • Water quality in aquatic ecosystems (sediment, turbidity, phosphorous, nutrients etc)

Erosion control / prevention Maintenance of nutrients and soil cover and preventing negative effects of erosion (e.g. impoverishing of soil, increased sedimentation of water bodies)	• Soil erosion rate by land use type
Pollination Maintenance of natural pollinators and seed dispersal agents (e.g. birds and mammals)	• Abundance and species richness of wild pollinators • Range of wild pollinators (e.g. in km, regular/aggregated/random, per species)
Biological control Seed dispersal, maintenance of natural enemies of plant and animal pests, regulating the populations of plant and animal disease vectors etc., disease regulation of vectors for pathogens	• Abundance and species richness of biological control agents (e.g. predators, insects etc) • Range of biological control agents (e.g. in km, regular/aggregated/random, per species) • Changes in disease burden as a result of changing ecosystems
Cultural services	
Aesthetic information Amenities provided by the ecosystem or its components	• Number of residents benefiting from landscape amenity • Number of visitors to a site to enjoy its amenity services
Recreation & ecotourism Hiking, camping, nature walks, jogging, skiing, canoeing, rafting, diving, recreational fishing, animal watching etc.	• Number of visitors to protected sites per year • Amount of nature tourism
Cultural values and inspirational services, e.g. education, art and research	• Number of products which's branding relates to cultural identity • Number of visits to sites, specifically related to education or cultural reasons • Number of educational excursions at a site • Number of TV programmes, studies, books etc. featuring sites and the surrounding area

Sources: building on, inter alia, MA 2005; Kettunen et al. 2009; Balmford et al. 2008, TEEB D0 Chapter 3

are difficult to quantify or monetise. Due to the still significant gaps regarding the applicability of related indicators, these have not yet been listed in Table 3.4.

APPLYING ECOSYSTEM SERVICE INDICATORS

Some of the few existing and commonly agreed indicators on regulating services have been drawn up from the environment sector (e.g. climate change and carbon sequestration/storage rates, natural flood protection: see Box 3.2). Extending their application will more effectively **link biodiversity with a range of environmental policy areas and policy instruments (e.g. REDD, REDD+, flood risk management)**. This can support new synergies and better communication of environmental and economic interdependencies and potential trade-offs amongst concerned stakeholders (e.g. companies, public institutions, civil society etc).

Ecosystem services indicators can also support more efficient integration of biodiversity considerations into other sector policies (e.g. agriculture, fisheries, forestry, energy, land use planning). They can create bridges between biodiversity, economic and social indicators and measure how impacts on capacity to provide ecosystem services could affect different sectors. Such tools can usefully contribute to more 'joined-up-thinking' and policy integration (see Box 3.3).

A policy area can specifically put ecosystem services to the forefront of its agenda – as has been done with forestry and carbon storage/sequestration or could be done with urban air quality and the cleansing capacity of forests. It is crucial to be aware of the risks of trade-offs between different ecosystem services – but also to take opportunities to create synergies (e.g. direct maintenance of benefits through reforestation, or investment in green infrastructure to support their continued provision by avoiding forest degradation).

Box 3.2: Examples of ESS indicators across environmental policy areas

Climate Change – Carbon sequestration/storage rates (Total amount of carbon sequestered/stored in Gt $C0_2$ equiv. = sequestration capacity/storage per hectare x total area of ecosystem)

Tropical forests have an annual global sequestration rate of around 1.3 Gt of carbon, or about 15% of total carbon emissions resulting from human activities. Forests in Central and South America are estimated to take up around 0.6 Gt C, African forests roughly 0.4 Gt, and Asian forests around 0.25 Gt. It is estimated that tropical and subtropical forests together store nearly 550 Gt of carbon, the largest amount across all biomes. Reforestation and halting forest degradation could enhance this further (Trumper et al. 2009). The EU therefore supports a new instrument to generate significant funding to achieve the objective of halting global forest cover loss by 2030 (the Global Forest Carbon Mechanism, see EC 2008b). This approach uses carbon sequestration rates and an ecosystem's capacity to store carbon as an indicator to describe benefits arising from forest ecosystems with regard to climate change mitigation policy. This ecosystem service can also be linked to new financial incentive mechanisms such as REDD (Reducing Emissions from Deforestation and Degradation in developing countries) being proposed under the UN Framework Convention on Climate Change (UNFCCC). REDD could make explicit the value of reduced CO_2 emissions and, compared to other GHG emission reduction alternatives, is estimated to be a low-cost mitigation option (Stern 2006; IPCC 2007; Eliasch 2008). Related policy instruments are discussed in Chapter 5.

Urban Air Quality – Atmospheric cleansing capacity (e.g. tonnes of particulates removed per hectare of ecosystem)

A study by Nowak et al. (Powe 2002 and references within) found that urban trees in Philadelphia, USA, had removed over 1,000 tons of air pollutants from the atmosphere in the year 1994. According to a UK study (Powe 2002), trees can be seen to absorb large quantities of pollutants e.g. between 391,664-617,790 metric tonnes of PM10 (particulate matter) and 714,158-1,199,840 metric tonnes of SO_2 per year.

Urban planning can use this capacity of green infrastructure to achieve air pollution control targets e.g. air quality standards. Values can be attached via the avoided morbidity and mortality impacts resulting from urban green infrastructure's contribution to reduced air pollution levels. In the context of a 'bubble' policy developed for a specific area (e.g. bubble policies for air pollutants set by the US Environmental Protection Agency), the development or conservation of green infrastructure could be used to balance air emissions from sources included in this area. By enabling trading of air emission rights, an economic value can be attached to such services.

Clean Drinking Water – Removal of nutrients by wetlands (amount/percentage); water quality in aquatic ecosystems (sediment, turbidity, phosphorus etc.)

Bionade Corporation produces and distributes organically manufactured non-alcoholic drinks in Germany, with a global turnover of 40 million Euros in 2007. Clean drinking water being a main ingredient, the company has initiated a project with the German NGO Trinkwasserwald e.V. to create 130 hectares of 'drinking water forests' throughout Germany linked to their capacity to prevent pollution. The NGO indicates that each hectare of conifer monoculture converted into deciduous broadleaved forest will generate 800,000 l/year for a one-off conversion cost of 6,800 EUR/hectare. Private contracts between the NGO and the public or private forest owners are signed for a period of twenty years (Greiber et al. 2009; for further examples, see Chapter 5).

Box 3.3: Examples of ESS indicators across sector policies

Agriculture – Abundance, species richness and range of wild pollinators (e.g. insects, mammals)

The indicator can be used to identify what proportion of production depends on pollination by wild insects or mammals, linking cultivated land to criteria such as abundance, species richness and range of wild pollinators.

- wild pollinator diversity and activity can vary with distance between natural forest and crop field for example Ricketts et al. (2004) show that for coffee, those sites near the forest were visited by a greater diversity of bee species that those further away, and nearer sites were visited more frequently and had more pollen deposited than further sites. Beyond roughly 1 km from forest, wild pollination services became insufficient, and coffee produced approximately 20% less as a result;
- an early estimate for the global value of wild and domestic pollination estimated the value at US$ 120 billion per year (Costanza et al. 1997). More recently, Losey and Vaughan (2006) estimated that wild pollinators alone account for about US$ 3 billion worth of fruit and vegetables produced in the US per year. In 2008, French (at INRA and CNRS) and German (at UFZ) scientists found that the worldwide economic value of the pollination service provided by insect pollinators, bees mainly, was €153 billion in 2005 for the main crops that feed the world. This figure amounted to 9.5% of the total value of the world agricultural food production (Gallai et al. 2009).

Building on this type of indicator, agri-environment payments can be linked to the capacity of farmland to provide pollination services, with the effectiveness of actions undertaken measured against the related indicator. Subsidies to agriculture could be reformed towards extensive farming systems supporting the provision of pollination services (see further Chapters 5 and 6).

Health – Atmospheric cleansing capacity (e.g. tonnes of particulates removed per hectare of forest) related to illness/mortality rate

The UK study on air cleansing capacity (see Box 3.2) estimated the impact of higher air quality in terms of net health effects (having trees compared to another land use) at between 65-89 cases of avoided early mortality and 45-62 fewer hospital admissions per year. The estimated net reduction in costs ranged between £222,308- £11,213,276. The range is dependent on the extent of dry deposition on days with more than 1mm rain and how early the deaths occur. In terms of health effects, Hewitt (2002) also found that doubling the number of trees in the West Midlands would reduce excess deaths due to particles in the air by up to 140 per year (Powe 2002 and references within). One of the measures to meet urban air quality and health standards (e.g. as set by the World Health Organisation) can include investments in protected areas to secure provision of these services (see Chapter 8).

Further examples:

Poverty – Number of wild species used as food and/or amount of wild animal/plant products sustainably collected

Energy – Forest biomass for bioenergy in Mtoe from different resources (e.g. wood, residues) from natural and/or sustainable managed forests

Although there are no commonly known policies mandating 'no net loss' of ecosystem services at regional or national level, it is not inconceivable that such targets will be adopted in the future (see Chapter 7 for project level use of 'no net loss'). **The development of ecosystem services indicators will inevitably have to be accompanied by a clear definition of relevant policy goals to ensure the effectiveness of such indicators as an integration tool.** A widely-recognised set of indicators on the quality of ecosystems and their capacity to provide ecosystem services will be necessary to effectively measure progress towards those targets and the efficiency of approaches taken.

A streamlined or small executive set of headline indicators would arguably be sufficient for high level target setting and communication by policy makers, politicians, the press and business, supported by wider sets for measurement and monitoring. Initiatives such as Streamlining European 2010 Biodiversity Indicators (SEBI 2010) and the CBD global headline indicators have started taking into account a limited number of indicators relating to ecosystem capacity to provide services and goods (e.g. water quality of freshwater ecosystems) and to sustainable use of provisioning services (e.g. ecological footprint; area of forest, agricultural and aquaculture ecosystems under sustainable management). Table 3.2 above outlines indicators

Box 3.4: Using indicators in policy: the ecological footprint for measuring sustainable use of provisioning services

As noted in Chapter 2, ecological footprint analysis compares human demand on nature with the biosphere's ability to generate resources and provide services. It measures how much biologically productive land and water area an individual, a city, a country, a region, or humanity requires to produce the resources it consumes and to absorb the waste it generates. The following examples show how the footprint has been applied in decision-making.

SEBI 2010: The Ecological Footprint has been included in the set of 26 indicators developed by the Initiative. According to the latest SEBI 2010 review, natural resource use and waste generation within Europe is more than two times greater than the continent's natural capacity to provide these resources and absorb these wastes. This ecological deficit means that Europe cannot sustainably meet its consumption demands from within its own borders. The EU-27 on its own has a footprint of 4.7 global hectares per person, twice the size of its biocapacity.

Source: Schutyser and Condé 2009

European Union (EU): The European Commission is incorporating the footprint into its dialogue and considering how and where to integrate its measurement, notably as regards its impact outside the territory of the EU. An analysis of the potential to use the footprint and related assessment tools in the EU Thematic Strategy on the Sustainable Use of Natural Resources has been carried out. The European Commission supports the wider improvement of this tool.

Source: Ecologic et al. 2008; EC 2009

Switzerland: The government has completed a scientific review of the National Footprint Accounts. Officials are now incorporating footprint data into the nation's Sustainability Development Plan.

Source: Global Footprint Network 2009

South Australia: The state is using the Ecological Footprint as a regional target – aiming to reduce its footprint by 30% by 2050.

Source: South Australia's Strategy Plan 2007 considered by the CBD and taken up by the SEBI 2010 initiative. Box 3.4 highlights the use of the ecological footprint in policy across different countries.

