TOPIC GUIDE:
Ecosystem Services

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About Topic Guides

Welcome to the Evidence on Demand series of Topic Guides. The guides are being produced for Climate, Environment, Infrastructure and Livelihoods Advisers in the UK Department for International Development (DFID). There will be up to 30 Topic Guides produced 2013-2014.

The purpose of the Topic Guides is to provide resources to support professional development. Each Topic Guide is written by an expert in the field. Topic Guides:

- Provide an overview of a topic;
- Present the issues and arguments relating to a topic;
- Are illustrated with examples and case studies;
- Stimulate thinking and questioning;
- Provide links to current best 'reads' in an annotated reading list;
- Provide signposts to detailed evidence and further information;
- Provide a glossary of terms for a topic.

Topic Guides are intended to get you started on a subject with which you are not familiar. If you already know about a topic then you may still find it useful to take a look. Authors and editors of the guides have put together the best of current thinking and the main issues of debate.

Topic Guides are, above all, designed to be useful to development professionals. You may want to get up to speed on a particular topic in preparation for taking up a new position, or you may want to learn about a topic that has cropped up in your work. Whether you are a DFID Climate, Environment, Infrastructure or Livelihoods Adviser, an adviser in another professional group, a member of a development agency or non-governmental organisation, a student, or a researcher we hope that you will find Topic Guides useful.

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I would like to read items in the reading list. Where can I access them?

Most resources mentioned in the Topic Guides are readily available in the public domain. Where subscriptions to journals or permissions to access to specialist libraries are required, these are highlighted.

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- Use the Have Your Say section on the Evidence on Demand website (www.evidenceondemand.info). Here you can email our team with your thoughts on a guide. You can also submit documents that you think may enhance a Topic Guide. If you find Topic Guides useful for your professional development, please share your experiences here.
- Send an email to the Evidence on Demand Editor at enquiries@evidenceondemand.org with your recommendations for other Topic Guides.

About the Topic Guide: Ecosystem services

The purpose of this Topic Guide is to assemble a set of learning resources that will contribute to the development of the professional competence of DFID Advisers around the issue of ecosystem services and integrating this issue into project and programme design processes. The specific objectives are to:

- Ensure that DFID Advisers fully understand the relationship between ecosystem services and the key sectors and policy areas in which DFID works; this will specifically involve understanding the value of these services, and their potential role in achieving sustainable poverty reduction;
- Identify where and how ecosystem services could be affected (positively and negatively) by, or could affect (positively and negatively), activities in DFID core sectors;
- Explore where and how an examination of ecosystem services can contribute to the development of stronger business cases and improved development outcomes;
- Enable DFID Advisers (1) to provide operational advice on ecosystem services across a wide range of sectors and (2) to clearly articulate the benefits of examining ecosystem services – in a manner easily understood by those in other technical disciplines (this will involve, for example, clearly articulating the economic and social benefits).

This Topic Guide provides a practical overview of the concept of ecosystem services and their relevance to development. It reviews the broad evidence around the links between ecosystem services and human well-being and highlights the risks and opportunities that need to be considered in core development sectors including infrastructure, disaster risk reduction, health and private sector development. It provides some specific guidance on how (and whether) a consideration of ecosystem services can be integrated into development decision-making.

Recommended reading and other resources are highlighted for those seeking a more detailed examination of the evidence base within specific sectors or for those who simply wish to expand their knowledge of ecosystem services further. This is particularly the case around the complex issue of governance of ecosystem services and the conflicts that arise around control of ecosystem services – for example in large scale land acquisition, in intensive agricultural production, and in the management of water and other scarce resources. Additional Topic Guides are available to provide more detailed insights into specific sectors where management of ecosystem services is critical; these are available for download from www.evidenceondemand.info.

Of particular relevance are Evidence on Demand's Topic Guides on Agriculture and Growth; Water Security and Economic Development; and Agricultural Productivity. Also of interest, and soon to be published, will be a Topic Guide on urban pollution and another on the linkages between climate, environment and conflict.

Report summary

1. Ecosystem services are the **benefits that people obtain from nature**. There is a wide range of these services, but they can be broadly categorised into four different types:

- ***Provisioning services***: These are the 'goods' or products obtained from ecosystems (such as food or fuel);
- ***Regulating services***: These are the benefits obtained from the regulation of ecological processes (such as decomposition, primary production, and nutrient or energy fluxes);
- ***Cultural services***: These are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences;
- ***Supporting services***: These are the basic services or 'ecosystem processes' that are necessary for the production of all other ecosystem services. These include soil formation, photosynthesis, primary production, nutrient cycling and water cycling.

2. All of humanity is dependent on ecosystem services for survival, but **the poor are disproportionately dependent** because of their limited ability to purchase alternatives or substitutes. Ecosystem services also make significant contributions to the economies of poor countries:

- Forestry provides more than 10% of the GDP in many of the poorest countries and up to 20% of export earnings in several developing countries;
- Fisheries account for between 10% and 33% of government budgets in several West African countries;
- Soil degradation accounts for losses of up to 9% of agricultural GDP in developing countries.

3. Ecosystem services can contribute to the **effectiveness and sustainability of development interventions**. It is frequently far cheaper to maintain ecosystem services than to invest in more expensive – and often less effective – man-made alternatives. Maintaining wetlands for flood control, for instance, is usually substantially cheaper than using high-cost flood-proof construction methods or rebuilding the roads, bridges and buildings that get washed away. Conserving an upstream forest typically costs far less than investing in new water filtration and treatment plants downstream, or undertaking expensive de-silting activities. But ecosystem services are in decline and their potential to generate these benefits is becoming progressively compromised. Furthermore, the very same development interventions that benefit from ecosystem services can be one source of the environmental degradation that compromises their continued delivery.

4. Ecosystems are complex, dynamic systems. Individual ecosystem services do not exist in isolation, but interact in a similarly complex and dynamic manner. Sometimes there are synergies between services, but **trade-offs are common**. Specific attention, therefore, needs to be paid to ecosystem services in development decision-making in order to maximise the opportunities they present and minimise the risks and trade-offs.

5. Straightforward **environmental impact assessment is not enough** as it does not consider interactions within complex systems and between ecological and social systems. Furthermore, it is insufficient to simply explore how development can affect ecosystems and what mitigative action might be required to protect them. Assessing development options

through an ecosystem services lens helps decision-makers clarify how and where development decisions *depend* on ecosystems and how best to *invest* in them in order to **maximise positive development outcomes.**

Overall, adopting an ecosystem approach can help improve development policy and decision-making by:

- **Increasing long-term resilience** of development policies and interventions;
- **Reducing risks** from failing natural systems;
- **Reducing public costs** from degraded natural services;
- **Supporting a natural safety net** for poor people in rural areas.

6. There are a number of different ways in which ecosystem thinking can be incorporated into development decision-making – firstly **within internal processes** and secondly **within development partner processes**. Within DFID, the business case process is an obvious starting point. But ecosystem thinking should also extend to country and sector strategy papers, to the guidance provided to partners and contractors in project proposal formulation and development, and to developing country government partners as they prepare national and sector policies and plans. A plethora of practical guidance can help guide the process, and initiatives, such as the study on The Economics of Ecosystems and Biodiversity (TEEB)[1] and the Wealth Accounting and Valuation of Ecosystem Services (WAVES)[2]. These provide a wealth of lessons learned on different approaches.

7. Private corporations are rapidly waking up to the fact that their operations depend on ecosystem services and not taking them into account in decision-making presents both an operational and reputational risk. They are also realising – and cashing in on – the opportunities that ecosystem-based enterprises present, especially in the context of a push toward a greener economy. **Development decision-making is in danger of being left behind** and in having to race to catch up to 'ecosystem-proof' its investments – just as it had to 'climate-proof' them a decade ago. Adjusting development decision-making to incorporate consideration of the risks and opportunities associated with ecosystem services may seem like a daunting and onerous task, but it is an essential mechanism to ensure development interventions are sustainable, effective and provide **long-term value for money**.

1 www.teebweb.org
2 www.wavespartnership.org

SECTION 1

Understanding ecosystem services

What are ecosystem services?

Ecosystem services are the benefits that people obtain from the natural environment. These benefits include, for example, pollination services provided by birds and insects, soil nutrient cycling provided by soil invertebrates and microorganisms, climate regulation provided by forest canopies, and food and fuel based on plant and animal products.

There is a wide range of these services and they can be categorised in different ways. The most common is that used by the international study the 'Millennium Ecosystem Assessment'[3] (MA), which groups ecosystem services into four different types:

- ***Provisioning services***: These are the 'goods' or products obtained from ecosystems;
- ***Regulating services***: These are the benefits obtained from the regulation of ecological processes (such as decomposition, primary production and nutrient or energy fluxes);
- ***Cultural services***: These are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences;
- ***Supporting services***: These are the basic services or 'ecosystem processes' that are necessary for the production of all other ecosystem services. These include soil formation, photosynthesis, primary production, nutrient cycling and water cycling.

The international initiative on The Economics of Ecosystems and Biodiversity (TEEB) identifies 22 different types of ecosystem service (not including basic ecosystem processes), which are summarised in Table 1.

Ecosystem goods, services and processes – what's the difference?

"Primary production (an ecosystem process) is necessary for there to be a wheat crop (a final service), but the good, which may be flour, requires many other inputs (cultivation, harvesting, transport and preparation) before it can be consumed. Similarly, an ecosystem might be managed to grow trees (a final ecosystem service), which can be used for a variety of different goods, such as timber, fuel wood, carbon storage or recreation…. Typically, the focus for environmental and habitat management is the final ecosystem service rather than either the underpinning processes or the goods" (Mace et al. 2012).