Ecosystem services indicators can also be included in corporate reporting standards (e.g. Global Reporting Initiative) to communicate the impacts of lost services on company performance (e.g. paper and forestry, water quality and beverage industry) and the impacts of companies on provision of these services (e.g. metals and mining). Further details on business and ecosystem services can be found in TEEB D3.

A small set of headline indicators may be enough for communication and high-level target setting but **there is also value in having detailed ecosystem service indicators for certain policy instruments**. These include e.g. policy assessments, Environmental Impact Assessments (EIA) and national accounting as well as procedures to analyse companies' economic dependency and impacts on ecosystem services through materiality or Life Cycle Assessments (LCA). In policy and environmental impact assessments, such indicators help us to answer questions on the economic, social and environmental consequences of different policy or planning options affecting biodiversity (see Chapter 4). With regard to national accounting, indicators can be integrated into Systems of National Accounts (SNA) through the development of satellite accounts (see Box 3.5). More details on national accounting can be found in sections 3.3 and 3.4 below.

Ecosystem service indicators are not an isolated part of measurement but can effectively complement macroeconomic and social indicators to further describe interactions between nature and society. Ways to move to more sustainable measurement of the wealth of nations and well-being of societies are discussed in sections 3.3.1 and 3.3.2 respectively.

Box 3.5: Using indicators in policy: the Final Ecosystem Services approach in national accounting

Switzerland commissioned a feasibility study on the use of the 'final ecosystem services' (FES) approach developed by Boyd and Banzhaf (2007) for its national income accounting. FES are defined as components of nature that are directly enjoyable, consumable or usable to yield human well-being. The schematic account matrix distinguishes between FES indicators attributable to four main benefit categories: Health, Safety, Natural Diversity and Economic Benefits. The study analyses in more detail the application of accounting indicators in the category 'health' and for the benefit of 'undisturbed sleep' (see example below).

Schematic account matrix for final ecosystem services (FES)

benefit category (FOEN Product group)		**Benefit**		**Ecosystem Services**		**Relevant intermediate products, processes, functions**
		Type of benefit	**Description**	**Description**	**Unit**	
Distinction between: • Health • Safety • Natural diversity • Factors of production		Active use value, passive use value, existence value	Benefit 1	Ecosystem Service 1	…*Persons/year…	
				Ecosystem Service 2	…*Persons/year…	
				…	…*Persons/year…	
			Benefit 2			
Example	*Health*	*Passive use value*	*Undisturbed sleep*	*Night-time sound level below limit (at place of residence)*	*# Persons/year where defined threshold is not exceeded in dB(A) between 22 – 06 hours*	*Natural sound absorbers*

Source: Ott and Staub 2009

CHALLENGES AND NEXT STEPS

The extent to which ESS indicators are ready for use varies depending on the availability of data, the capacity to summarise characteristics at multiple spatial and temporal scales and communication of the results to non-technical policymakers (Layke 2009). There are more and better indicators for provisioning services than for regulating and cultural services, due to our clear and immediate dependency on provisioning services which are mostly incorporated into marketed commodities (e.g. wood for timber, fuel and food).

The flow of benefits from regulating and cultural services is not as visible or easily measurable: many non-market services are therefore enjoyed for free. Proxy indicators can help us estimate benefits associated with these services by referring to the capacity of an ecosystem to provide them – but these are only a short-term solution. **More widespread use of ecosystem services in decisions will require us to improve regulating and cultural service indicators** (Layke 2009). Promising ideas such as the trait concept (Layke 2009), which seeks the clear definition of characteristics required for the provision of services, are available but need further elaboration.

ESS indicators need to take account of the sustainability of provisioning and other services over time, to ensure that the long-term benefit flow of services is measured. Overexploitation of benefits arising from some provisioning services (e.g. overexploitation of fish stocks) as well as cultural services (e.g. tourism) and regulating services (e.g. reforestation activities for carbon capture) could lead to a depletion of benefits and social trade-offs. Indicators referring to those services therefore need to take sustainable productivity into account. This calls for a clear definition of what sustainability actually means with regard to those services. It is crucial to develop a baseline in order to determine where critical thresholds (e.g. population of fish stock within safe biological limits, soil critical loads) and alternative future pathways under different policy scenarios (e.g. fisheries subsidies reform, subsidies in the agriculture sector) may lie. However, settingcritical thresholds raises substantial problems linked to ignorance, uncertainties and risk associated with ecological systems. Safe minimum standards may be a way to overcome these challenges (see TEEB D0 Chapter 5).

Not all ecosystem service indicators can be quantified: there is a risk that policy makers focus more on those for which quantifiable information is available. As stated in TEEB D0 Chapter 3, "reliance on existing indicators will in all likelihood capture the value of a few species and ecosystems relevant to food and fibre production, and will miss out the role of biodiversity and ecosystems in supporting the full range of ecosystem services, as well as their resilience into the future." To avoid risks of creating a policy bias by focusing on a subset of indicators high on the political agenda or the agenda of vested interests, we need to increase efforts to find complementary non-quantified indicators.

In parallel, ESS valuations that focus on a single service should be systematically cross-checked with broader measurements to assess the capacity of ecosystems to continue delivering the full variety of other services potentially of interest. This capacity depends on ecosystem robustness, integrity and resilience, not on asset value. We therefore need to compare eco-nomic benefits from ecosystem services exploitation to the additional costs required to maintain ecosystem capital in the broadest sense (i.e. to mitigate overall degradation), rather than sticking to narrow measurement of the losses of benefits resulting from natural resource depletion.

TEEB D0 Chapter 3 discusses in more detail the lessons learned from initial application of existing indicators and highlights key opportunities and constraints arising from their use.

To better identify the beneficiaries of ecosystems services and those who guarantee their provision to society, we need more research on the link between biodiversity and ecosystem condition and on the provision of ecosystems services. This is particularly acute for indicators on regulating and cultural services: data are often insufficient and indicators inadequate to characterise the diversity and complexity of the benefits they provide (Layke 2009).

Improving measurement can be a long process but it is of fundamental importance to arrive at good solutions. In the long term, measurement is often a good investment and can be a cost-effective part of the answer – spotting risks early and addressing them efficiently can help avoid much higher damage costs later on. As sections 3.3 and 3.4 show, indicators feed directly into macro-economic aggregrates and thus form an integral part of accounting systems.

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3.3 'GREENING' OUR MACRO-ECONOMIC AND SOCIETAL INDICATORS

"Choices between promoting GDP and protecting the environment may be false choices, once environmental degradation is appropriately included in our measurement of economic performance."

Stiglitz-Sen-Fitoussi Report on the Measurement of Economic Performance and Social Progress, 2009.

3.3.1 TRADITIONAL APPROACHES TO MEASURING WEALTH AND WELL-BEING

A range of 'traditional' indicators are used to measure countries' economic performance and in policy making, These include: GDP and GDP growth, national income, final consumption, gross fixed capital formation (GFCF), net savings, international trade balance, international balance of payments, inflation, national debt, savings rates and so on. On the social side, some of the indicators most commonly used relate to unemployment, literacy, life expectancy and income inequality. A useful combined indicator that straddles more than one domain is the human development index (HDI).

These conventional aggregates feed into and are an integral part of national accounting systems (see 3.4 below). However, they only tell part of the story as they do not systematically cover the loss of biodiversity. Indicators for biodiversity and ecosystem services are already a step in the right direction towards complementing them. As section 3.2 showed, we now have a swathe of environmental indicators, from water quality to more recent measurements of CO_2 emissions. Many argue that there are in fact too many separate tools to have anywhere near as much public, press and political attention as the consolidated traditional economic indicators. CO_2 is starting to be an exception, but while helpful, does not address ecosystems and biodiversity directly.

We can illustrate the slow process of change through the example of trade deficits e.g. where imports exceed exports. These feature every week in many newspapers or magazines yet there is little mention of green trade deficits i.e. the impacts on biodiversity related to imports and exports of goods and services. The tool of ecological footprint analysis (see Box 3.4 above) can help to fill this gap by helping to **identify creditor and debtor nations** from a biodiversity perspective. 'Water footprints' can also offer useful information to consumers – to put it simply, when bananas are imported, so are the water and the nutrients from the soil.

Certain countries – notably the most developed countries – are significant environmental debtor nations. Most developing countries are creditor countries. However, there is little reflection of this debt or credit in traditional measurement and decision making or in market signals. Some countries have responded to the understanding that a continued growth in their footprints cannot go on for ever and are using the footprint as a policy target to reduce their environmental impacts or increase resource efficiency (see Box 3.4).

The next section shows how traditional approaches can be gradually adapted to support more sustainable measurement.

3.3.2 TOOLS FOR MORE SUSTAINABLE MEASUREMENT

Part of the solution is understanding that for many of the economic terms used in everyday policy making, there are already parallels that take nature into account.

Economic assets – natural assets. The concept of capital derives from economics: capital stocks (assets) provide a flow of goods and services which contributes to human well-being. This concept has traditionally been equated with manufactured goods which produce, or facilitate the production of, other goods and services.

This 'manufactured capital' is only part of the picture. We can also talk of 'human capital' (skills and knowledge, quality of the labour force), 'social capital' (universities and hospitals) and 'natural capital' – the stock of our natural resource from which ecosystem services flow. These four types of capital are defined in Box 3.6. While some do not like to equate nature to 'natural capital', the term has its use in communicating the importance of nature in the context of our economic activities.

Infrastructure and green infrastructure. Traditionally infrastructure spending focused on roads, rail, schools etc. There is now increasing appreciation of the importance of investing in 'green infrastructure' – this not only includes protected area networks (see Chapter 8) but also investments in watersheds that provide waste services (see Chapters 5 and 9), city gardens that provide amenities, and in some countries, green roof programmes to help biodiversity and adaptation to climate change.

Man-made capital depreciates, natural capital 'appreciates'. Man-made infrastructure degrades and requires continuous maintenance – e.g. flood protection levies, water pre-treatment plants – and associated costs. Natural infrastructure can often do its own maintenance e.g. mangroves or flood plains vis-à-vis flood protection. There is little talk of proactive investment in natural capital formation, yet this is a common theme running through programmes for afforestation, investment in watersheds, forest management, restoration and investment in protected areas.

Gross fixed capital formation, natural capital formation. Most governments regularly monitor the level of gross fixed capital formation (GFCF) (i.e. investment in infrastructure), but rarely the level of natural capital formation. Some elements are included but offer a very incomplete picture of natural capital. For example, when a forest is felled (e.g. to convert to agricultural use), current SNA guidelines suggest recording a positive GFCF in an agriculture land asset up to the amount of the felling works[5].

Box 3.6: Four types of capital[4]

Manufactured Capital: Manufactured (or human-made) capital is what is traditionally considered as capital: produced assets that are used to produce other goods and services. Examples include machines, tools, buildings and infrastructure.

Natural Capital: In addition to traditional natural resources, such as timber, water, and energy and mineral reserves, natural capital includes natural assets that are not easily valued monetarily, such as species diversity, endangered species and the ecosystems which perform ecological services (e.g. air and water filtration). Natural capital can be considered as the components of nature that can be linked directly or indirectly with human welfare.

Human Capital: Human capital generally refers to the health, well-being and productive potential of individual people. Types of human capital include mental and physical health, education, motivation and work skills. These elements not only contribute to a happy, healthy society but also improve the opportunities for economic development through a productive workforce.

Social Capital: Social capital, like human capital, is related to human well-being, but on a societal rather than individual level. It consists of the social networks that support an efficient, cohesive society and facilitate social and intellectual interactions among its members. Social capital refers to those stocks of social trust, norms and networks that people can draw upon to solve common problems and create social cohesion. Examples of social capital include neighbourhood associations, civic organisations and cooperatives. The political and legal structures that promote political stability, democracy, government efficiency and social justice (all of which are good for productivity as well as being desirable in themselves) are also part of social capital.

Source: GHK et al. 2005 building on Ekins 1992

National Net Savings, 'Genuine' Savings. Countries measure how much money is saved on average as the result of all positive and negative economic transactions. However, because some economic revenue comes from rent on natural capital, these should not all be considered as part of Net Savings as they currently are in the SNA. Part of these receipts should be reinvested to maintain the income flow in a sustainable way, just as companies do with regard to depreciation of other capital. In addition, human capital and ecosystem capital should be maintained like other forms of capital.

The World Bank's 'adjusted net or genuine savings' indicators measure a 'truer' level of saving in a country by not just looking at economic growth but also taking into account the depreciation of produced capital, investments in human capital (as measured by education expenditures), depletion of minerals, energy, forests and damage from local and global air pollutants (World Bank 2006). These indicators should also include the degradation of ecosystem capital which relates to maintenance of all ecological functions, instead of – as is currently attempted for forests – being limited to depletion which only relates to the maintenance of income from forest exploitation.

GDP vs National Income that takes nature into account. GDP (the sum of sectors' value added) measures only the economic transactions which have taken place during the accounting period, not the welfare, well-being or wealth of a country. Because these transactions are the basis for taxation (the main government resource) and are also closely correlated to employment, GDP has been overplayed in macroeconomic decisions and is sometimes misinterpreted as a welfare indicator by journalists and many economists. Once GDP is restored to its original status, the question of an alternate or supplementary headline aggregate comes to the fore.

The international Commission on the Measurement of Economic Performance and Social Progress (the 'Stiglitz-Sen-Fitoussi Commission') (Stiglitz et al. 2009) has addressed current limitations and flaws in GDP use (see Box 3.7).

Correcting the prices for consumption, imports and exports. Some talk of 'greening GDP' when they actually mean 'greening the economy' – i.e. reducing the impact on nature. One way to do this is to change market signals to encourage activities that take nature into account – e.g. getting the prices right through full

Box 3.7: The Stiglitz-Sen-Fitoussi Commission's critique of GDP

The Commission has addressed current limitations and flaws in GDP use, insisting on the need to pay more attention to other existing aggregates, namely National Income and Households Consumption. It started by looking at the properties of the National Income. Derived from GDP, the Income aggregate aims to measure how much money we can dispose of freely for our own expenditures:

- where part of GDP is regularly sent abroad – e.g. to pay revenue to a foreign shareholder of domestic companies or to families of immigrant workers – GDP is adjusted for these transfers of revenue with the rest of the world, leading to the so-called 'Gross National Income';
- a second adjustment is made to take into account the normal degradation of productive capital and the need to repair or replace it, to produce a Net National Income (National Income).

The Commission examined which elements of this Income are not disposable (e.g. income tax for the Households sector) and which other imputations should be considered e.g. non-market services supplied by the government sector. It concluded by proposing the compilation of a Net Disposable National Income, mostly targeted at improving households' well-being.

If we take a step further in this direction and consider that the Consumption of Natural Capital still needs to be taken into account, we can propose the calculation of an Adjusted Net Disposable National Income. Being linked to production processes, this imputation will mostly draw upon business accounts.

Source: building on Stiglitz et al. 2009 cost recovery charges, resource costing, subsidy reform and the polluter pays principle (taxes, liability, regulation). The development and greening of markets and supply chains e.g. via green public procurement, can also help (see generally Chapters 5 to 7).

National accounts currently record household final consumption as well as imports and exports at purchasers' prices. Normal market prices cover production and distribution costs (intermediate consumption, labour, taxes and financial costs), the entrepreneur's profit plus an allowance for compensating fixed capital depreciation resulting from wear and tear (as noted above). In national accounts, no such element is recorded for the depreciation of the ecosystem capital. This means that purchasers' prices are underestimated in cases where commodities originate from degrading ecosystems.

If we set the target of maintaining ecosystem capacity in a good state (e.g. 'halt biodiversity loss', "ensure sustainable development" or the many equivalent regional or national objectives), the implicit value of ecosystem degradation potentially attached to each commodity unit needs to be considered as a concealed negative transfer to future generations and/or – in the case of international trade – from suppliers to consumers.

Measuring and valuing these concealed transfers is important to assess the reality of each country's economic performance. From a well-being perspective, this sheds light on the sustainability of consumption patterns and on distributional effects resulting from distorted international trade. Systematic implementation of product traceability – starting to be done though fair trade or for organic products (see Chapter 5) – and printing the full price on the product would help the many consumers keen to act responsibly to make informed choices. It would also be a measure to help protect sustainably-managed industries against arguably unfair competition from ecosystem-degrading competitors who do not pay for their degradation and thus receive an implicit subsidy (see Chapters 6 on subsidies and 7 on full cost recovery and polluter pays principle).

This type of measurement approach would also help in policy design and lead to future GDP statistics being less out of step with nature.

3.4 INTEGRATING ECOSYSTEMS INTO NATIONAL INCOME ACCOUNTING

"A country could cut down all its forests and deplete its natural resources and this would show only as a positive gain to GDP despite of the loss of [natural] capital".

Robert Repetto (1987) in
Millennium Ecosystem Assessment (MA) 2005

3.4.1 THE RATIONALE FOR ECOSYSTEM ACCOUNTING

Ecosystems are badly – and even equivocally – recorded in national economic accounts, at best as an economic resource able to generate monetary benefit for their owners i.e. they feature only in proportion to this private benefit. A range of ecosystem services supporting production are merely considered as externalities. Free amenities and regulating services supplied by thriving ecosystems are absent from the picture.

The TEEB project has always acknowledged accounting as an essential component because the protection of public goods (e.g. the life-support functions provided by ecosystem services and the sustainable use of these services) goes to the heart of sustainable development and how it can accommodate economic growth. Proper accounting is necessary to support properly informed decisions. The indicators discussed in sections 3.2 and 3.3 above need to feed directly into such accounting systems.

At present, the actual value of ecosystem services is only accounted for either when they are incorporated into the price of products or when the services are (at risk of being) lost and the cost of alternatives becomes evident. When their market price is zero, however, as is often the case, services are effectively taken not to exist and can thus be appropriated for production or simply degraded without any recording. These free ecosystem services need in some way to be measured, valued and added to existing measures such as GDP to provide more inclusive aggregates to guide decisions by policy makers, businesses and consumers.

The need for change is widely acknowledged, not just in TEEB but also in processes like 'Beyond GDP'[6], the OECD's Global Project on Measuring the Progress of Societies'[7] and the Stiglitz-Sen-Fitoussi Commission (see Box 3.7). Economic commentators also recognise the increasing urgency for action, given the unsustainable externalities resulting from over-consumption of ecosystem services, most visible in climate change and loss of biodiversity. Add in growing demography, the emergence of big economic players and chaotic economic development in general and it becomes obvious that accounting for the real value of what we produce and consume is essential for taking personal and collective decisions.

Today's unparalleled multiple systemic crises – economic/financial, climate/energy and ecosystems/biodiversity – have jointly spawned **crises of governance and trust**. Citizens, business and government are increasingly concerned about accumulating debts, the exposure of concealed debts and the ability of huge untested rescue packages to work. Social crisis could be exacerbated. These three crises share common features, all relating to shortcomings in societal accounting mechanisms: over-destruction of financial, human and natural capital, over-consumption fuelled by often hidden debt and the shifting of risks and debts from the strongest to the weakest (the ever-increasing North-South debt) or to future generations.

Underlying this lack of complete accounting are factors that include:

- lack of transparency in consumer transactions of financial, food, fibre and energy products;

- misleading market price signals that did not cover all costs and risks;
- neglect of public goods such as the built and natural infrastructure, security, cooperation, equity, nature, clean air and water.

Yet early signals could have been recognised in advance of these crises: financial transactions accounting for more than 90% of the world's total transactions; two digit profit rates raised as an accounting standard for companies; pension liabilities putting pressure on public budgets/debts (which will increase markedly in coming decades of aging population); the average very low progress towards the Millennium Development Goals (MDGs) and even increases in malnutrition in many countries; the melting of ice caps and glaciers; and a rate of ecosystem degradation and species extinction unprecedented in the Earth's history.

These crises highlight the need for governance that maintains capital, meets the needs of today's and future generations and enhances citizen participation. Fair, transparent and robust accounts are an important support for any such governance model. Robustness relates to the completeness of recording and the elimination of double counting – such properties are essential when calculating the true results of economic activity (profit of companies, taxable revenue of households or Nation's product, income and savings). Fairness relates to distributional equity considerations between rich and poor within countries, between rich and poor parts of the world and between present and future generations. Transparency concerns full disclosure of the use of different types of capital, the positive and negative impacts (externalities) on them from such uses and how their costs/benefits vary between today's needs and those of future generations.

3.4.2 LIMITATIONS OF CONVENTIONAL ACCOUNTING SYSTEMS

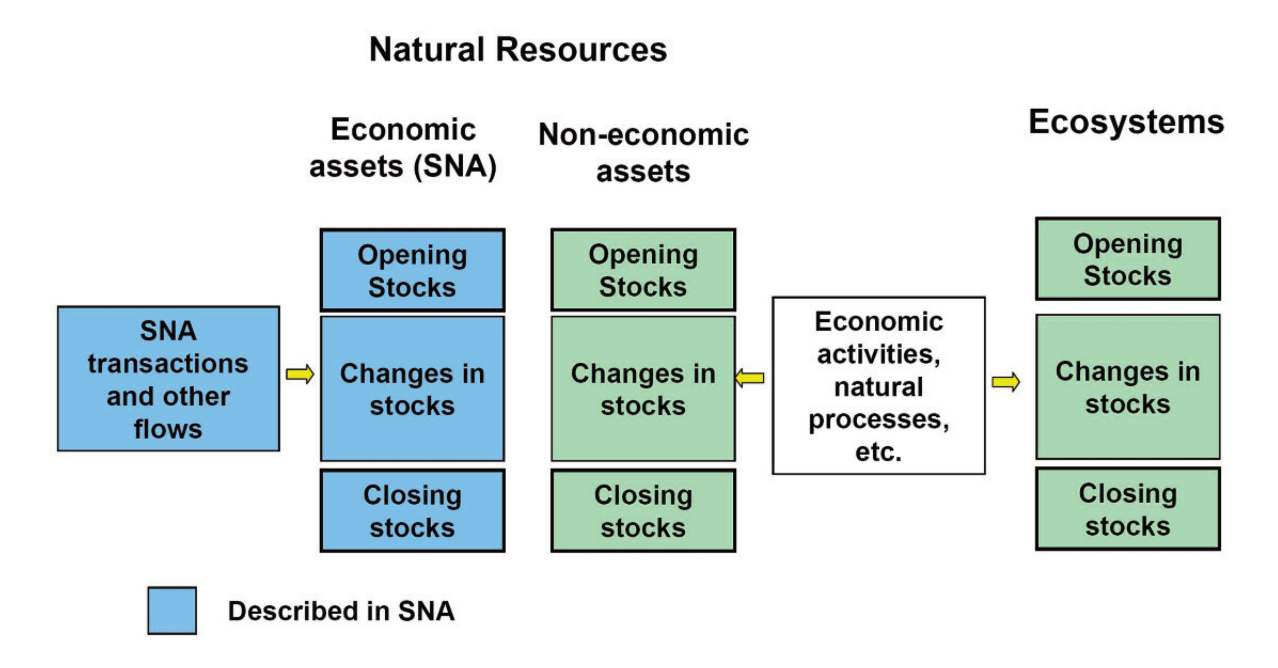
The UN System of National Accounts (UN SNA), is the globally recognised accounting framework that brings coherence to hundreds of mainly economic (but also some social and environmental) statistics sources available in countries. SNA is the framework from which variables such as GDP, production, investment and consumption are produced annually, quarterly and sometimes even monthly.