[3] www.maweb.org

Provisioning services	*Regulating services*	*Habitat services*	*Cultural and amenity services*
1 **Food** (e.g. fish, game and fruit)	7 **Air quality regulation** (e.g. capturing [fine] dust and chemicals)	16 **Maintenance of life cycles of migratory species** (includes nursery services)	18 **Aesthetic information**
2 **Water** (e.g. for drinking, irrigation and cooling)	8 **Climate regulation** (includes carbon sequestration and influence of vegetation on rainfall)	17 **Maintenance of genetic diversity** (especially in gene pool protection)	19 **Opportunities for recreation and tourism**
3 **Raw materials** (e.g. fibre, timber, fuel wood, fodder and fertilizer)	9 **Moderation of extreme events** (e.g.. storm protection and flood prevention)		20 **Inspiration for culture, art and design**
4 **Genetic resources** (e.g. for crop-improvement and medicinal purposes)	10 **Regulation of water flows** (e.g. natural drainage, irrigation and drought prevention)		21 **Spiritual experience**
5 **Medicinal resources** (e.g. biochemical products, models and test-organisms)	11 **Waste treatment** (especially water purification)		22 **Information for cognitive development**
6 **Ornamental resources** (e.g. artisan work, decorative plants, pet animals and fashion)	12 **Erosion prevention**		
	13 **Maintenance of soil fertility** (includes soil formation)		
	14 **Pollination**		
	15 **Biological control** (e.g. seed dispersal and pest and disease control)		

Source: Elmqvist et al. (2010)

Table 1 TEEB typology of ecosystem services[4]

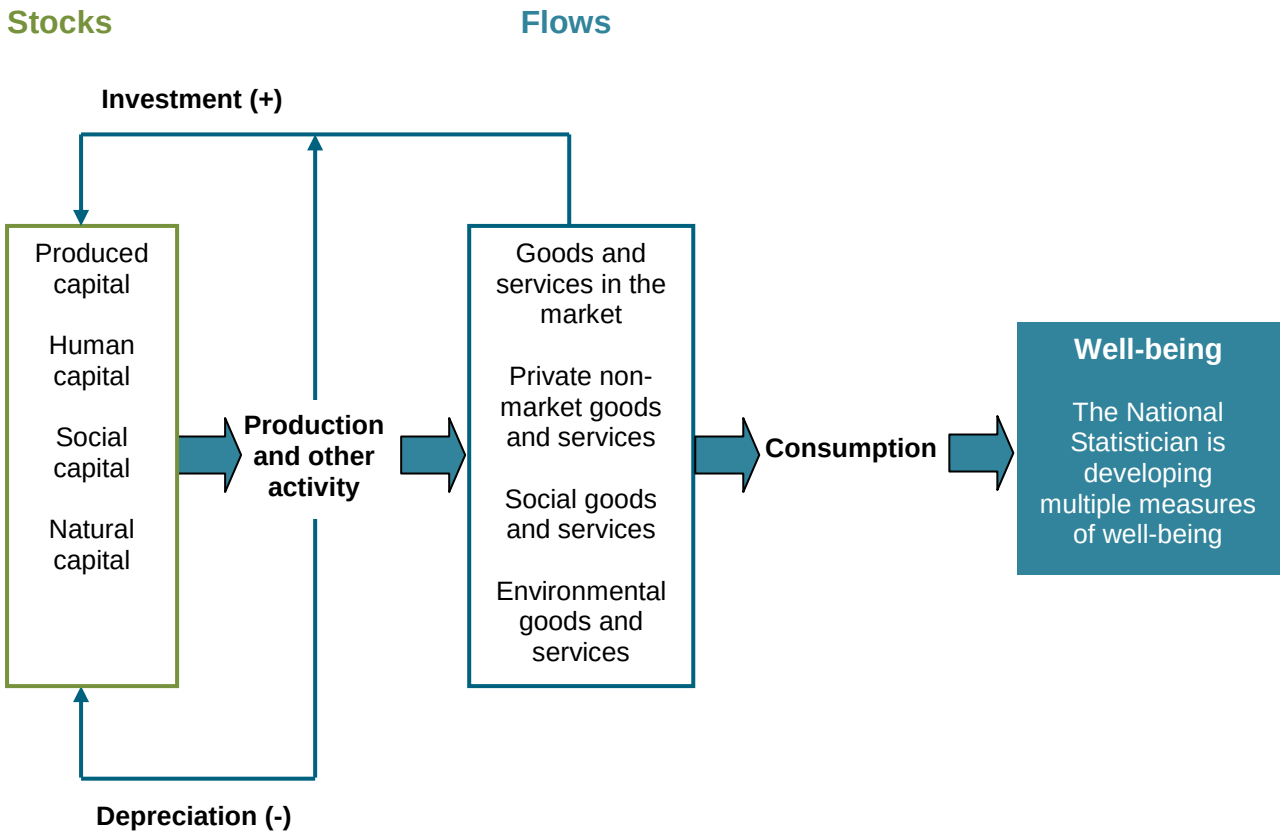
Natural capital, stocks and flows

Ecosystems – and the services they generate – provide the basic infrastructure for life on earth. Economists, accountants and financiers are well used to the concepts of stocks and flows, where a stock is the amount or value of an asset at a given point in time while flows are the additions to or deductions from that stock over a period of time. Similarly, nature can be thought of as a stock of natural capital from which ecosystem services (flows) are derived and which generate benefits for people (Figure 1).

[4] The typology used by TEEB is different to that used by the MA. It omits supporting services since it classifies these as ecological phenomena, which then generate the services which make a contribution to human well-being rather than as services themselves. It adds 'habitat services' on the basis that the provision of services, such as gene pool protection and nurseries, is directly dependent on the state of the habitat providing the service.

Just as it is important not to deplete the capital which generates financial flows, so it is important not to deplete natural capital and thus undermine its ability to sustain the flow of ecosystem services. Yet ecosystem stocks have been severely degraded over the last 50 years and their ability to generate ecosystem service flows is compromised (MA 2005a).

Figure 1 Stocks and flows of natural capital and ecosystem services



Source: Reproduced from DEFRA 2011

The technological fix: can substitutes resolve the problem of ecosystem service decline?

Technological substitutes are available for some (but not all) ecosystem services and can reduce the pressure on these in the short term. Nevertheless, population pressure and economic growth continue to increase aggregate demand for most ecosystem services.

Furthermore, the adverse impacts associated with the production of some substitutions may compromise many ecosystems' abilities to provide other services. Substitution of fuelwood by fossil fuels, for example, reduces pressure on forests and lowers indoor air pollution, but may increase net greenhouse gas emissions. Substitutes are also often costlier to provide than the original ecosystem services (MA 2005a).

Ecosystem services and biodiversity – what is the difference?

The term ecosystem services is often used in conjunction with the term biodiversity – for example in the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES). While the two terms are used almost synonymously, they are not the same thing. However, a review of the evidence base (Elmqvist et al. 2010) shows that biodiversity is important for the delivery of many services. The evidence is particularly strong around the positive link

between biodiversity and improved productivity in both terrestrial and aquatic systems. Overall, though, they conclude that "…it is not yet possible to account accurately for the role of biodiversity, nor the probable impact of its decline, on ecosystem service delivery in general" (Elmqvist et al. 2010, p. 55).

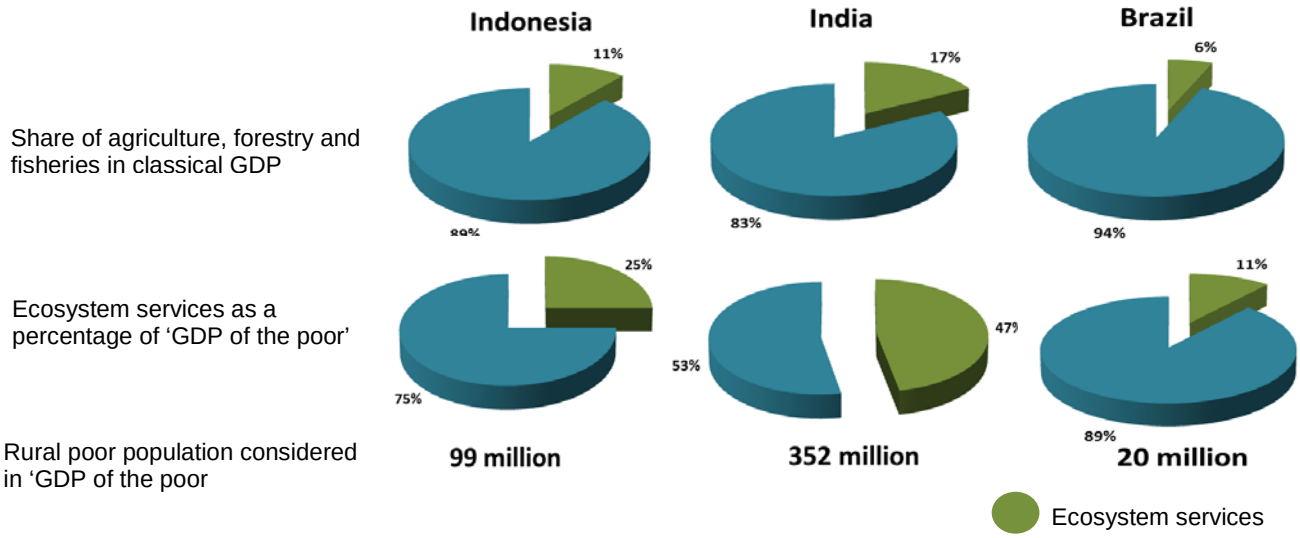
SECTION 2

Ecosystem services and the poor

While the relationship between natural capital, ecosystem services and human well-being is neither linear nor fully understood (technology and other external factors clearly have a mediating influence), it is clear from the very nature of ecosystem services and the functions they perform – described in Section 1 – that all of humanity depends on them to some extent for survival. This is particularly true in the case of poor people. Rich people use more ecosystem services overall, but the poor are disproportionately dependent on ecosystem services because of their limited ability to purchase alternatives or substitutes. Ecosystem services can, therefore, represent the very bottom line and safety net of their everyday existence.

To illustrate this point, the TEEB came up with the concept of 'GDP of the poor'.[5] Using India as a case study, they showed that the value of forest services, such as fresh water, soil nutrients and non-timber forest products (NTFPs), to national GDP was approximately 7%. However, if forest services' contribution to poor people only – rather than the whole economy – was calculated, it was more like 57% of GDP of the poor. Further examples are shown in Figure 2 and Table 2.

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



Source: Adapted from TEEB (2010a).