Historically the impetus for such accounts has always come from the need to mobilise resources in times of crisis. From the first sets of accounts developed in the 17th and 18th century in England[8] and France[9], the material balance of the USSR economy of 1925[10], to the first official national income statistics produced for the USA[11] in 1934, the UK[12] in 1941 and several European countries after 1945, the common purpose was either to mobilise resources to fight wars and/or to pay for peacetime reconstruction. After the Second World War, the Marshall Plan for post-war construction in Europe spawned the development of a first Standardised System of National Accounts published in 1952[13]. The following year the United Nations published a revised version for global use known as the 1953 SNA.

This backdrop of reconstruction and re-industrialisation strongly influenced the SNA's almost exclusive focus on the economic factors of production and consumption. Its creators were well aware of the SNA's limitations. In his Nobel Memorial lecture in 1984, the 'father' of the SNA, Richard Stone, stated that accounts for society ought to rest on three pillars: economic, socio-demographic and environmental. He highlighted that issues such as pollution, land use and non-renewable resources offered plenty of scope for accounting and that GDP should in effect be complemented by other variables when considering overall societal welfare. Since then, there has been only limited progress with including natural capital in SNA revisions: the 2008 revision still does not record subsoil assets depletion in the same way as fixed capital consumption (United Nations et al. 2008).

The intrinsic limitations of SNA when analysing the social functions of the economy led to the introduction of 'satellite' accounts in the 1993 SNA revision, one of which was developed as the System of Economic Environmental Accounting (SEEA) (United Nations et al. 2003: see Figure 3.3 below). However, the SEEA of 1993 failed because it did not recognise the need for asset accounts in physical units or acknowledge the concept of ecosystem.

Figure 3.3: SNA and Environmental-Economic Accounting



Source: Hassan 2005

A few countries developed satellite accounts for environmental protection expenditures, for natural assets (sub-soil, water, forest), for pollution (emissions accounts) or for other material flow accounts (see also TEEB Climate Issues Update 2009). However, too little use was generally made of these satellite accounts. This led to the creation of the London Group on Environmental Accounting – a group of national and environmental accountants from various OECD and developing countries – and to the revision of the SEEA in 2003 to present a better balance between monetary and physical accounts.

The 2003 SEEA now offers best accounting practices for physical units for natural assets, such as land ecosystems and water systems. With respect to valuation issues, however, it still artificially divides ecosystems into a resource component (timber, fish stocks, water in reservoirs…) where depletion is calculated according to conventional economic rules and where valuation remains uncertain for 'environmental degradation'. Addressing these shortcomings in ecosystem accounting is a key challenge for the SEEA 2012/2013 revision. Ecosystem accounts and valuation issues are planned to be part of a specific volume.

3.4.3 PRACTICAL STEPS TOWARDS ECOSYSTEM ACCOUNTING

Against this background, elements of a framework for ecosystem accounting have been developed and are being tested by the European Environment Agency with many partners. Several analyses and methodological approaches have been developed and presented in papers (Weber 2007, 2009). Land accounting has been established on the basis of land-cover change detection for Europe (EEA 2006) and can be applied to the global level using similar methodologies developed with ESA, FAO, UNEP, IGBP and other relevant bodies.

Under the auspices of TEEB, the European Environment Agency has been working on Ecosystem Accounting for the Mediterranean Wetlands. This methodological case study is being carried out to illuminate the possible contribution of environmental accounting in general, and ecosystem accounting in particular, to the economics of ecosystems and biodiversity. It has come to findings and confirmations of the following points on ecosystem accounting methodologies (see Box 3.8).

Box 3.8: Practical elements for ecosystem accounting, based on EEA Mediterranean Wetlands case study

1. **Ecosystem accounts can be implemented across the three geographical scales most relevant to prevailing governance models and societal welfare considerations.** The basic scales are the Global/Continental, the National/Regional and the Local. Each scale corresponds to a different governance framework. The Global/Continental scale is the one of general objectives, stated by international conventions, requiring simplified accounts that monitor main trends and distortions for all countries. The National/Regional scale is where the enforcement of environmental policies and regulations prevails, through environmental agencies, and ministries of economy, statistical offices and courts. The Local scale is the action level: local government, site level, management, projects, case studies, and business. This is the scale where assessing and valuing ecosystem services is essential and feasible because informed actors can express their real preferences.

2. **From a policy and data point of view, ecosystem accounting should be prioritised from a top-down perspective, not bottom-up[14].** Each of the three governance scales addressed above can be assigned a mission, an access to data and a time frame. If there is any chance of integrating the environment in economic decision-making, the strategy should consider the three interconnected tiers and their feasibility.

3. **Simplified global-scale ecosystem accounts** annually updated for assessing losses (gains) in total ecological potential in physical units and the costs of restoring the ecosystem for maintaining their functions and consequently their capacity of delivering their services from one year to the next. This maintenance cost is the ecosystem capital consumption which can be used in two ways: 1/ calculation of the value of domestic and imported products at their full cost in addition to their purchase price and 2/ subtraction from the Gross National Product (altogether with fixed capital consumption) for calculating a new headline aggregate, the Adjusted Disposable National Income (ADNI). Simplified global-scale ecosystem accounts can be produced at short notice on the basis of global monitoring programmes and international statistics.

4. **Integrated national economic-environmental accounts with ecosystem accounts.** The first task is to compute ecosystem capital consumption and use this to derive ADNI on the basis of national socio-economic statistics and monitoring systems. The second task is to integrate such ecosystem accounts with the national accounting matrixes and the monetary and physical indicators used for policy making. The process for implementing these national accounts is the revision of the UN SEEA by 2012/2013.

5. **Local/private actors** are increasingly demanding guidance for taking into account the environment in their everyday decisions on development projects of various types. As the Mediterranean Wetlands case study shows, ecosystem accounts would be very helpful for planning departments and environmental protection agencies to fully internalise environmental considerations when considering e.g. the costs-benefits of development proposals. Businesses are also interested as shown by their response to carbon accounting and recent interest in biodiversity considerations. Progress at this scale could be by developing guidelines based on the general principles but adapted at needs of the various communities of users.

6. **Socio-ecological systems are the appropriate analytical units for such accounting.** They reflect higher levels of interaction between ecosystem and people. Stocks and flows of land cover, water, biomass/carbon, and species/biodiversity are the priority accounts to be established in view of calculating the ecological potential[15] of many terrestrial socio-ecosystems. A simplified formula as well as a more

sophisticated one can be used depending on operational targets, scales and data availability. Ecosystem services are the outcomes of ecosystem functions which are directly or indirectly used by people. UNEP and EEA have taken steps in order to come to an international standard ecosystem services classification to use in environmental accounting and ecosystem assessments more generally.

7. **Asset valuation is both very feasible and very useful in the context of cost benefits assessments of impacts of projects.** It helps policy makers achieve trade-offs between possible future benefits from new developments and the total present benefits from economic natural resources and main non-market ecosystem services, and to see if benefits compensate losses. In the case of regular national accounting, the method contains several risks. The main one relates to the non-use values – often of a public good nature – which tend to be ignored or inadequately valued because of the problems mentioned previously. For renewable assets the valuation of the stocks is not even necessary. What matters first is that the ecosystems are renewing, that their multiple functions can be maintained over time, whatever the present preference for one or other service they deliver. The degradation of ecological potential can be observed and measured in physical units. It is then possible to calculate a restoration cost in reference either to the average cost of maintenance works or to the benefit losses of reducing extraction or harvesting down to a level compatible with the resilience of the socio-ecological systems.

8. **Maintenance of the ecosystem capital is the other approach of valuation.** It considers in a holistic way the capacity of ecosystems to deliver services in the present and future. Two elements are to be considered, 1/ actual expenditures for environmental protection and resource management and 2/ additional costs potentially needed to mitigate ecosystem degradation. When the actual expenditures are not sufficient to maintain the ecosystem, additional costs may be necessary and an allowance made accordingly. This is what is done by business and national accounts under the expressions 'cost of capital maintenance' or 'fixed capital consumption'. 'Ecosystem capital consumption should be calculated in the same way as fixed capital consumption' and added to it. This would result in an adjustment in the calculation of company profit or national income. As for the fixed capital, this adjustment measures what should be reinvested to maintain an equivalent productive (and in the case of ecosystems, reproductive) capacity of the asset. This is what should be set aside at the end of the accounting period and be made available at the beginning of the following one for restoring capacities. This is an important accounting number which can support actions such as reduced distribution of dividends and accordingly reduced taxes on benefits.

3.4.4 USING AVAILABLE INFORMATION TO MEET POLICY MAKERS' DEMANDS

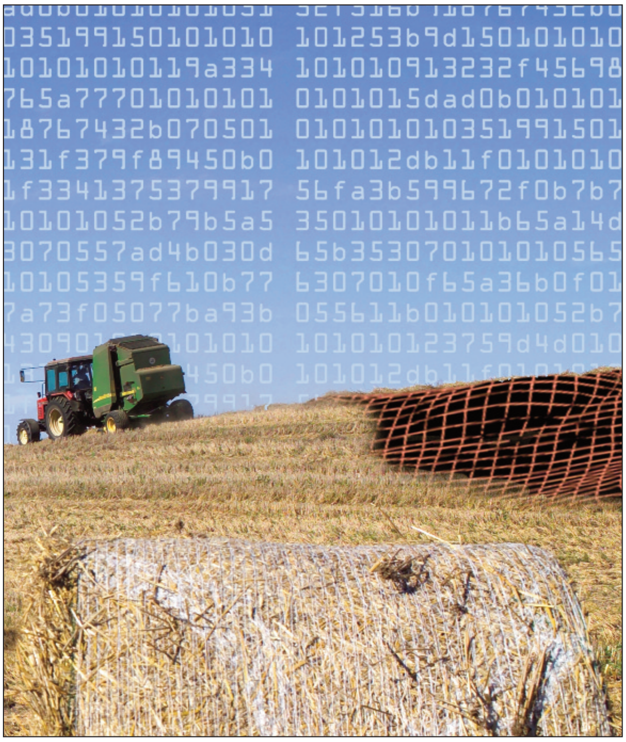
The data issue requires a strategic response. On the bright side, we have made tremendous progress with data collection in the last 30 years. Earth observation satellites, ground positioning systems, *in situ* real time monitoring, data bases, geographical information systems and internet are shorthand for a well known story. Public and private organisations have developed capacities and networks which make it possible today to take the first steps towards ecosystem accounting. The dark side has two aspects. The first concerns the lack of guidelines for accounting for ecosystem benefits and costs, especially at local government/agency and business levels. The Mediterranean case study (see Box 3.8) shows that data are regularly collected by the natural park bodies yet compiling them into an integrated framework is a huge effort. We need to make progress on drafting such guidelines at the local level, starting from the needs of local actors for information on physical state, costs and benefits in relation to their mandate.

The second difficulty relates to restrictions to data access imposed by some public organisations. This situation should stop, at least for public data paid by the public's money, In practice, it is already being addressed by the new data policies of the major space agencies, the open access policy of most environmental agencies and initiatives to facilitate access to scientific knowledge and data. Statistical offices have also considerably improved access to their databases and developed local statistics. However, more progress is still needed e.g. to merge further statistical and GIS data and develop grid data bases.

Data collection will develop if and only if it meets the needs of policy makers, companies and the public. A new product results from iterations between the supply and demand sides. The supply side brings together intuition of a need and technical capacities to meet it, draws sketches, designs models, prototypes etc. The demand side expresses needs, preferences and finally validates the supplied product by using it. Environmental accounting methodologies have been designed proficiently over the past three decades, and tested in various contexts but have not yet met the demand side requirements.

All the initiatives launched before the present financial and economic crises (see 3.4.1) note that physical indicators are part of the response to better reflect the social and environmental interactions of economic development, and all request new monetary indicators. The current crises amplify this need. It is therefore essential for the supply side to start sketching new products on the basis of existing data. These products will be coarse and simple at the start but will give users preliminary elements for better assessing trade-offs and decisions based on accounts of the past and derived outlooks.

For example, the 2007 Beyond GDP Conference[16] has created an interim follow up 'basket of four' indicators (Ecological Footprint, Human Appropriation of Net Primary Production (HANPP), Landscape Ecological Potential and Environmentally Weighted Material Consumption). The EEA proposes an ecosystem diagnosis to support ecosystem accounting based on a 'Cube' of six indicators, the main additions relating to water and biodiversity. The 2010 biodiversity target



Copyright: André Künzelmann, UFZ

process, guided by CBD headline indicators and followed by regions across the world provides a much higher quality and consistent basis to support decision makers than was the case only five years ago.

Decision makers need tools such as indicators to feed into accounting systems and guide their decision processes e.g. do international and national policies that govern land use and management provide the correct response to the biodiversity decline? What is the current status of biodiversity? What are the key pressures likely to affect it now and in the future? Good indicators should be policy relevant, scientifically sound, easily understood, practical and affordable and sensitive to relevant changes (CBD 2003; see also TEEB D0 Chapter 3).

Discussions on possible new targets beyond 2010 have started at both the policy and scientific levels. Regardless of their outcome, most indicators discussed here will still be relevant for any new target. The proposal in section 3.2 for five biodiversity/ecosystem indicators (aligned with the Beyond GDP, CBD headline indicators and EEA Cube that looks at elements of ecological potential) could also provide a useful starting point for a post-2010 baseline discussion.

3.5 BUILDING A FULLER PICTURE: THE NEED FOR 'GDP OF THE POOR'

"Progress measured by a single measuring rod, the GNP, has contributed significantly to exacerbate the inequalities of income distribution"

Robert McNamara, President of the World Bank, 1973

The tools described above – adjusting national income (GDP) for ecosystem services (flows) and natural capital (stock) losses – are necessary adjustments but insufficient if a significant set of beneficiaries are poor farming and pastoral communities.

In such cases, we need a more encompassing measure of societal well-being that better reflects the position of society's poorest – those who are most at risk from the consequences of mismeasurement and the loss of ecosystem services. The right income aggregate to measure and adjust is the 'GDP of the Poor'.

3.5.1 A TALE OF TWO TRAGEDIES: THE MEASUREMENT GAP AROUND THE RURAL POOR

Traditional measures of national income, like GDP which measures the flow of goods and services, can be misleading as indicators of societal progress in mixed economies because they do not adequately represent natural resource flows. This flaw materially misrepresents the state of weaker sections of society, especially in rural areas.

To move beyond paradigms focused on income, human development indices (HDI) have been developed to provide a broader-based measure of development. However, HDI also fails to take account of the contribution of natural resources to livelihoods. The World Bank has published total wealth estimates (Dixon, Hamilton and Kunte 1997) which seek to account for the contribution of natural capital, but this is a stock concept. Clearly, there is also a need for a flow variable which can adequately capture the value of natural resource flows, even though these are mainly in the nature of public goods.

Developing 'green accounts', with corresponding adjustments in traditional GDP to account for the depletion of natural capital, is a step in this direction b Genuine Savings Indicator (Pearce and Atkinson 1993) does not indicate the real costs of degradation of natural resources at the micro level. Yet real and often acute costs are felt at the micro level, mainly by the poorest and most vulnerable sections of society (see 3.5.3 below), though these are not usually recorded systematically or brought to the attention of policy makers.

Particularly for developing countries, where many poor people are dependent on natural resources for employment and subsistence, the result is often a tale of two tragedies:

- the first is that the exclusion of ecosystem service flows from society's accounting systems results in a lack of policy attention and public investment in ecosystem and biodiversity conservation. This carries attendant risks of triggering the well-documented **'tragedy of the commons'** – in other words, an *unsustainable* future for generations to come;
- the second tragedy is intra-generational rather than inter-generational. It concerns the **'tyranny of the average'** i.e. the implicit assumption that an increase in any measure of average progress (e.g. GDP Growth) can reflect progress in the *distribution* of well-being within society at large.

A 'beneficiary focus' helps us to better recognise the human significance of observed losses of ecosystems and biodiversity. Moving beyond broad measures of income such as GDP to target the well-being of the poor is particularly relevant tor transitional economies as the key beneficiaries of forest biodiversity and ecosystem services are the rural poor and forest-dwellers.

In this section, we advocate the need for an adapted measure of GDP – the 'GDP of the Poor' that can show the dependence of poor people on natural resources and the links between ecosystems and poverty (section 3.5.2). This takes the form of a three dimensional metric which integrates the economic, environmental and social aspects, thereby indicating the vulnerability of these sections of the population if valuable natural resources are lost (section 3.5.3). Once adjusted for equity, the real cost of loss of biodiversity is different – so this indicator could reflect the impact of loss in biodiversity to the 'real income' and well-being of the poor.

3.5.2 POVERTY AND BIODIVERSITY: FROM VICIOUS TO VIRTUOUS CIRCLE

The links between poverty and biodiversity can be examined through the lenses of livelihoods, distribution, vulnerability and causality.

From a livelihood perspective, abundant biodiversity and healthy ecosystems are important for food security, health, energy security, provision of clean water, social relations, freedom of choice and action. They provide the basic material for good life and sustainable livelihoods and guard against vulnerability (MA 2005). Treating these flows of value to society as externalities results in understating GDP as a measure of total income. In particular, this omission from national accounts of many ecosystem services and biodiversity values misstates the GDP of the Poor who are the key beneficiaries of such services (e.g. direct harvesting of food, fuelwood and non-timber forest products; indirect flows such as the flow of freshwater and nutrients from forests to aquifers and streams to their fields). The predominant economic impact of loss or denial of such inputs from nature is on the income security and well-being of the poor.

An analysis of vulnerability leads to similar conclusions. Natural resources are of course used not only by the poor but by society at large – countries, companies and local communities. However, the vulnerability of different user groups to changes in biodiversity varies according to their income diversity, geographical location and cultural background, among other factors. Table 3.5 illustrates this by reference to end users of forest ecosystems in the state of Para, Brazil, showing their respective vulnerability to climate change and natural hazards. The highest vulnerability is found at the level of local communities in and near forests, largely due to their lack of mobility and access to resources.

Poverty-environment linkages are multi-dimensional and context-specific, reflecting geographic location, scale and the economic, social and cultural characteristics of individuals, households and social groups (Duriappah 1997). "Poverty can be due to a range of lack of the various assets (and income flows derived from them): (a) natural resource assets; (b) human resource assets; (c) on-farm physical and financial assets; (d) off-farm physical and financial assets. A household might be well endowed in one asset but poor in another, and the type of poverty can influence the environment-poverty links" (Reardon and Vosti 1995).

Duriappah (1997) identifies two kinds of poverty: exogenous (external to the group) and endogenous (internal to the community) when he notes that the root cause of environmental degradation is not only poverty but several other factors. Exogenous poverty – factors like greed, institutional and policy failures – leads to environmental degradation which in turn leads to endogenous poverty (e.g. due to degradation of natural assets). Services commonly affected by such degradation include depletion or degradation of water availability, water quality, forest biomass, soil fertility and topsoil as well as inclement micro-climates.

The two types of poverty thus reinforce each other. **Poverty, where it leads to degradation of natural capital to support needs, reduces the services generated by ecosystems which – with lack of investment resources – leads to more poverty and thus creates a vicious circle.**

An example of these linkages (see Box 3.5) is from Haiti, the poorest country in the Western Hemisphere with 65% of its people surviving on less than US$1 a day. Deforestation was shown to have led to much higher vulnerability and loss of life (compared to the neighbouring Dominican Republic) as a result of a cyclone which affected both countries.

Natural resource degradation can thus aggravate loss of natural resources because of the poverty trap. It is essential to break the vicious circle and create a virtuous circle. A proactive strategy of investment in natural capital is needed to help increase the generation of ecosystem services.

Table 3.5: Illustration of differences in forest dependence, vulnerability to climate change impacts and factors affecting the vulnerability of different forest user groups for the State of Para, Brazil

User group	Main goods and services	Level of vulnerability	Factors affecting: Exposure	Factors affecting: Sensitivity	Factors affecting: Adaptive capacity
Federation	Biological diversity; timber and non-timber products; emission reductions; hydro-electric energy	Low for some goods and services, high for others	Geographic location; GHG emissions	Deforestation and un-controlled logging increases sensitivity	Mobility of resources; accessibility to technology, human and financial resources; diversity of land uses; biological diversity
State government (e.g. Pará)	Biological diversity; timber and non-timber products; emission reductions	Medium to high	Geographic location; GHG emissions	Deforestation and un-controlled logging increases sensitivity	Limited mobility; limited access to technology and resources; limited diversity of land uses
Logging companies	Timber	High	Geographic location; GHG emissions	Demand for timber; unauthorized forest conversion; forest degradation	Limited mobility and access resources; SFM and diversification of species harvested may increase adaptive capacity and reduce sensitivity
Forest communities in Pará	Timber and non-timber forest products; drinking water; soil restoration	High to very high	Geographic location; GHG emissions	High dependence on forest products and services in an area of high potential exposure	Diversity of uses; maintenance of biodiversity; very limited mobility and access to resources
Communities outside forests in Pará	Some timber and non-timber forest products; energy from wood	High to very high	Geographic location; GHG emissions	Market demand for agriculture products; poor soil management	Very limited mobility and access to resources; limited diversity

Source: Louman et al. 2009

Box 3.5: Environmental degradation and vulnerability: Haiti and the Dominican Republic

The relationship between environmental degradation and impacts on vulnerable populations is evidenced through the contrasting impacts of Hurricane Jeanne felt in Haiti and the Dominican Republic (DR). Haiti was originally fully forested but from 1950-1990 the amount of arable land almost halved due to soil erosion: deforestation reduced the evaporation back into the atmosphere and total rainfall in many locations has declined by as much as 40%, reducing stream flow and irrigation capacity.

By 2004 only 3.8% of Haiti was under forest cover compared to 28.4% of DR. Floods and Jeanne killed approximately 5,400 people in Haiti due to a loss of green cover, destruction of storm-protecting mangroves and a loss of soil-stabilising vegetation, causing landslides that led to most casualties. In DR, which is much greener and still has 69,600 hectares of mangroves, Jeanne claimed less than 20 lives (Peduzzi 2005).

This stark difference reflects the impacts that deforestation and resource degradation have on the resilience of poor people in the face of environmental hazards. It also demonstrates the higher risks experienced by vulnerable populations that do not have enough disposable income, insurance or assets to recover from disasters. With an average income of 30.5 US$/month, Haitians are not only more vulnerable but are also deeply affected by the worsening status of the environment. This has translated into political turmoil, overexploitation of resources that perpetuates the poverty-ecosystem degradation trap, health concerns and an emergence of environmental refugees that has implications for bordering countries' stability and natural resources.