Not only are the poor disproportionately dependent on ecosystem services for their livelihoods, they are also disproportionately vulnerable to losses of ecosystem services because of their limited ability to pay for substitutes. The MA made a significant contribution in documenting and communicating the importance of ecosystem services to human well-being (MA 2005a). It documented serious degradation of the world's ecosystems and their

[5] 'GDP of the poor' refers to the monetary value of goods and services that accrue to the poorer sectors of society in a country rather than to the country as a whole.

subsequent inability to deliver ecosystem services, pointing out that 15 of the 24 ecosystem services evaluated have been degraded over the past half-century. Critically, the MA noted that "…the harmful effects of the degradation of ecosystem services are being borne disproportionately by the poor, are contributing to the growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict" (MA 2005d, p2)

Service	Examples
Forest products	• Forestry provides more than 10% of the GDP in many of the poorest countries and up to 20% of export earnings in several developing countries • The forestry sector in developing countries provides formal employment for 10 million people and informal employment for a further 30–50 million • A quarter of the world's poor and over 90% of people living in extreme poverty depend on forests for some part of their livelihoods
Fisheries	• Fisheries account for 10–33% of government budgets in several West African countries (Guinea Bissau, Mauritania and Sao Tome) • Fisheries products are the largest agricultural export from African least developed countries • Fisheries provide employment for over 38 million fishers in developing countries – the majority small-scale – and up to 150 million (particularly women) in associated processing and marketing • In Africa, 30–45 million people depend on fish for their livelihoods • In low income, food-deficient countries, fish accounts for 22% of protein consumption
Soil productivity	• Soil degradation accounts for losses of up to 9% of agricultural GDP in developing countries • Economic rates of return of 30% have been shown as a result of soil and water conservation projects in sub-Saharan Africa
Water flows	• Many developing countries lack the man-made infrastructure to manage hydrological variability. Restoring wetlands can provide a cost-effective alternative. The Zambezi Basin has an estimated value of US$3 million in reducing flood-related damage, US$16 million in groundwater recharge and US$45 million in water treatment services • In Mongolia it was found that every US$1 invested in upper catchment watershed management generates at least US$15/year for downstream users

Source: OECD 2008

Table 2 Examples of the contribution of ecosystem services to poor countries and poor people

More changes to the world's ecosystems have occurred in the last 50 years than in the whole of human history. The MA projects even greater declines over the coming decades, particularly in light of continued population growth, industrialisation and economic growth, and climate change. This has potentially serious implications for the sustainability of development investments.

The Intergovernmental Panel on Climate Change says that temperature increases of up to 3°C are very likely to trigger substantial changes in the structure and functioning of all ecosystems. And these changes will happen in a time frame that may not be sufficient to allow the ecosystems to adapt naturally.

The implications of this for all of us are not good. The implications for the poor are even worse, given their dependence on ecosystem services. The converse is also true – investing in ecosystem services could hold great potential for pro-poor growth (OECD 2008; World Resources Institute et al. 2005).

A note of caution…
Vira et al. (2012) point out that the main evidence base relating to the importance of ecosystem services to the poor has focused on provisioning services. The wider regulatory and supporting services, such as hydrological services, climate regulation and soil nutrient enrichment, have usually not been explicitly investigated for their pro-poor support functions. To this extent, the empirical knowledge base is still limited.

Daw et al. (2011) further note that analysis of ecosystem service flows is rarely disaggregated by gender, ethnicity or socio-economic status and thus can overlook trade-offs between different groups and hide variations in the fortunes of the poorest. The assumption that safeguarding or increasing the flow of an ecosystem service will automatically contribute to well-being and poverty alleviation does not always hold true and needs to be tested for each individual case.

SECTION 3

Managing ecosystem services

Synergies and trade-offs

Ecosystems are complex, dynamic systems. Individual ecosystem services do not exist in isolation but interact in a similarly complex and dynamic manner (Paavola and Hubacek 2013). This interaction between services generates both synergies and trade-offs.

Synergies arise when the production of one service enhances the production of another. For example, maintaining soil quality may promote nutrient cycling and primary production, enhance carbon storage and, hence, climate regulation, help regulate water flows and water quality, and improve most provisioning services, notably food, fibre and other chemicals (Elmqvist 2010).

But **trade-offs are common** (see Case study 1). For example, managing a particular ecosystem in a way that generates food and fuel that contribute to human well-being may also support the breeding and release of pests and diseases, which affect human health or damage agricultural crops.

Trade-offs can take a number of different forms including:

1. Service trade-offs: manage for one service – lose another (particularly common between provisioning and regulating services);
2. Temporal trade-offs: benefits now – costs later;
3. Spatial trade-offs: benefits here – costs there;
4. Beneficiary trade-offs: some win – others lose (particularly those with less political or economic power).

Maximising the synergies and minimising the trade-offs between ecosystem services has key implications for **natural resources governance.** Weak governance is repeatedly identified as a key barrier or a reason for the failure of interventions aimed at achieving environmental and developmental benefits (e.g. UNDP 2012). Governance challenges include lack of clearly defined, secure and enforceable land and resource rights, lack of clearly defined roles and responsibilities, and an imbalance in power relations exacerbated by elite capture and corruption.

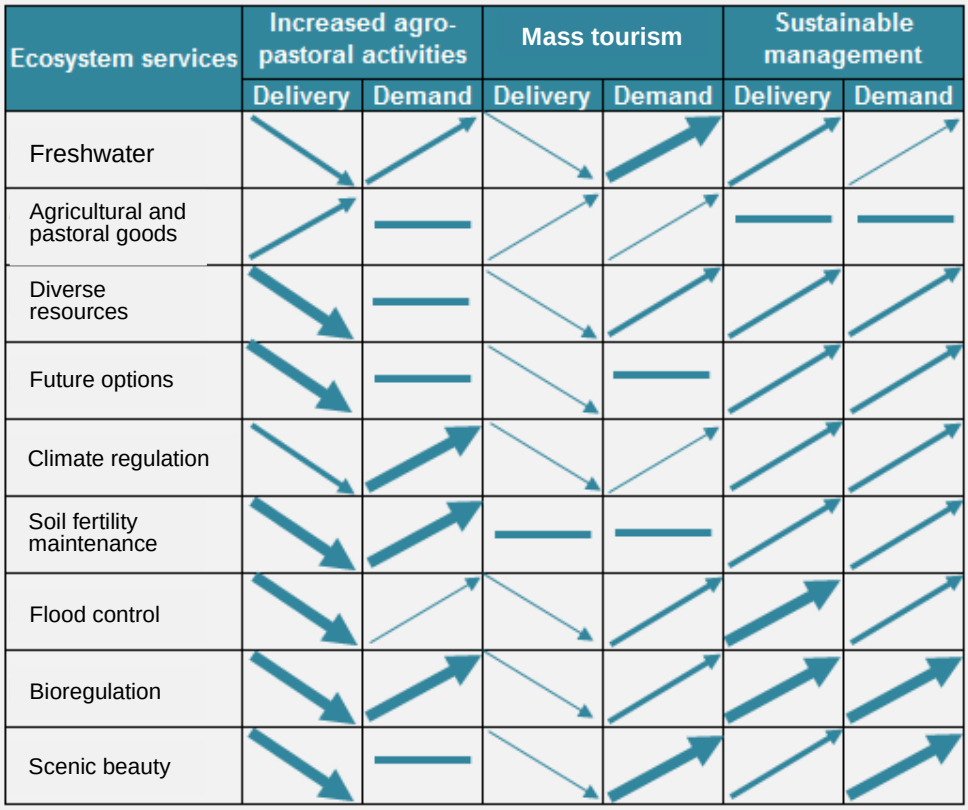
Many ecosystem services have significant economic value (some of which is starting to be captured in some ‘Payments for Ecosystem Services’ schemes which generate incentives for ecosystem service management and conservation). But they also have social and political value and generate competition from different levels and different sectors for access, control and benefits.

Attention to power and distributional issues thus needs to be built into governance systems for ecosystem services if they are to maximise benefits for poor people and contribute to long-term sustainable poverty alleviation. One particular distributional issue is gender – as discussed below.

Case study 1. Ecosystem services and human well-being in the tropical dry forest of the Chamela Region, Mexico

The Chamela Region is located on the Pacific coast of western Mexico. By the early 1990s, 73% of the tropical dry forest had been altered, degraded or converted as a result of the expansion of agriculture and livestock keeping. Three plausible future scenarios were developed for the Chamela Region: increased agricultural and cattle raising activities; mass tourism; and sustainable forest management. These scenarios worked through the expected delivery of and demand for ecosystem services and the possible outcomes for human well-being. Clear trade-offs between the services can be seen.

Figure: Expected delivery and demand of ecosystem services under three development scenarios



Note: The direction of the figure arrows indicates an increase or decrease, and arrow widths denote the intensity of such a process (a wider arrow means a stronger increase or decrease)
Source: Adapted from Maass et al. 2005

Ecosystem services and gender

Women are often affected more by ecosystem decline than men. More often than not they have restricted access to resources and information, and have limited power in decision-making, making them more vulnerable to ecosystem service disruption than men. For example, women and girls are often those responsible for collecting water, an assignment that gets more difficult when water gets degraded. And when ecosystem services improve, women can be crowded out of the benefits by men.

Daw et al. (2011) use an example from Tanzania to illustrate the point. Here, better prices for octopus increased the value of the fishery ecosystem service. However, the well-being of women fishers, the traditional beneficiaries, was negatively affected because they were out-competed by men attracted into the fishery by high prices.

Ironically, women often possess more knowledge about how to maintain or improve ecosystem services than men. Research from India and Nepal, for example, has shown that community forests with a high proportion of women in key decision-making bodies had significantly improved forest conditions (Agrawal 2009). Similarly, in the midst of a drought in the Federated States of Micronesia, it was women who dug into the ground and created a new well that filled with drinkable fresh water. Women's work on the land had given them a considerable understanding of hydrology, but planners and decision-makers had originally not considered their contributions (WEDO 2007).

Managing complexity

By considering the potential impacts of their development plans on a wide range of ecosystem services and, conversely, the potential for ecosystems to contribute to desired outcomes, decision-makers can anticipate potential trade-offs and mitigate problems that may arise. But analysis of ecosystem service flows has to consider not just aggregate flows and benefits, but how these are disaggregated between different social groups – rich and poor, men and women, old and young.

DFID is currently funding a major research programme – Ecosystem Services for Poverty Alleviation (ESPA)[6] to better understand the contribution of ecosystem services to sustainable poverty reduction.