Source: Peduzzi 2005

3.5.3 PRACTICAL STEPS TOWARDS MEASURING THE GDP OF THE POOR

Tackling poverty and biodiversity loss requires us to ensure efficient and sustainable utilisation of natural resources. The development paradigm should take into account the nexus between growth, poverty and environment.

The first step for economies where rural and forest-dweller poverty is a significant social problem is to use a sectoral GDP measure which is focused on and adapted to their livelihoods. **At a micro-level, the inclusion of ecosystems and biodiversity as a source of economic value increases the estimate of effective income and well-being of the rural and the forest-dwelling poor, if all services are systematically captured.** Initially, adding the income from ecosystem services to the formal income registered in the economy will appear to reduce the relative inequality between the rural poor and other groups, insofar as urban populations (rich and poor) are less dependent on free flows from nature. However, if natural capital losses – which affect the rural poor much more – are factored in, the picture of inequality changes again: it is clear that where natural capital is being lost, the rural poor are even less well off.

Moving towards this kind of measurement has useful potential for policy making. The examples below illustrate by how much income would change if all services were systematically quantified (for details, see Annex). The methodology used considers the sectors in national accounts that are directly dependent on availability of natural capital i.e. agriculture and animal husbandry, forestry and fishing. If these three sectors are properly accounted for, the significant losses of natural capital observed have huge impacts on their respective productivity and risks. We collectively identify these sectors as the GDP of the [rural] poor that is registered in the economy. To get the full GDP of the Poor, however, non-market benefits in these sectors (including non-market forestry products) and ecosystem services also need to be added.

We should emphasise that degradation of ecosystems and loss of biodiversity has different impacts at the macro and micro level. At the micro level, it leads to the erosion of the resource base and environmental services. **Viewed from an 'equity' perspective, the poverty of their beneficiaries makes these ecosystem service losses even more acute as a proportion of their incomes and livelihoods.**

Three case studies were conducted for India, Brazil and Indonesia to test this emerging methodology for country analysis purposes. The results are synthesised in Table 3.6 below and presented in the Annex (see Boxes 3.A1 to 3.A3 and Table 3.A1).

For India, the main natural resource-dependent sectors – agriculture, forestry and fisheries – contribute around 16.5% to the GDP. When the value of ecosystem services provided by forests and the value of products not recorded in GDP statistics are added, **this increases the adjusted contribution of agriculture, forestry and fishing to GDP from 16.5% to 19.6%**. For the rural poor, the per capita value from the agricultural, forest and fisheries sectors combined was 138.8 US$/capita (average for the rural poor). When non-market goods are included as well as the value of ecosystem services, per capita effective income goes up to 260 US$/capita. This is a much larger increase than for the average across the economy as a whole.

A similar pattern is also observed in the Brazilian and Indonesian case studies, where the increase is even more significant. The role of ecosystem services and non-market priced goods, including forest products, also play a predominant role in the income of the rural poor in Brazil and Indonesia.

These figures are a first estimate useful not only to test the indicator, but to illustrate the importance of the information that can be obtained. Though only a few of the ecosystem services could be added and generally conservative estimates have been used, the results underline the potential for further development of this indicator.

The analysis also emphasises that even with the partial evidence available, the issue of the rural poor's dependency on income from non-market products and services is a critical one to factor into policymaking. Their dependency and their increasing loss of livelihood from the erosion of natural capital, underlines the need for a strategy for investing in the natural capital stocks that support the GDP of the Poor.

Table 3.6: GDP of the Poor and share of GDP

Natural-resource dependent sectors and ESS (2005)	Brazil	Indonesia	India
Original share of GDP (%) – agriculture, forestry, fisheries	6.1%	11.4%	16.5%
Adjusted share of GDP (%) + non market + ESS	17.4%	14.5%	19.6%
Original per capita unadjusted 'GDP of the poor' (US$/capita)	51	37	139
Adjusted GDP of the poor per capita (US$/capita)	453	147	260
Additional GDP of the poor from ESS and non market goods (US$/capita)	402	110	121
Share of ESS and non market goods of total income of the poor (%)	89.9%	74.6%	46.6%

Chapter 3 has looked at the range of issues of measuring to manage our natural capital – from scientific, biodiversity and ecosystem service indicators to economic and other macro indicators. This underlines the fact that insufficient use is made of nature-related indicators. It has shown that national accounting frameworks and the associated GDP indicator integrate only part of what we need to measure – with natural capital accounts not yet generally developed, they only present part of the picture of the wealth of nations, well-being of societies and progress. Lastly, the Chapter looked at the social dimension and at the experimental indicator of GDP of the Poor, highlighting the higher dependency and vulnerability of the rural poor to the provision of services from natural capital and changes to the underlying natural capital stock.

Chapter 4 will look at how the values of ecosystems and biodiversity can be calculated, how they are used in policymaking and **how such values (both monetary and non-monetary appreciation) can be integrated into policy assessments**.

Endnotes

[1] 'Measures' are actual measurements of a state, quantity or process derived from observations or monitoring. 'Indicators' serve to indicate or give a suggestion of something of interest and are derived from measures. An 'index' is comprised of a number of measures in order to increase their sensitivity, reliability or ease of communication (see TEEB D0 Chapter 3 for further definitions used in TEEB).

[2] International workshop in Reading, UK, organised by sCBD and UNEP-WCMC: http://www.cbd.int/doc/?meeting=EMIND-02)

[3] http://www.jncc.gov.uk/page-2199

[4] In addition, immaterial capital (e.g. patents, licences, brands) plays a core role in modern economic development.

[5] See 2008 SNA, 10.44, http://unstats.un.org/unsd/nationalaccount/SNA2008.pdf;

[6] In November 2007, the European Commission, European Parliament, Club of Rome, OECD and WWF hosted the high-level conference "Beyond GDP" with the objectives of clarifying which indices are most appropriate to measure progress, and how these can best be integrated into the decision-making process and taken up by public debate. A direct outcome of the conference was the publication in 2009 of the Communication "GDP and beyond: Measuring progress in a changing world" by the European Commission, which includes an EU roadmap. http://www.beyond-gdp.eu/index.html

[7] The project exists to foster the development of sets of key economic, social and environmental indicators to provide a comprehensive picture of how the well-being of a society is evolving. It also seeks to encourage the use of indicator sets to inform and promote evidence-based decision-making, within and across the public, private and citizen sectors. http://www.oecd.org/pages/0,3417,en_40033426_40033828_1_1_1_1_1,00.html

[8] Known as Verbium Sapienta (1665). Produced by William Petty for resource mobilisation during the 2nd Anglo-Dutch war 1664-1667

[9] Known as La dime royale (1707). Published by Sebastien le Prestre de Vauban, and based on his experience of mobilising resources for the construction of military forts on French borders.

[10] Published by Wassily Leontief, Nobel Prize winner 1973, as "The balance of the economy of the USSR, A methodological analysis of the work of the Central Statistical Administration" (1925)

[11] Published by Simon Kuznets, Nobel Prize winner 1971.

[12] Published by Richard Stone, Nobel Prize winner 1984.

[13] Published by OEEC (precursor to OECD)

[14] The difficulties of Accounting for Ecosystems, starting from cases studies and the valuation of ecosystem services, were considered in a recent article (Mäler 2009). The authors state in the conclusion that "When we deal with ecosystem services, we the analysts and we the accountants must figure out the accounting prices from knowledge of the working of every ecosystem. It is therefore—at least for now—impossible to design a standardised model for building a wealth based accounting system for ecosystems. We have to develop such an accounting system by following a step by step path, going from one ecosystem to another."

[15] The ecological potential is measured from multi-criteria diagnosis (rating) based on these accounts, possibly completed on indicators related to populations' health and to external exchanges.

[16] See http://www.beyond-gdp.eu/

REFERENCES

Baillie, J.E.M.; Collen, B.; Amin, R.; Resit Akcakaya, H.R.; Butchart, S.H.M.; Brummitt, N.; Meagher, T.R.; Ram, M.; Hilton-Taylor, C. and Mace, G.M. (2008) Toward monitoring global biodiversity. Conservation Letters 1: 18-26.

Balmford, A.P.; Crane, A.; Dobson, R.; Green, E. and Mace, G. M. (2005) The 2010 challenge: data availability, information needs and extraterrestrial insights. Philosophical Transactions of the Royal Society of London 360: 221-228.

Balmford, A.; Rodrigues, A.S.L.; Walpole, M.; ten Brink, P.; Kettunen, M.; Braat, L. and de Groot, R. (2008) The Economics of Biodiversity and Ecosystems: Scoping the Science, Cambridge, UK: European Commission (contract: ENV/070307/2007/486089/ETU/B2). URL: http://ec.europa.eu/environment/nature/biodiversity/economics/teeb_en.htm (last access Oct 30, 2009).

Boyd, J. and Banzhaf, S. (2007) What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63: 616-626.

Braat, L. and ten Brink (Eds.) with Bakkes, J.; Bolt, K.; Braeuer, I.; ten Brink, B.; Chiabai, A.; Ding, H.; Gerdes, H.; Jeuken, M.; Kettunen, M.; Kirchholtes, U.; Klok, C.; Markandya, A.; Nunes, P.; van Oorschot, M.; Peralta-Bezerra, N.; Rayment, M.; Travisi, C. and Walpole, M. (2008) The Cost of Policy Inaction (COPI): The Case of not Meeting the 2010 Biodiversity Target. European Commission, Brussels.

Butchart, S.H.M.; Stattersfield, A.J.; Baillie, J.E.M.; Bennun, L.A.; Stuart, S.N.; Akçakaya, H.R.; Hilton-Taylor, C. and Mace, G.M. (2005) Using Red List indices to measure progress towards the 2010 target and beyond. Philosophical Transactions of the Royal Society 360: 255-268.

Butchart, S.H.M.; Akçakaya, H.R.; Chanson, J.; Baillie, J.E.M.; Collen, B.; Quader, S.; Turner, W.R.; Amin, R.; Stuart, S.N., and Hilton-Taylor, C. (2007) Improvements to the Red List Index. Public Library of Science ONE, 10.1371/journal.pone.0000140.

CBD – Convention on Biological Diversity (2003) Monitoring and Indicators: Designing National-Level Monitoring Programmes and Indicators.CBD, Montreal.

CBD – Convention on Biological Diversity (2009) 2010 Biodiversity Target: Indicators. URL: http://www.cbd.int/2010-target/framework/indicators.shtml (last access October 30, 2009).

Collen, B.; Loh, J.; Whitmee, S.; McRae, L.; Amin, R. and Baillie, J. (2009) Monitoring change in vertebrate abundance: the Living Planet Index. Conservation Biology 23: 317-327.

Costanza, R.; d'Arge, R.; Groot, R.d.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O'Neill, R.V.; Paruelo, J.; Raskin, R.G.; Sutton, P. and Belt, M. (1997) The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

Danielsen, F.; Burgess, N.D. and Balmford, A. (2005) Monitoring matters: examining the potential of locally-based approaches. Biodiversity and Conservation 14: 2507–2542.

Dixon, J.; Hamilton, K. and Kunte, A. (1997) Measuring the Wealth of Nations, Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development. Environmentally Sustainable Development Studies and Monographs, Series 17, Washington D.C.

Dobson, A. (2005) Monitoring global rates of biodiversity change: challenges that arise in meeting the Convention on Biological Diversity (CBD) 2010 goals. Philosophical Transactions of the Royal Society of London 360: 229-241.

Duraiappah, A.K. (1998) Poverty and environmental degradation: A review and analysis of the nexus. World Development 26 (12): 2169-2179.

EC – European Commission (2008a) A mid-term assessment of implementing the EC Biodiversity Action Plan, (COM (2008) 864 final), Commission of the European Communities, Brussels.

EC – European Commission (2008b) Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss (COM (2008) 645/3). Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels.

EC – European Commission (2009) GDP and beyond: Measuring progress in a changing world (COM (2009) 433). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels.

Ecologic, SERI and Best Food Forward (2008) Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use. Report to the European Commission, DG Environment. URL: http://ec.europa.eu/environment/natres/pdf/footprint_summary.pdf (last access Oct 30, 2009).

EEA – European Environment Agency (2006) Land accounts for Europe 1990-2000. EEA Report No 11/2006 prepared by Haines-Young, R. and Weber, J.-L., European Environment Agency, Copenhagen, Denmark. URL: http://reports.eea.europa.eu/ eea_report_2006_11/en (last access Oct 30, 2009).

EEA – European Environment Agency (2007) Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. EEA, Copenhagen, Denmark.

Ekins, P. (1992) A Four-Capital Model of Wealth Creation. In Ekins, P. and Max-Neef, M. (Eds.). Real-Life Economics: Understanding Wealth Creation. London/New York, Routledge: 147-155.

Eliasch, J. (2008) Climate Change: Financing Global Forests: The Eliasch review. URL: http://www.occ.gov.uk/activities/eliasch/full_report_eliasch_review(1).pdf (last access Nov 6, 2009).

Folke, C.; Carpenter, S.; Walker, B.; Scheffer, M.; Elmqvist, T.; Gunderson, L. and Holling, C.S. (2004) Regime shifts, resilience, and biodiversity in ecosystem management. Annual Review of Ecology, Evolution and Systematics 35: 557-581.

Gallai, N.; Salles, J-M.; Settele, J. and Vaissière, B. (2009) Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics 68 (2009) 810-821

GHK, IEEP, PSI et al. (2005) SRDTOOLS Methods and tools for evaluating the impact of cohesion policies on sustainable regional development (SRD) Contract no.: 502485 Sixth Framework Programme Priority 8.3.1 Task 11 Regio Underpinning European Integration, Sustainable Development, Competitiveness and Trade Policies.

Global Footprint Network (2009) Footprint for Nations. URL: http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_for_nations/ (last access Oct 29, 2009).

Godfrey, L. and Todd, C. (2001) Defining Thresholds for Freshwater Sustainability Indicators within the Context of South African Water Resource Management. 2nd WARFA/Waternet Symposium: Integrated Water Resource Management: Theory, Practice, Cases. Cape Town, South Africa.

Greiber T.; van Ham C.; Jansse G. and Gaworska M. (2009) Final study on the economic value of groundwater and biodiversity in European forests. 070307/2007/486510. IUCN ROfE, IUCN ELC and CEPF, Brussels 2009.

Hails, C.; Humphrey, S.; Loh, J. and Goldfinger, S (Eds.) (2008) Living Planet Report 2008. WWF, Gland, Switzerland.

Hammond, A. Kramer, W., Tran, J., Katz, R. and Walker, C. (2007) The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid. World Resources Institute, March 2007.

Hassan, R. (2005) The System of Environmental and Economic Accounting. Presentation given at FRANESA Workshop, June 12-16, Maputo.

Hewitt, N. (2002) Trees and Sustainable Urban Air Quality. URL: http://www.es.lancs.ac.uk/people/cnh/ (last access Oct 30, 2009).

IPCC – Intergovernmental Panel on Climate Change (2007) Climate Change 2007: the Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge, UK: Cambridge University Press.

IUCN – International Union for Conservation of Nature (2001) IUCN Red List categories and criteria: Version 3.1. IUCN Species Survival Commission, Gland, Switzerland and Cambridge, UK.

Kettunen, M.; Bassi, S.; Gantioler, S. and ten Brink, P. (2009) Assessing Socio-economic Benefits of Natura 2000 – a Methodological Toolkit for Practitioners. Output of the project Financing Natura 2000: Cost estimate and benefits of Natura 2000 (Contract No.: 070307/2007/484403/MAR/B2). Institute for European Environmental Policy (IEEP), Brussels, Belgium.

Layke C. (2009) Measuring Nature's Benefits: A Status Report and Action Agenda for Improving Ecosystem Services Indicators. Mainstreaming Ecosystem Services – Policy Series No. 2. External Review Draft. World Resources Institute (WRI).

Leopold, A. (1953) Round River, Oxford University Press, Oxford.

Loh, J.; Green, R.E.; Ricketts, T.; Lamoreux, J.; Jenkins, M.; Kapos, V. and Randers, J. (2005) The Living Planet Index: using species population time series to track trends in biodiversity, Philosophical Transactions of the Royal Society of London 360 (1454): 289-295.
Losey, J. E. and Vaughan, M. (2006) The Economic Value of Ecological Services Provided by Insects. BioScience 56: 311-323.

Louman, B. et al. (2009) Forest ecosystem services: a cornerstone for human well-being. In: Seppälä, R. (Ed.) Adaptation of forest and people to climate change: a global assessment report. IUFRO World No. 22. 15-27.

MA – Millennium Ecosystem Assessment, (2005) Ecosystems and human well-being: Biodiversity synthesis. World Resources Institute, Washington, D.C.

Mace, G.M. and Baillie, J. E.M. (2007) The 2010 biodiversity indicators: challenges for science and policy. Conservation Biology 21: 1406-1413.

Mäler, K.G.; Aniyar, S. and Jansson, Å. (2009) Accounting for Ecosystems. Environmental & Resource Economics 42(1): 39-51.

Meadows, D. (1998) Indicators and Information Systems for Sustainable Development – a Report to the Balaton Group. The Sustainability Institute, Hartland, USA. URL: www.sustainability-institute.org/ resources.html#SIpapers (last access Oct 30, 2009).

Ott W. and Staub, C. (2009) Wohlfahrtsbezogene Umweltindikatoren – Eine Machbarkeitsstudie zur statistischen Grundlage der Ressourcenpolitik. Bundesamt fuer Umwelt, Bern. Switzerland. URL: http://www.bafu.admin.ch/publikationen/publikation/01041/index.html?lang=en&downloadshop=NHzLpZig7t,lnp6I0NTU042l2Z6ln1ad1IZn4Z2qZpnO2Yuq2Z6gpJCDdIN8fWym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2IdvoaCVZ,s-.pdf (last access Oct 30, 2009).

Pearce, D.W. and Atkinson, G. (1993) Capital Theory and the Measurement of Sustainable Development: An Indicator of Weak Sustainability. Ecological Economics 8: 103-108.

Peduzzi, P. (2005) Tropical Cyclones: Paying a High Price for Environmental Destruction. Environment and Poverty Times 3. URL: http://www.grida.no/publications/et/ep3/page/2587.aspx (last access Oct 30, 2009).

Pimm, S.L.; Russell, G.J.; Gittleman, J.L. and Brooks, T.M. (1995) The future of biodiversity. Science 269: 347-350.

Powe, N.A. and Willis, K.G. (2002) Social and Environmental Benefits of Forestry. Phase 2: Mortality and Morbidity Benefits of Air Pollution Absorption by Woodland Landscape benefits. Report to the Forestry Commission, UK. URL: http://www.forestry.gov.uk/pdf/sebreport0703.pdf/$FILE/sebreport0703.pdf (last access Oct 30, 2009).

Reardon, T. and Vosti, S. (1995) Links between rural poverty and the environment in developing countries: asset categories and investment poverty. World Development 23 (9): 1495-1506.

Ricketts, T. H.; Daily, G. C.; Ehrlich, P. R. and Michener, C. D. (2004). Economic value of tropical forest to coffee production. PNAS 101: 12579-12582.

Salafsky, N.; Margoluis, R. and Redford, K.H. (2001) Adaptive management: a tool for conservation practitioners, Biodiversity Support Program, Washington, D.C.

Schutyser, F. and Condé, S. (2009) Progress towards the European 2010 target. EEA Report No 4/2009. URL: http://www.eea.europa.eu/publications/progress-towards-the-european-2010-biodiversity-target (last access Oct 30, 2009).

South Australia's Strategic Plan (2007) Objective 3 – Attaining Sustainability. URL: http://www.saplan.org.au/content/view/97/ (last access Oct 30, 2009).

Stern, N. (2006) The Stern Review on the Economics of Climate Change. Cambridge University Press, Cambridge.

Stiglitz, J.E.; Sen, A. and Fitoussi, J.-P. (2009) Report by the Commission on the Measurement of Economic Performance and Social Progress URL: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf (last access Oct 30, 2009).

ten Brink P.; Miller, C.; Kettunen, M.; Ramsak, K.; Farmer, A.; Hjerp, P. and Anderson, J. (2008) Critical Thresholds – Evaluation and Regional Development. European Environment 18: 81-95.

Torras, M. (2000) The Total Economic Value of Amazonian Deforestation 1978-1993. Ecological Economics 33: 283-297

Trumper, K.; Bertzky, M.; Dickson, B.; van der Heijden, G.; Jenkins, M. and Manning, P. (2009) The Natural Fix? The role of ecosystems in climate mitigation. A UNEP rapid response assessment. UNEP-WCMC, Cambridge, UK

Tucker, G.M.; Bubb, P.; d.Heer, M.; Miles, L.; Lawrence, A.; van Rijsoort, J.; Bajracharya, S.B.; Nepal, R.C.; Sherchan, R.C. and Chapagain, N. (2005) Guidelines for biodiversity assessment and monitoring for protected areas. King Mahendra Trust for Nature Conservation / UNEP-WCMC, Kathmandu, Nepal / Cambridge, UK.

Turner, W.R.; Brandon, K.; Brooks, T.M.; Costanza, R.; da Fonseca, G.A.B. and Portela, R. (2007) Global conservation of biodiversity and ecosystem services. BioScience 57: 868-873.

United Nations (1968) A System of National Accounts, Studies in Methods. Series F, No. 2, Rev. 3, New York.

United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2003) Integrated Environmental and Economic Accounting (SEEA 2003). URL: http://unstats.un.org/unsd/env Accounting/ seea2003.pdf (last access Oct 30, 2009).

United Nations, European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2008). System of National Accounts (SNA 2008). URL: http://unstats.un.org/unsd/nationalaccount/SNA2008.pdf (last access Oct 30, 2009).

UNDP – United Nations Development Program (2002) RBM in UNDP: Selecting Indicators, Signposts in Development. URL: http://www.undp.org/cpr/iasc/content/docs/MandE/UNDP_RBM_Selecting_indicators.pdf (last access Oct 30, 2009).

UNEP-WCMC (2009) International Expert Workshop on the 2010 Biodiversity Indicators and Post-2010 Indicator Development. UNEP-WCMC, Cambridge, UK. http://www.cbd.int/doc/meetings/ind/emind-02/official/emind-02-0709-10-workshop-report-en.pdf (last access Oct 30, 2009).

van Beukering, P.J.H.; Cesar, H.J.S. and Janssen, M.A. (2003) Economic valuation of the Leuser National Park on Sumatra, Indonesia. Ecological Economics 44: 43-62.

Weber, J.-L. (2007) Implementation of land and ecosystem accounts at the European Environment Agency. Ecological Economics 61 (4): 695-707.

Weber, J.-L. (2008) Land and ecosystem accounts in the SEEA revision. Position paper for the UN London Group meeting, Brussels, 29 September-3 October 2008.