> "Decision-makers may be focused on reducing poverty, increasing food production, strengthening resilience to climate change or producing energy. Development projects and policies intended to meet these goals often go forward unwittingly at the expense of nature – a dam to produce electricity reduces sediment flows and alters temperature gradients, shifting biodiversity structure, and a national plan to expand agriculture may increase deforestation, leading to soil erosion and could, in some circumstances, result in downstream flooding. Ultimately, development goals may be undermined as the effects of these trade-offs are felt by people who depend on nature for their livelihood and well-being, whether it is fish stocks for food, protection from downstream flooding or spiritual sustenance." (Vira et al. 2012)

Nevertheless, basic knowledge of the functions and benefits of ecosystem services described in Section 1 highlight some clear links to the core development sectors of infrastructure, water and sanitation, disaster risk reduction, health and private sector development – as discussed in the next section.

6 http://www.espa.ac.uk/

SECTION 4

Relevance of ecosystem services to core development sectors

For many years now development professionals have recognised the need to climate-proof their investments as they have realised that climate change has the potential to undermine development interventions. The same is true with ecosystem services – perhaps more so, since climate regulation is among the services provided by ecosystems. Taking account of ecosystem services in development decision-making therefore makes financial sense.

Examining development investments through an ecosystem services lens is not, however, intended to simply explore how development can affect ecosystems and what actions might need to be taken to mitigate any adverse impacts. Rather, it is intended to help decision-makers assess how development decisions *depend* on ecosystems and how best to *invest* in them in order to **maximise positive development outcomes**.

> "Recognizing the links between ecosystem services and development goals can mean the difference between a successful strategy and one that fails because of an unexamined consequence for a freshwater supply, an agricultural product, a sacred site, or another ecosystem service." (Ranganathan et al. 2008)

It can often be cheaper to maintain ecosystem services than to invest in more expensive – and often less effective – man-made alternatives (GIZ 2012). Examples can be drawn from across a range of development sectors – from infrastructure to health, and from water and sanitation to economic growth – as to how an ecosystem approach has resulted in a more cost-effective way of delivering on development goals and supporting development processes, especially to the poor. Just as it is clear that development interventions need to be 'climate-proofed', so many examples can be found where failing to 'ecosystem-proof' them has resulted in costs or unintended outcomes that have the potential to undermine development gains.

Climate proofing and ecosystem proofing are in fact linked since climate change alters the quantity, quality and timing of ecosystem service flows, which in turn increases the vulnerability of those individuals, communities and sectors that depend on the services. But at the same time, healthy ecosystems can, in some cases, help reduce or mitigate climate change impacts. For example, vegetation provides climate regulating services by capturing carbon dioxide from the atmosphere, while other ecosystem services, such as water and erosion regulation, natural hazard protection and pest control, can help protect communities from climate-induced events such as increased floods, droughts and pest outbreaks.

Incorporating ecosystems into climate-proofing assessments can help policy makers think through how natural processes might be affected by changes to the climate and how policies need to take account of and manage these risks.

The rest of this section provides examples of the risks and opportunities for different development sectors – many of which are inter-related and all of which are further affected by climate change.

Infrastructure

Ecosystem services can be central to achieving sustainable and cost-effective outcomes from infrastructure projects. For example, the functioning of conventional built water infrastructure (e.g. dams, reservoirs, irrigation systems, levees and canals) relies directly on ecosystem services:

- Dams benefit from forests that stabilise soils and hold back erosion upstream;
- Lakes and wetlands provide water storage and therefore reduce the reservoir volume needed and thus the cost of built water storage.

But the building of water infrastructure can impinge on the very ecosystem services that help support it – for example if forests are cleared or wetlands drained. A critical challenge in developing pro-poor water security is to provide the built water infrastructure that is needed while finding ways of sustaining ecosystem services. One ESPA-funded project implemented by IUCN highlights the need to recognise river basins themselves as infrastructure. They are 'natural infrastructure', providing provisioning, regulating, supporting and cultural ecosystem services, such as water storage, conveyance, flood regulation, safe water supply and water for food. Infrastructure planning and investment can then consider portfolios of infrastructure, based on the economic, social, and environmental costs and benefits of alternate mixes of natural and built infrastructure (Table 3).

Green infrastructure	Benefits	Grey infrastructure	Benefits
Forests and wetlands	Clean water, firewood, pollination, carbon storage and sequestration, foods, fibres, medicinal plants, timber, etc.	Water filtration facility	Clean water
Forests upstream of hydroelectric facility	Reliable power, erosion control, plus all the benefits above	Periodic sediment dredging	Reliable power and flood control
Mangroves	Shoreline protection from storms, fisheries habitat, fuelwood, tourism and jobs, and carbon storage and sequestration	Sea walls	Shoreline protection from storms (though surges can be displaced to other areas)
Coral reefs	Reduced beach erosion, fisheries, habitat and breeding ground for ocean species, coastal protection from storms, tourism attraction	Breakwaters and groins	Reduced beach erosion
Floodplains	Flood prevention, breeding ground for fish and birds, water purification and ground water recharge, soil fertility	Dykes and canals	Flood prevention
Wetlands	Clean effluent, carbon storage and sequestration, coastal protection, fisheries, foods, fibres, medicinal plants, etc.	Water treatment facility	Clean effluent from municipal or industrial processes

Source: Adapted from Krchnak et al. 2011

Table 3 Examples of green and grey water infrastructure providing the same benefits

> "Just as development projects can jeopardize the benefits that flow from ecosystem services, changes in ecosystems can endanger project outcomes." (Landsberg et al. 2013)

Other forms of infrastructure, such as roads and other transport infrastructure, can also have adverse impacts on ecosystem services and vice versa. Construction of roads, for example, usually results in a road bed being raised above the surrounding land surface with the effect that it can act as a dam and restrict the amount of water reaching downstream areas. Ditches dug for road drainage can also drain adjacent wetlands as well. There are also indirect impacts. Opening new roads in previously undisturbed areas, for example, can lead to accelerated exploitation and degradation of ecosystems – as access to markets for natural products becomes feasible. But just as roads can degrade ecosystems, so ecosystems can degrade roads – soil erosion and landslides resulting from deforestation can destabilise built infrastructure, leading to high maintenance costs, as a bare minimum, or to loss of life in extreme circumstances.

While large-scale infrastructure development projects are generally subject to environmental impact assessments (EIAs), these can often fail to consider the potential impacts on or by ecosystem services. EIA tends to consider environment as a 'thing' that may be affected by development (whether it is in terms of a land area that may be disturbed or degraded or species that may be displaced or lost).

Focusing on ecosystem services, however, requires consideration of the uses to which the environment is put and the benefits it generates and which may be lost by the infrastructure development. Both the EU and the International Finance Corporation (IFC) require consideration of ecosystem services in projects that they fund in order to "…maintain the benefits from ecosystem services" (IFC 2012). Similarly the Natural Capital project is working with the Inter-American Development Bank to assess transport project impacts and dependence on ecosystem services, and to incorporate this into project planning.

But infrastructure development can also be enhanced - or even replaced - by ecosystem services. As described in Table 3 above, some elements of the environment can be considered as 'natural' or 'ecological' infrastructure and can often complement or even out-compete built infrastructure. Unlike built infrastructure, ecological infrastructure often provides multiple services. Wetlands, for example, provide water filtration, flood protection, carbon sequestration and fisheries (Box 1). A wastewater treatment plant, in contrast, simply purifies water. Managing ecosystems for their services can be a more cost-effective option than investing in infrastructure and dealing with the consequences of the environmental degradation. Maintaining wetlands for flood control, for instance, is usually substantially cheaper than using high-cost flood-proof construction methods or rebuilding the roads, bridges and buildings that get washed away. Conserving an upstream forest typically costs far less than investing in new water filtration and treatment plants downstream, or undertaking expensive de-silting activities.

Box 1 Cost effectiveness of natural water infrastructure in Uganda

A study of the Nakivubo Swamp in Kampala, Uganda was undertaken to quantify the value of the wetland's wastewater purification and nutrient retention functions and compare them with the potential gains from wetland conversion for industrial and residential developments. Both the avoided costs of replacing natural wetland functions with technological solutions and the foregone expenditures on mitigating or offsetting the effects of wetland loss were estimated.

The results showed the high annual economic value of the swamp's wastewater purification and nutrient retention services – between US$1 million (using replacement cost methods)

and US$1.75 million (using mitigative expenditures methods). Even after accounting for the costs of wetland management (optimising waste treatment potential and maintaining ecological integrity, approximately US$235,000) there was a significant net benefit.

These results provided a powerful argument against further wetland conversion, demonstrating that the swamp saves the government money by providing wastewater management services more cheaply than man-made infrastructural developments. Being able to demonstrate such positive outcomes is particularly useful where public funds are limited, and can help direct funds to their most efficient use.

Source: IUCN (2003)

Water and sanitation

Closely linked to infrastructure is the issue of water and sanitation. Water is central to the delivery of most other ecosystem services (Krauze and Wagner 2007). Achieving development-related water and sanitation targets will require a significant increase in the number of people provided with clean water – which in turn is dependent on the protection of various provisioning and regulating ecosystem services. Ecosystems help meet people's need for water by regulating the water cycle, filtering impurities from water and regulating the erosion of soil into water.

Population growth and economic development have led to rapid water resource development, however, and many naturally occurring and functioning systems have been replaced with highly modified and human-engineered systems. These are not only more expensive and less durable, but their installation can also come at significant cost to natural systems – as discussed in the infrastructure section above.

The Millennium Ecosystem Assessment (MA) neatly summarises the links between ecosystem services and the achievement of development goals relating to water and sanitation (Table 4).