World Bank (2006) Where Is the Wealth of Nations? Measuring Capital for the 21st Century, The World Bank, Washington D.C. URL: http://siteresources.worldbank.org/INTEEI/214578-1110886258964/20748034/All.pdf (last access Oct 30, 2009).

Worm, B., Barbier, E.B.; Beaumont, N.; Duffy, J.E.; Folke, C.; Halpern, B.S.; Jackson, J.B.C.; Lotze, H.K.; Micheli, F.; Palumbi, S.R.; Sala, E.; Selkoe, K.A.; Stachowicz, J.J. and Watson, R. (2008) Impacts of biodiversity loss on ocean ecosystem services. Science 314: 787-790.

Quotes

Page 2: Simon Kuznets in 1934, in: Kuznets, S. (1934) National Income, 1929-1932. 73rd US Congress, 2nd session, Senate document no. 124, page 7.

Page 2: Simon Kuznets in 1962, in: Kuznets, S. (1962) How To Judge Quality. The New Republic, October 20, 1962.

Page 3: Joseph Stiglitz, 2005, in: Foreign Affairs. URL: http://www.foreignaffairs.org/.html (last access Oct 30, 2009).

Page 21: Stiglitz-Sen-Fitoussi Report on the Measurement of Economic Performance and Social Progress, 2009. URL: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf (last access Oct 30, 2009).

Page 32: Robert McNamara, President of the World Bank, 1973. URL: http://www.foe.co.uk/community/tools/isew/annex1.html (last access Oct 30, 2009).

ANNEX: COUNTRY-BASED CALCULATIONS OF GDP OF THE POOR

Box 3.A1: Country GDP of the Poor Calculations – India

Agriculture and allied activities contribute around 16.5% to the GDP, with per capita income of US$ 2,220 (adjusted for purchasing power parity). A large proportion of timber, fuelwood and non-timber forest products are not recorded in the official GDP, so these were added as adjustments. To these tangible benefits we have also included the contribution of ecotourism and biodiversity values and ecological services provided by forest ecosystems, based on estimates from the Green Accounting for Indian States Project (GAISP). The adjusted contribution of agriculture, forestry and fishing to GDP has increased from 16.5% to 19.6%.

More specifically:

- not all of the contribution of agriculture, forestry and fishing can be attributed to poor people;
- we assumed that fuelwood and NTFPs are totally consumed by the poor;
- for ecotourism, we assumed that with international tourists, there is a leakage of around 40% out of India and only the remaining 60% is captured by the host country. Of this 60%, part of the income accrues to the government, tour operators, hotels and restaurants (we assumed 50%) and only the remainder goes to the local people. For domestic tourists, we also assume that officially recorded revenue is captured by the formal sector and only the rest accrues to local people;
- for bioprospecting, from a strict ‘equity’ perspective, it can be argued that the entire revenue should be captured by locals. However, we assume that locals get a royalty of only 25% and that the rest goes to the bioprospector or to the relevant government and agency. This is a very rough approximation: in practice, local people may often get considerably less than this (see also the section on Access and Benefit Sharing in Chapter 5);
- the other ecological services considered are carbon sequestration, flood control, nutrient recycling and water recharge for which the locals directly benefit (except for carbon).

Based on this, **the per capita GDP accruing to the poor (whom we define as population holding less than 1 hectare of agricultural land, people dependent on forests and the small fishing community) is 260 US$/year.** If this income is deducted from GDP, the per capita income available for the rest of the community is 435 US$/year. However, if ecosystems are degraded, the cost may not be equal to the benefits forgone for the following reasons:

- the costs can be higher because if local people try to get the same benefits elsewhere, it costs them much more (marginal utility of income generated is always lower than marginal disutility from spending the money);
- the marginal utility of a dollar obtained by a poor person is always higher than that of a rich person;
- the poor do not have any buffer from degradation of ecosystem services in the form of institutions and financial resources, unlike the rich.

For these reasons, a loss of a dollar would hurt poor people more than a dollar to the rich. We therefore need to use equity weighting. We have used the ratio of mean per capita expenditure on food of households at the top of the pyramid to that of the households at the bottom of the pyramid as the equity weight. This data has been taken from a survey by the World Resources Institute (Hammond et al. 2007).

Box 3.A2: Country GDP of the Poor Calculations – Brazil

In Brazil, agriculture and allied activities contribute only around 6.1% to the GDP, with per capita income of US$ 8151 (adjusted for purchasing power parity). After accounting for unrecorded goods and unaccounted services from forests in the national accounts, based on a study by Torras (2000) adjusted for inflation, the adjusted contribution of agriculture, forestry and fishing to GDP has increased to 17.4%. This is not surprising given that forests cover 87% of Brazil's land area (of which primary forests cover 50% of the land area). Brazil has an active market for environmental services, the benefits of which are shared by several stakeholders.

We assumed that climate regulation services provided by forests are captured by global populations and the rest of the ecological services will accrue to Brazilians. Of this we assumed that only 10% of the benefits (except ecological services) and 2% of ecological services (assumed in proportion to the area held by the poor) accrue to the rural poor (Brazil has only 14% rural population). Based on this, the per capita GDP accruing to the poor (whom we define as population holding less than 4 hectares of agricultural land, people dependent on forests and the small fishing community) is 453 US$/year and that available for the rest of the community is 1,416 US$/year. After adjusting for the equity weighting (ratio of mean per capita expenditure on food of households occupying the top of the pyramid to that of the bottom of the pyramid), the inequality-adjusted cost per person for the poor community is US$ 642.

Box 3.A3: Country GDP of the Poor Calculations – Indonesia

Agriculture and allied activities contribute around 11.4% to the GDP, with per capita income of US $ 2931 (adjusted for purchasing power parity). After accounting for unaccounted timber, fuelwood and non-timber forest products, ecotourism, biodiversity values and ecological values that are not recorded in the GDP, the adjusted contribution of agriculture, forestry and fishing to GDP has increased to 14.5%. These values were taken initially from a study by Beukering et al. (2003). However, based on expert opinion in Indonesia*, these values seem to be a little higher for the country as a whole: we have therefore revised the estimates upwards to reflect the reality.

As valuation is context and area specific, it is better to consider a range of values across the country rather than transferring one estimate for the entire region. The following conservative range of estimates seem to be an appropriate lower band, based on various studies conducted in Indonesia:

- unrecorded timber and fuelwood used directly by forest-dependent poor communities: 40–60 US$/hectare/year;
- non-timber forest products: 22–30 US$/hectare/year;
- ecotourism and biodiversity: 12-20 US$/hectare/year;
- ecological services: 40–60 US$/hectare/year*.

The same study was used to calculate the proportion of benefits shared by poor people. The different groups of stakeholders identified as benefiting from forest ecosystems include: 1) local communities (households, small-scale farmers and entrepreneurs); (2) local government (the body responsible for maintaining infrastructure and collecting local taxes); (3) the elite logging and plantation industry (owners of concessions); (4) national government (law enforcement); and (5) the international community (representing global concerns for poverty, climate change and biodiversity loss).

If the forests are harvested selectively, the share of benefits received by the local community is estimated to be 53%, by local governments 10%, by elite industries 14%, by national governments 5% and by the international community 18%. In this study, we have assumed that poor people get 53% of the total benefits. Based on this, the per capita GDP accruing to the poor (whom we define as population holding less than 4 hectares of agricultural land, people dependent on forests and the small fishing community) is 147 US$/year and that available for the rest of the community is 425 US$/year.

As the loss of one dollar of benefits derived from ESS to the rich is not same as one dollar to the poor, we should use equity-adjusted income (equity weights were derived by dividing the mean per capita expenditure on food of households in the top of the pyramid to that of the bottom of the pyramid). Based on this, the inequality-adjusted cost per person for the poor community is US $ 327.

**Source: Ahmad, Mubariq (2009), Mimeo based on experts discussion in reference to various segmented forest valuation studies known in the circle of Forestry Department, Bogor Agriculture University*

Table 3.A1: Equity-adjusted income of the poor (adjusted for purchasing power parity, 2005)

		Brazil	**Indonesia**	**India**
Gross domestic product (US$ millions)	(1)	1517040	670840	2427390
Contribution of agriculture, forestry, livestock and fishing (US$ millions)	(2)	92397	76715	401523
Of which contribution by the poor (per hectare value multiplied with area of small holdings less than 1 ha) (US$ millions)	(3)	993	3708	48867
Percentage contribution of agriculture, forestry and fishing to GDP	(4)	**6.1 %**	**11.4 %**	**16.5 %**
Total population (millions)	(5)	186	229	1094
Of which poor (millions)	(6)	19.6	99	352
Per capita agricultural GDP of the poor	(7=3/6)	**50.7**	**37.4**	**138.8**
Per capita GDP for the rest of the population (less GDP of the poor and rest of the population) (8 = (1 - 3)/(6 - 7)		9104,6	5138,9	3208,0
Adjustments for unrecorded timber and fuel wood from forestry GDP (US$ millions)	(9)	5870	6660	16477
Adjustments for contribution of NTFPs to the economy (US$ millions)	(10)	57158	5230	11691
Adjustments for ecotourism and biodiversity values (US$ millions)	(11)	28866	1823	17285
Adjustments for other ecological services (US$ millions)	(12)	79193	6800	28282,6
Adjusted contribution of agriculture, forestry and fishing to GDP	(13 = 9+10 +11+12+2)	263484	97227	475258
Adjusted contribution of agriculture, forestry and fishing to the poor	(14)	8870	14579	91580
Per capita adjusted agricultural GDP for the dependent population	(15=14/6)	**452.6**	**147**	**260.1**
Per capita adjusted GDP for the entire population	(16=13/5)	1416	425	435
Equity adjusted cost per person for agriculture dependent community	(17 = equity weight*15)	***641.9***	***327***	***307.0***
Contribution of Ecological services to classical GDP (in US$ millions)	(18= 13-2)	171807	20512	73735
Additional contribution to GDP	(19=18/1)	11.0%	3.1%	3.1%
Total Share of GDP	(20-19+5)	**17.4%**	**14.5%**	**19.6%**
Contribution to the poor (in US$ millions)	(21 = 14-3)	7877	10872	42713

For figures see country notes below:

1) Brazil: Brazil has a population of 20 million dependent on forests including 350,000 indigenous people. The figures also include population with less than one hectare agricultural land and fishing population. The equity weights are based on the ratio of consumption expenditures on food of the top expenditure group to the bottom expenditure groups based on survey by the world resources institute.

2) Indonesia: Indonesia has 80 to 95 million people who are directly dependent on forests (based on a publication on forest dependent population by FAO). The figures also include population with less

than one hectare agricultural land and fishing population. Of the 40 million households who are dependent on agriculture, 14% have less than 1 ha of land holdings in Indonesia. The equity weights are based on the ratio of consumption expenditures on food of the household occupying the top of the pyramid to those in the bottom of the pyramid based on a survey by the world resources institute.

3) India: The values for forests are based on the Green Accounting for Indian States Project (GAISP) floor values adjusted for the year 2005. For timber, fuelwood only open forests are considered. For the rest very dense and dense forests are considered. For the forest dependent population, based on the publication forest dependent population, India has 200 million people who are directly dependent on forests. To this are included, population with less than one hectare agricultural land and fishing population. The equity weights are based on the ratio of consumption expenditures on food of the agricultural households with more than 4 hectares agricultural land to the households having less than 1 ha land.

4) Note: the services to agriculture, fishery and livestock can be captured through the productivity approach method, i.e. any decrease or deterioration in services is already reflected in the value added in agriculture, livestock and fishing sectors. So these values were not calculated separately').