Ecosystems influenced by water and sanitation interventions	Ecosystem services contributing to meeting water and sanitation targets	Synergies (benefits to ecosystem services from achieving water and sanitation targets)	Trade-offs (threats to ecosystems from achieving water and sanitation targets)	Interventions required to minimise costs
Freshwater and wetlands (through increased water withdrawal and pollution) Coastal and marine (through increased water withdrawal and pollution) Agro-ecosystems (through increased demand for water) Urban ecosystems (through faecal	Provisioning of freshwater Water flow regulation and aquifer recharge Water filtration and purification Water cycling	Improved sanitation systems can reduce local microbial pollution and total nutrient load Wastewater treatment can reduce chemical water pollution	Increased demand for surface and groundwater, particularly if traditional sewer technology used Unless accompanied by wastewater treatment, increased access to urban sewers and lead to increased microbial, nutrient and other pollution of freshwater ecosystems	Appropriate pricing mechanisms to regulate water demand Integrated water resources management Improved sanitation technology

Ecosystems influenced by water and sanitation interventions	Ecosystem services contributing to meeting water and sanitation targets	Synergies (benefits to ecosystem services from achieving water and sanitation targets)	Trade-offs (threats to ecosystems from achieving water and sanitation targets)	Interventions required to minimise costs
pollution) Drylands, forests and other ecosystem that compete with humans for water			May require additional water storage facilities	

Source: Adapted from MA 2005b

Table 4 The link between ecosystem services and water and sanitation targets

Disaster risk reduction

Nearly 1.2 million people have lost their lives in disasters related to natural hazards over the past two decades. Associated economic losses are estimated to total approximately US$70 billion per year (UNEP and SRC 2008). Ecosystem services shape both the exposure of people to hazards and the ability of people to cope with hazards. The ongoing degradation of these services is expected to result in both more variable ecological dynamics and more human exposure to hazard (UNEP and SRC 2008).

Many forms of natural disasters can be linked to mismanagement of natural resources, and a poor understanding of ecosystem processes. Flooding and landslides in Haiti, for example, have been linked to high levels of deforestation (Sudmeier-Rieux et al. 2006).

On the other hand, well-managed ecosystems can mitigate the impact of most natural hazards – such as landslides, hurricanes and cyclones – and ecosystem services can play a significant role in disaster prevention, mitigation and adaptation measures. Regulating services are particularly important. For example, vegetation cover and root structures protect against erosion and increase slope stability by binding soil together and preventing landslides; coastal wetlands, tidal flats, deltas and estuaries reduce the height and speed of storm surges and tidal waves (Box 2). But the availability of provisioning services also plays a critical role in determining the ability of local people to recover after the disaster – for example when harvests fail as a result of drought or flooding.

Box 2 Cost-effective flood control from ecosystem services in Vietnam

In the northern coastal regions of Vietnam, more than 70% of the population is threatened by natural hazards – particularly flooding from sea surges. For the last decade, local people have planted and conserved mangroves as a form of protection and as an alternative to constructing artificial dykes and sea walls. Planting and protecting nearly 12,000 hectares of mangroves cost US$1.1 million but saved an estimated annual expenditure on dyke maintenance of US$7.3 million. Furthermore, during Typhoon Wukong in 2000, it is estimated that the planted areas suffered significantly less damage than neighbouring provinces.

Source: Reid 2011

The 2009 UN International Strategy for Disaster Reduction Global Assessment Report identified ecosystem degradation as one of the main drivers of disaster risk worldwide. Environmental degradation reduces the capacity of ecosystems to meet people's need for food and other products, and to protect them from hazards through services such as flood regulation, slope stabilisation and protection from storm surges. Conversely, healthy and

diverse ecosystems tend to be more robust in the face of extreme weather events, and can be better able to continue providing benefits to communities in post-disaster situations (Table 5). The role of ecosystems in mitigating environmental hazards is particularly significant in the context of climate change, whereby extreme weather events are expected to increase in both frequency and severity. Consequently, the United Nations Office for Disaster Risk Reduction (UNISDR) has recognised that ecosystem-based disaster management policies, practices and guidelines need to be an integral part of disaster risk reduction and this is reflected in the Hyogo Framework for Action.

Ecosystem	Disaster risk reduction benefits
Upland forests	• Vegetation cover and root structures protect against erosion and increase slope stability by binding soil together, helping to prevent or reduce the severity of landslides. • Forests can protect against rockfall and stabilise snow, reducing the risk of avalanches. • Catchment forests, especially primary forests, can reduce risk of floods by increasing infiltration of rainfall, and delaying peak floodwater flows, except when soils are fully saturated. • Forests on watersheds are important for water recharge and purification, drought mitigation and safeguarding drinking water supply for some of the world's major cities.
Wetlands and floodplains	• Wetlands and floodplains control or reduce floods in coastal areas, inland river basins, and mountain areas subject to glacial melt. • Peatlands, wet grasslands and other wetlands store water and release it slowly, reducing the speed and volume of runoff after heavy rainfall or snowmelt in springtime. • Coastal wetlands, tidal flats, deltas and estuaries can reduce the height and speed of storm surges and tidal waves. • Marshes, lakes and floodplains release wet season flows slowly during drought periods.
Coastal zones	• Coastal ecosystems function as a continuum of natural buffer systems and can help protect against hurricanes, storm surges, flooding and other coastal hazards – a combined protection from coral reefs, seagrass beds, and sand dunes/coastal wetlands/coastal forests is particularly effective. • Research has highlighted several cases where coastal areas protected by healthy ecosystems have suffered less from extreme weather events than more exposed communities. • Coral reefs and coastal wetlands such as mangroves and saltmarshes can absorb (low-magnitude) wave energy, reduce wave heights and reduce erosion from storms and high tides. • Coastal wetlands can buffer against saltwater intrusion and adapt to (slow) sea-level rise by trapping sediment and organic matter. • Non-porous natural barriers such as sand dunes (with associated plant communities) and barrier islands dissipate wave energy and act as barriers against waves, currents, storm surges and tsunami.
Drylands	• Natural vegetation management and restoration in drylands can help to ameliorate the effects of drought and control desertification, as trees, grasses and shrubs conserve soil and retain moisture. • Shelterbelts, greenbelts and other types of living fences can act as barriers against wind erosion and sand storms. • Maintaining vegetation cover in dryland areas, and agricultural practices such as use of shadow crops, nutrient enriching plants, and vegetation litter increases resilience to drought. • Prescribed burning and creation of physical firebreaks in dry landscapes reduces fuel loads and the risk of unwanted large-scale fires.

Source: Sudmeier-Rieux (2013)

Table 5 Potential disaster risk reduction benefits from healthy ecosystems

Health and hunger

Ecosystem services are intimately linked to human health in other ways beyond disaster risk reduction. They help maintain good health – through provision of basic necessities such as food, fuel, freshwater and so on. They help prevent ill health – for example through waste management and detoxification and through the regulation of infectious diseases. And, when ill health does occur, they help to treat it through the provision of natural medicines and through the contribution of pharmaceutical products to modern medicines.

Adequate food and nutrition is one of the fundamental requisites of good health. Wild foods are locally important in many developing countries, but sources of such foods are declining due to land conversion – and associated habitat degradation – and over-exploitation of some key species and populations, e.g. fisheries. Food production through agriculture is thus a key component of human health strategies but it too is highly dependent on ecosystem services such as soil fertility and structure, nutrient cycling and pollination (Box 3).

Box 3 Pollinators and food production in Mexico

Pollinators are an essential part of the food production process for many crops. They are also important in contributing to gene flow between cultivated species and wild crop relatives, and are of particular importance to poor people for whom wild plant foods can be an important insurance and coping mechanism.

In Mexico, a survey of 316 plant species used for food found that nearly 85% depended to some degree on pollinators. Non-pollinator dependent food crops (cereals) covered a greater cultivated area and produced higher overall volumes, but pollinator dependent crops were of generally higher profitability per hectare.

Source: Ashworth et al. (2009)

But agricultural interventions to reduce hunger and improve food security have significant implications for the maintenance of essential ecosystem services:

- Increasing crop yields through increasing inputs can result in water pollution and significant degradation of ecosystem services.
- Upstream crop irrigation can compromise downstream water services. And climate change may further increase the offtake of water for irrigation because of increased evaporation.
- Increasing the land area for agriculture – particularly when achieved through forest clearance – can result in a wide range of ecosystem service knock-on effects including increased erosion and decreased soil fertility.
- Agricultural intensification can limit availability of, and access to, wild foods.

The pressure to increase agricultural outputs in the short term is thus occurring at the expense of ecosystems' long-term capacity for food production. Sustainability in food production demands attention to the potential trade-offs with other ecosystem services and exploration of methods for sustainable intensification.

Ecosystem services are critical for cleansing the environment of waste and contaminants but the MA estimates that these services are now over-stretched, leading to local and global waste accumulation and associated health risks. Changes to ecosystems can also increase the risk of the spread of infectious diseases, for example, through changes in the number of disease-vector breeding sites or depletion of disease-vector predators. Diseases of

international concern that are associated with ecosystem change and degradation include malaria, dengue fever, schistosomiasis, cholera and cryptosporidiosis (MA 2005c).

Millions of people around the world depend fully or partly on natural medicines. According to the World Health Organization, traditional medicines are estimated to be used by 60% of the world's population and in some countries are extensively incorporated into the public health system (WHO 2014). Medicinal plant use is the most common medication tool in traditional medicine and complementary medicine worldwide. Although synthetic medicines are available for many purposes, the global need and demand for natural products persists both for direct use as medicinal products and for biomedical research.

Private sector development

Many development planning processes target, or involve, the private sector. Private sector engagement with ecosystem services is premised around three different objectives:

1. Risk reduction
2. Continued access to key inputs
3. New business opportunities.

Private companies often depend significantly on ecosystem services – particularly water provision (Lambooy and Levashova 2011). At the same time, however, their operations can result in ecosystem degradation. This can become an operational or reputational risk to corporate performance in the longer term.

Consideration of dependencies and impacts on ecosystem services allows companies to undertake more comprehensive and reliable trade-off analyses as part of their decision-making processes. Analysis by the World Business Council for Sustainable Development shows how different business sectors have both dependencies and impacts on the range of ecosystem services (Figure 3). The Natural Value Initiative recently developed an 'Ecosystem Services Benchmark' to enable institutional investors to better understand the risks and opportunities associated with the impacts and dependencies of the companies in which they invest in relation to biodiversity and ecosystem services.[7]

TEEB (2010b) and BSR (2014) highlight how the private sector is beginning to take ecosystem services into account in its decision-making processes – for example by incorporating them into risk assessments, operations and supply chain management, financial accounting, auditing and reporting. Further work is needed – for example to expand conventional environmental management systems to incorporate ecosystem services – but some innovative approaches are emerging (Box 4).

One increasingly common approach is for the private sector to engage in payments for ecosystem services (PES) schemes: particularly payments for water. Coca-Cola, for example, has water protection plans for each of its key water sources. It also has a principle of replenishment rather than just consumption whereby, based on calculations of total use (freshwater inputs minus treated wastewater), bottling plants must undertake watershed restoration and conservation activities in order to replenish an equivalent amount of water.[8]

[7] http://www.naturalvalueinitiative.org/content/003/303.php

[8] http://www.coca-colacompany.com/water-stewardship-replenish-report/

Box 4 Incorporating ecosystem services into private sector practices – some current examples

- **Coca-Cola**'s Sustainable Agricultural Guiding Principles emphasise the importance of maintaining important ecosystem services, such as natural pest and disease controls, pollination and freshwater flows to maintain production.
- **Rabobank Group** believes it is important that clients know which ecosystem services constitute an opportunity or a business risk, and which factors can have an adverse impact on these services; this advice is incorporated into the bank's lending and investment policies.
- **The Dow Chemical Company** is investigating methods for valuing ecosystem services in order to support its decision-making around the design, construction and operation of manufacturing sites.
- **Rio Tinto** is exploring the potential for designing and implementing ecosystem service offsets and investments in non-operational, land-based assets.

Source: BSR (2014)

Figure 3 The private sector and ecosystem services: risks and opportunities

	Biodiversity dependent industries (e.g. fishing, agriculture, forestry)		Large 'footprint' industries (e.g. mining, oil and gas, construction)		Manufacturing & processing (e.g. chemicals, ICT, consumer products)		Green' enterprises (e.g. organic farming, ecotourism)		Financial services (e.g. banking, insurance & other financial intermediaries)	
Key Ecosystem Services	**Depend**	**Impact**	**Depend**	**Impact**	**Depend**	**Impact**	**Depend**	**Impact**	**Depend**	**Impact**
Provisioning										
Food	▲	▲	△	▲	▲	▲	▲	△	▲	▲
Timber & fibers	▲	▲	▲	▲	▲	▲	▲	△	▲	▲
Freshwater	▲	▲	▲	▲	▲	▲	▲	△	▲	▲
Genetic / Pharmaceutical resources	▲	▲	△	△	▲	▲	▲	△	▲	▲
Regulating										
Climate & air quality regulation	▲	▲	▲	▲	▲	▲	▲	△	▲	▲
Water regulation & purification	▲	▲	▲	▲	▲	▲	▲	△	▲	▲
Pollination	▲	▲	—	△	△	△	▲	▲	▲	▲
Natural hazard regulation	▲	▲	▲	△	▲	△	▲	△	▲	▲
Cultural										
Recreation & tourism	△	▲	—	▲	—	△	▲	▲	▲	▲
Aesthetic / non-use values	△	▲	—	▲	—	△	▲	▲	△	▲
Spritual values	△	▲	—	▲	—	△	▲	▲	△	▲

▲ Moderate to Major relevance △ Minor relevance — Not relevant (typically)

Note: "Supporting services" are not included in this table as they are already captured within provisioning, regulating and cultural services

Source: Reproduced from WBCSD (2011)

Ecosystem services are not just a dependency or risk that needs to be managed, however. They can also provide new business opportunities. For example WBCSD (2011) highlights a number of recent emerging markets:

- The global carbon market grew from virtually nothing in 2004 to over US$140 billion in 2009.
- The current global biodiversity offset market is worth a minimum US$3 billion and is expected to grow rapidly.
- Sustainability-related global business opportunities in natural resources may be in the order of US$2–6 trillion by 2050.

In addition to supporting big business, ecosystem services can also help in the establishment of small enterprises. WRI et al. (2008) highlight how, in particular, they can form the basis of viable and sustainable enterprises for the rural poor. Bowd et al. (2012) present an approach for applying an ecosystem services framework to assist in the identification of opportunities for economic empowerment at two estuary study sites in the Eastern Cape Province of South Africa. The approach aims to provide a structured mechanism for identifying potential estuary-based enterprises that considers both resource conservation and the dependence of human well-being on natural capital.

Climate change

Climate change and ecosystem services are intimately connected – as some of the preceding sections have already shown. Regulation of climate is an ecosystem service mediated by carbon storage and sequestration, and affected by human activity; climate change in turn alters the functions of ecological systems and compromises their ability to produce the ecosystem services on which human well-being depends (Box 5). One of the greatest impacts of climate change will be on water cycles – including changes to precipitation, evaporation, soil moisture, groundwater recharge and runoff. A review on the links between climate change, water ecosystem services and poverty conducted for DFID by IIED (Mayers et al. 2009) noted that:

- Water insecurity linked to climate change threatens to increase malnutrition by 75–125 million people by 2080, with staple food production in many sub-Saharan African countries falling by more than 25%.
- Marked reductions in water availability in East Africa, the Sahel and Southern Africa are predicted as rainfall declines and temperature rises, with large productivity losses in basic food staples. Projections for rainfed areas in East Africa point to potential productivity losses of up to 33% in maize and more than 20% for sorghum and 18% for millet.
- Rising sea levels are likely, resulting in freshwater losses in river delta systems in countries such as Bangladesh, Egypt and Thailand.

Box 5 Climate change affects the ability of ecosystem services to support the poor

The International Coral Reef Initiative estimates that fish catches from coral reefs support 1 billion people in Asia alone. Climate change is causing the sea to warm and to become more acidic (as a result of more CO_2 in the atmosphere) and this is already having a negative impact on coral reefs – and on the fisheries they support. In the Caribbean it is estimated that nearly 30% of warm-water corals have disappeared since the beginning of the 1980s and that one-third of coral reef species are already at risk of extinction. Given the particular dependence of poor people of fisheries – for food and as a source of income – this is an issue of real concern.
Source: http://www.icriforum.org/

Boyd (2010) points out that altered natural systems can lead to social change. “Commercial and agricultural production, populations, and land development will themselves migrate in response to changes in the natural world. These migrations will create feedbacks of their own, since the changed human footprint will place new stresses on natural systems. In other words, ecosystem goods and services will both drive social adaptation and become stressed by that adaptation”. The potential consequences of climate change thus need to be carefully thought through.

But there is another side to the ecosystem services–climate change equation. Ecosystem services can help both mitigate the effects of climate change and help people adapt to the consequences of climate change. According to Munang et al. (2013), “ecosystem based approaches to adaptation (EbA) harness the capacity of nature to buffer human communities against the adverse impacts of climate change through the sustainable delivery of ecosystems services”. Healthy, fully functioning ecosystems are not only likely to be more resilient to stressors and therefore better able to support adaptation to impacts but they also provide many other benefits including – crucially – carbon sequestration.

Terrestrial and marine ecosystems are both sources and sinks of carbon. About 2500 gigatonnes (Gt) of carbon are stored in terrestrial ecosystems and an additional 38,000 Gt in the oceans (albeit only c. 1000 Gt in the upper layer). Carbon from these sources is exchanged naturally to and from the atmosphere. But small changes in ocean and terrestrial sources and sinks can have large implications for atmospheric CO_2 levels – the degradation of many ecosystems significantly reducing their carbon storage and sequestration capacity.

REDD+ (Reduced Emissions from Deforestation and forest Degradation) is a Payments for Ecosystem Services (PES) scheme that recognises the role of forests in carbon storage and sequestration and seeks to generate financial incentives to reduce the release of stored carbon into the atmosphere as a result of deforestation. However, similar schemes are yet to emerge to incentivise the conservation of soil and ocean carbon.

Munang et al. (2013) suggest EbA has a number of advantages over other adaptation approaches:

- it can deliver multiple co-benefits;
- it can help avoid maladaptation and contribute to a ‘no regrets’ approach;
- it addresses both adaptation and mitigation;
- it is cost effective; and
- it provides lasting and sustainable solutions – especially when used in combination with other methods and approaches.

A recent review of the evidence base showed an overall positive effect of EbA in contributing to climate change adaptation (Doswald et al. 2014). It should be noted, however, that there was very limited evidence as to the effectiveness of EbA compared with other adaptation options. Nevertheless, the evidence does support Munang et al’s assertion that EbA interventions can bring multiple social, economic and environmental benefits.

SECTION 5

Integrating ecosystem services into development policy and practice: when and how?

Ecosystem services provide a framework for thinking about the way that the natural environment works as a system, or valuing the ecosystem services it provides at different times and scales and to different people; and for assessing the costs and risks of failing to take ecosystem services into account (DEFRA 2010). The previous sections have highlighted the opportunities and risks associated with ecosystem services for a number of core development sectors – and for poverty alleviation more broadly. Incorporating ecosystem thinking into development decision-making can therefore help plan interventions more effectively and efficiently.

The UK Government's approach to valuing the environment in economic appraisals has adopted an ecosystem approach (DEFRA 2010; https://www.gov.uk/government/collections/the-green-book-supplementary-guidance), which is as relevant to international development as it is to domestic decision-making. The guidance explains that, in essence, adopting such an approach is about:

1. Looking for opportunities to work with natural systems to deliver policy objectives; and
2. Conducting a thorough impact assessment that considers the positive and negative impacts of the policy options on the services we get from nature.

The rationale? Overall, adopting an ecosystem approach can help improve development policy and decision making by:

- **increasing long-term resilience** of development policies and interventions,
- **reducing risks** from failing natural systems,
- **reducing public costs** from degraded natural services.

Entry points

There are a number of different ways in which ecosystem thinking can be incorporated into development decision-making – firstly within internal processes, and secondly within development partner processes. The German development agency (GIZ) has produced a guide to incorporating ecosystem services in development decision-making and identifies the following as key entry points (GIZ 2012):

- Formulation and review of (national) development goals,
- Sector-specific and/or spatial planning processes,
- Project development and proposal formulation,
- Environmental and Climate Assessments,
- Sector networks and working groups.

Within DFID, the requirements of the International Development Act (IDA) (http://www.legislation.gov.uk/ukpga/2002/1/contents) to promote *sustainable* development, the spending targets under the International Climate Fund (ICF), and the Technical Quality Standards under the Smart Rules are the starting point. These policies and regulations recognise that climate change and the degradation of natural resources could drive poor people deeper into poverty and threaten the sustainability of our development efforts.

Guidelines to assist programme teams to ensure DFID investments are compliant with those policies seek to ensure that:

- Climate and environment risks associated with programmes are identified, mitigated and managed;
- Opportunities for environmental improvement or climate change mitigation and adaptation are identified and programme design adjusted where it makes sense; and
- DFID's investment portfolio complies with UK and international environmental laws and standards.

Assessing the potential impacts of a proposed investment on ecosystem services and, conversely, the potential contribution of ecosystem services to a development outcome, could enrich the analysis of environmental risks and opportunities. Box 6 shows how this is done in the context of investment proposals put to the International Finance Corporation (IFC) (see also Landsberg et al. 2013 for practical tips).

Box 6 Excerpt from IFC Performance Standard 6

Management of Ecosystem Services

24. Where a project is likely to adversely impact ecosystem services, as determined by the risks and impacts identification process, the client will conduct a systematic review to identify priority ecosystem services. Priority ecosystem services are two-fold: (i) those services on which project operations are most likely to have an impact and, therefore, which result in consequent adverse impacts to Affected Communities; and/or (ii) those services on which the project is directly dependent for its operations (e.g. water). When Affected Communities are likely to be impacted, they should participate in the determination of priority ecosystem services in accordance with the stakeholder engagement process as defined in Performance Standard 1 [Assessment and Management of Environmental and Social Risks and Impacts].

25. With respect to impacts on priority ecosystem services of relevance to Affected Communities and where the client has direct management control or significant influence, adverse impacts should be avoided. If these impacts are unavoidable, the client will minimize them and implement mitigation measures that aim to maintain the value and functionality of priority services. With respect to impacts on priority ecosystem services on which the project depends, clients should minimize impacts on ecosystem services and implement measures that increase resource efficiency of their operations, as described in Performance Standard 3 [Resource Efficiency and Pollution Prevention]. Additional provisions for ecosystem services are included in Performance Standards 4 [Community Health, Safety, and Security], 5 Land Acquisition and Involuntary Resettlement, 7 [Indigenous Peoples] and 8 [Cultural Heritage].

Source: IFC (2012)

Process

Addressing ecosystem services in development decision-making – whether conducted internally as part of an internal screening process for investment loans or grants, or in the development of a country assistance strategy; by implementing partners as part of project development and proposal formulation; or by developing-country partners as part of national or sectoral development planning processes – requires consideration of a number of key issues. Ranganathan et al. (2008) summarised these into five key steps that capture the key issues that DFID advisers might want to take into account in their own processes or in those contracted to partners:

1. Identify all the ecosystem services that a decision either depends on or affects. A decision depends on an ecosystem service if the service serves as an input or if it enables, enhances or influences the conditions necessary for a successful outcome. A decision affects an ecosystem service if actions associated with the decision alter the quantity or quality of a service. This systematic mapping process should capture upstream and downstream effects as well as temporal trade-offs. It is also important to remember that sometimes development interventions/decisions may affect ecosystem services indirectly rather than directly, by influencing the key drivers of ecosystem change.

2. Prioritise this list in terms of its relevance to the development decision/intervention. The ones which will need to be prioritised are those for which no cost-effective substitute exists and those where the impact limits or enhances the ability of others to use or benefit from that service. Different users and beneficiaries of ecosystem services are likely to have very different perspectives, and so wide stakeholder consultation and participation is an essential requirement of an effective assessment.

3. Conduct a detailed analysis of the condition and trends of the most relevant ecosystem services. Key questions to answer in this assessment are:

    - What are the condition and trends of the selected ecosystem services?
    - What are the major drivers affecting the ecosystem services?
    - What thresholds or irreversible changes have been observed in the ecosystem services?

4. Conduct an economic valuation if necessary. Economic valuations of ecosystem services can be useful for enabling different services to be expressed using a ‘common denominator’ (economic value), and allows trade-offs to be explicitly evaluated. However, economic valuation is complex and particularly difficult where functioning markets do not exist, and in cases where ecosystems shift dramatically and non-linearly. Furthermore, if the development intervention is more concerned with, for example, health impacts then this may not always be required.

5. Analyse the risks and opportunities that arise from a decision using information gathered in previous steps. This might also draw on scenarios of future change. Risks and opportunities can relate to both the dependence of the decision’s goals on ecosystem services and how the decision affects services that other stakeholders rely on. Essentially this process involves trade-offs analysis. Questions to consider include:

    - Does the decision/intervention depend on ecosystem services that were either previously unrecognised or in a poorer condition than previously known?

- Could the goals of the decision be jeopardised because users are competing for an ecosystem service in limited supply? If so, are cost-effective substitutes available?
- Are there any unforeseen impacts of the decision on ecosystem services that others depend on for their well-being?

Similarly, GIZ (2012) developed a step-wise approach to integrating ecosystem services in development decision-making (Table 6).

Step	Key issues
Screening and prioritising	• How does the development plan/intervention depend on and affect ecosystem services? • Which are the priority ecosystem services? • Who are the main stakeholders that are affected by ecosystem services? • How are the benefits and costs distributed between different groups? • Do potential areas of conflict, competition or synergy emerge?
Assessing condition and trends	• What kind of information and evidence exists and where are the evidence gaps? • What are the current conditions and likely future trends in the supply of and demand for the identified ecosystem services? • What and who are the main drivers of change? • What trade-offs might arise between development goals and the ecosystem services, or between stakeholder groups?
Governance	• Which institutions govern ecosystems and their services? Who participates in these, and in the decisions they make? • Which policies, regulations and other positive or negative incentives influence people's use and management of ecosystems and their services? Who or what do they target, and how are they enforced?
Integrating into decision-making	• What ecosystem service-related risks and opportunities to the development plan emerge? • What are the values of different services and who captures/pays for those values?

Source: Adapted from GIZ 2012

Table 6 Integrating ecosystem services into development planning – key issues to address

There is a wide range of tools and methods available to assist those undertaking ecosystem assessments. These include broad guidance on the full ecosystem assessment process (e.g. Ash et al. 2010) and sector-specific guidance (e.g. IPIECA (2011) provides detailed checklists and guidance for oil and gas industry projects). Key tools and resources are summarised in Section 7.

SECTION 6

Conclusions

Ecosystem services affect and are affected by development decisions. The impact that decisions have on ecosystem services can compromise their ability to provide basic life support functions to humanity and to poor people in particular. Conversely, investing in ecosystem services can increase the effectiveness of development interventions and generate wealth for poor people and poor countries.

Private corporations are rapidly waking up to the fact that their operations depend on ecosystem services and not taking them into account in decision-making presents both an operational and reputational risk. They are also realising – and cashing in on – the opportunities that ecosystem-based enterprises present, especially in the context of a push toward a greener economy.

This Topic Guide does not provide an assessment of the evidence base of the contribution of ecosystem services to human well-being and to the achievement of key development goals (but see the many volumes of the Millennium Ecosystem Assessment[9] for just such a review). Nevertheless, it is clear from the simple overview provided in this Guide that ecosystem services could be highly relevant to a number of core development sectors and should be considered carefully when developing policies and planning investments. Such considerations would help identify significant trade-offs – between services, between beneficiaries, between geographical locations and between time periods. They could also help decision-makers clarify how and where development decisions *depend* on ecosystems and how best to *invest* in them in order to **maximise positive development outcomes.**

Overall, taking ecosystem services into account in development policy and decision making could:

- **increase long-term resilience** of development policies and interventions,
- **reduce risks** from failing natural systems, and
- **reduce public costs** from degraded natural services.

Adjusting development decision-making to incorporate consideration of the risks and opportunities associated with ecosystem services may seem a daunting and onerous task, but just like climate-proofing, it can help ensure development interventions are sustainable, effective and provide long-term value for money.

9 www.maweb.org

SECTION 7

Tools and resources

Mapping and assessing ecosystem services

There are a number of tools and methods available to map and assess the state of ecosystem services, including remote sensing and geographic information systems (GIS), ecosystem inventories, models and scenarios.

- Inventories can be compiled to determine the 'stocks' of environmental services and are an important precursor to valuation.
- Models are particularly useful for dealing with data deficiencies as well as for describing interactions among systems and drivers.
- Scenarios are plausible alternative futures (rather than predictions, forecasts or attempts to show the most likely estimates of future trends) and are useful in supporting scientific research, informing collaborative learning processes and underpinning planning and decision-making processes.

The **World Resources Institute** (WRI) has developed a number of checklists and other tools for identifying and prioritising ecosystem services:

- An up-to-date list of ecosystem services is maintained on WRI's website at http://pdf.wri.org/esr_definitions_of_ecosystem_services.pdf
- An Excel spreadsheet tool that includes the list of ecosystem services and questions for evaluating ecosystem service dependence and impacts is available on WRI's website at http://docs.wri.org/esr_dependence_impact_assessment_tool.xls

Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)[10] is a family of tools to map and value the goods and services from nature which are essential for sustaining and fulfilling human life. InVEST enables decision-makers to assess the trade-offs associated with alternative choices and to identify areas where investment in natural capital can enhance human development and conservation in terrestrial, freshwater and marine ecosystems. See also Natural Capital Project (below).

ARtificial Intelligence for Ecosystem Assessment (ARIES)[11] is an online modelling platform to map the potential provision of ecosystem services, their users and biophysical features that can deplete service flows. It is designed to operate with scarce or uncertain data.

10 http://www.naturalcapitalproject.org/InVEST.html

11 www.ariesonline.org/

The **Toolkit for Ecosystem Service Site-based Assessment** (TESSA)[12] is a rapid assessment tool for measuring ecosystem services at the site scale. It is accessible to non-experts and delivers scientifically robust results.

The **Ecosystem Service Indicators Database**[13] is an online searchable database intended to make ecosystem service metrics and indicators readily available for use in policy dialogues and decisions, in ecosystem assessments, and in natural resource management decisions.

Ash et al. (2010) provide a 'how to' guide to ecosystem assessment – making the methods of the MA and the sub-global assessments widely accessible, with the aim of encouraging additional assessments.

Ranganathan et al. (2008) provide tools and checklists for assessing risks and opportunities related to ecosystem services.

Ecosystem service valuation

There is a range of economic valuation methods, including revealed and stated preference techniques, production function methods and benefit transfer, but there is still a need to improve the robustness of techniques. Economic valuation methods have tended to focus on provisioning services, and where value is generated through either direct or indirect use. Less attention has been paid to cultural ecosystem services and non-material values. While there is growing interest in non-monetary techniques, there is no widely accepted framework for eliciting less tangible values and including them in decision making.

The **Wealth Accounting and the Valuation of Ecosystem Services (WAVES)** partnership is a global initiative supported by the World Bank that aims to promote sustainable development by ensuring that the national accounts used to measure and plan for economic growth include the value of natural resources. It uses a natural capital accounting process and provides a wide range of technical papers highlighting its approach and methods.

The **Natural Capital Project (NatCap)** has developed simple, user-driven approaches to valuing nature, works closely with decision-makers and provides free, open-source ecosystem service software tools to a broad community of users.

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focussed on drawing attention to the economic benefits of biodiversity. Its objective is to highlight the growing cost of biodiversity loss and ecosystem degradation. TEEB presents an approach that can help decision-makers recognise, demonstrate and capture the values of ecosystems and biodiversity, including how to incorporate these values into decision-making.

Ecosystem service valuation[14] is a website with information on ecosystem valuation tools including benefit estimation, valuation methods, benefit indicators and practical considerations.

The **Guidance Manual for the Valuation of Regulating Services**[15] is a tool for estimating the economic value of regulating ecosystem services. It is aimed at environmental economists but is also accessible to other potential users.

12 http://www.birdlife.org/datazone/info/estoolkit
13 http://www.esindicators.org/
14 www.ecosystemservicevaluation.org
15 http://hqweb.unep.org/pdf/Guidance_Manual_for_the_Regulating_Services.pdf

Ecosystem service impact assessment

The WRI has developed useful guidance on how to incorporate an ecosystem services perspective into conventional environmental and social impact assessment. The **Ecosystem Services Review for Impact Assessment** **(ESR for IA)** provides practical instructions to environmental and social practitioners on how to incorporate ecosystem services throughout the ESIA process.

The UNEP 'Project for Ecosystem Services' (ProEcoServ) has produced a guide on incorporating ecosystem services into strategic environmental assessment (SEA) (UNEP 2014). The Guidance Manual - **Integrating Ecosystem Services in Strategic Environmental Assessment: A Guide for Practitioners** provides step-by-step instructions on addressing ecosystem services throughout the SEA process.

Corporate risk assessment

Business Ecosystems Training (BET)[16] is an online modular course provided by the World Business Council for Sustainable Development (WBCSD) and intended to help companies to measure, manage and mitigate their impact and dependence on ecosystems and the services they provide.

The **Global Water Tool**[17] is a WBCSD tool for companies and organisations to map their water use and assess risks relative to their global operations and supply chains.

The **Corporate Ecosystem Services Review (ESR)**[18] is a structured methodology developed by the WRI to assess business risks and opportunities associated with ecosystem services.

Sector guides

A wide range of sector-specific guides and checklists are also available.

The **Natural Value Initiative**[19] aims to mainstream biodiversity and ecosystem services into investment analysis. It has developed a toolkit – including an Ecosystem Services Benchmark – to enable the finance sector to:

- Evaluate how well the food, beverage and tobacco (FBT) sectors are managing biodiversity and ecosystem services risks and opportunities; and
- Engage with FBT companies to reduce their risk exposure through the responsible management and harvesting of natural resources.

IPIECA – the oil and gas industry association on social and environmental issues has collaborated with the International Association of Oil and Gas Producers to produce guidance[20] on ecosystem services for the sector. It provides a set of checklists to help identify the main ecosystem service dependencies and impacts of oil and gas developments

16 http://www.wbcsd.org/bet.aspx
17 http://www.wbcsd.org/work-program/sector-projects/water/global-water-tool.aspx
18 http://www.wri.org/publication/corporate-ecosystem-services-review
19 http://www.naturalvalueinitiative.org
20 http://www.ipieca.org/publication/ecosystem-services-guidance-biodiversity-and-ecosystem-services-guide

and it highlights key associated risks and opportunities and provides guidance on potential measures for managing them.

Additional resources

The Convention on Biological Diversity **Ecosystem Approach sourcebook** is a tool to help practitioners implement the ecosystem approach and share experiences. Still under construction, the sourcebook will have several components: a case study database, information about the ecosystem approach, and the various tools and techniques that can be used to implement it. A case study database is operational and searchable.

The **Ecosystem Services for Poverty Alleviation** **(ESPA)** programme is an interdisciplinary research programme funded by DFID, the Natural Environment Research Council and the Economic and Social Research Council. ESPA's research will provide the evidence and tools to enable decision-makers to manage ecosystems sustainably and in a way that contributes to poverty alleviation.

The **Ecosystem Services Partnership** **(ES-Partnership)** is a network connecting researchers working toward a better understanding and application of the concept of 'ecosystem services'. Key products of the partnership are networking and outreach, case studies, data and knowledge sharing, guidelines and toolkits and the support of calls for funding and cooperation.

The **Project for Ecosystem Services (ProEcoServ)** is a GEF-funded umbrella project implemented by UNEP which is intended to support the mainstreaming of ecosystem services into national development planning. Working in five pilot countries, the project has three key components:

- **Support Tools for Policy Making**: Development and application of multi-scale and locally valid tools and decision support models for development planning and policy making.
- **Assistance for Policy Implementation**: Support for the application of ecosystem and ecosystem service management approaches at national and transboundary levels.
- **Bridge between Science and Policy**: Strengthening of science–policy interfaces to reinforce multi-scale linkages from local to international actors, as well as to bridge the gap between research results and policy application in developing countries and the international biodiversity arena.

The **Intergovernmental Platform on Biodiversity and Ecosystem Services** **(IPBES)** provides a mechanism recognised by both the scientific and policy communities to synthesise, review, assess and critically evaluate relevant information and knowledge about ecosystem services generated worldwide by governments, academia, scientific organisations, non-governmental organisations and indigenous communities. This involves a credible group of experts in conducting assessments of such information and knowledge in a transparent way.

The **IUCN Red List of Ecosystems** compiles information on the state of the world's ecosystems at different geographic scales. Its central objective is to assess the risk of ecosystem collapse. The IUCN Red List of Ecosystems categories and criteria will be a global standard for how to assess the status of ecosystems, applicable at local, national, regional and global levels.

The **Millennium Ecosystem Assessment** **(MA)** involved the work of more than 1360 experts worldwide between 2001 and 2005. Their findings, contained in five technical volumes and six synthesis reports, provide a state-of-the-art scientific appraisal of the condition of and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control and natural resources) and the options to restore, conserve or enhance the sustainable use of ecosystems.

References

Ash, N., Blanco, H., Brown, C., Garcia, K., Henrichs, T., Lucas, N., Raudsepp-Hearne, C., Simpson, R. D., Scholes, R., Tomich, T., Vira, B. & Zurek, M. (eds.) (2010) *Ecosystems and human well-being. A manual for assessment practitioners*. Washington, D. C.: Island Press.

Ashworth, L., Quesada, M., Casas, A., Aguilar, R. & Oyama, K. (2009) 'Pollinator-dependent food production in Mexico.' *Biological Conservation*, *142(5)*, p1050-1057.

Bowd, R., Quinn, N., Kotze, D., Hay, D. & Mander, M. (2012) 'The identification of potential resilient estuary-based enterprises to encourage economic empowerment in South Africa: a toolkit approach', *Ecology and Society*, *17(3),* p15.

Boyd, J. (2010) *Ecosystem Services and Climate Adaptation*. Washington, D. C.: Resources for the Future.

BSR. (2014) *Private Sector Engagement with Ecosystem Services*. New York. Available at: http://www.bsr.org/reports/BSR_Private_Engagement_With_Ecosystem_Services_2014.pdf

Daw, T., Brown, K., Rosendo, S. & Pomeroy, R. (2011) 'Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being', *Environmental Conservation*, *38(4)*, p370-379.

DEFRA. (2011) *Natural capital: supporting evidence and analysis to the Natural Environment White Paper – The Natural Choice: securing the value of nature*. London. Available at: http://www.archive.defra.gov.uk/environment/natural/documents/newp-evidence-nat-capital-110607.pdf

DEFRA. (2010) *What Nature Can Do For You. A practical introduction to making the most of natural services, assets and resources in policy and decision making*. London.

Doswald, N., Munroe, R., Roe, D., Giuliani, A., Castelli, I., Stephens, J., Möller, I., Spencer, T., Vira, B., & Reid, H. (2014) 'Effectiveness of ecosystem-based approaches for adaptation: review of the evidence-base', *Climate and Development*, *Volume 6*, *Issue 2*. Available at: http://www.tandfonline.com/doi/abs/10.1080/17565529.2013.867247#.U-Hqm_ldXdg

Elmqvist et al. (2010) 'Biodiversity, Ecosystems and Ecosystem Services', in Kumar, P. (ed.) (2010) *The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations*. London/Washington, D. C.: Earthscan.

GIZ. (2012) *Integrating Ecosystem services in Development Planning. A stepwise approach for practitioners based on the TEEB approach*. Eschborn.

IFC. (2012) *Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources*. Washington, D. C.

IUCN. (2003) *Nakivubo Swamp, Uganda. Managing natural wetlands for their ecosystem services. Case Studies in Wetland Valuation No.7*. Gland.

IPIECA. (2011) *Ecosystem services guidance: Biodiversity and ecosystem services guide*. London.

Krchnak, K., Smit, M. & Deutz, A. (2011) *Putting Nature in the Nexus: Investing in Natural Infrastructure to Advance Water-Energy-Food Security*. IUCN/The Nature Conservancy. Available at: http://cmsdata.iucn.org/downloads/nexus_report.pdf

Landsberg, F., Treweek, J., Stickler, M., Henninger, N. & Venn, O. (2013) *Weaving Ecosystem Services into Impact Assessment*. Washington, D. C.: WRI.

Lambooy, T. & Levashova, Y. (2011) 'Opportunities and challenges for private sector entrepreneurship and investment in biodiversity, ecosystem services and nature conservation', *International Journal of Biodiversity Science Ecosystem Services & Management*, *7(4)*, p301-318.

Millennium Ecosystem Assessment (MA). (2005a) *Ecosystems and human well-being. Current state and trends*. Washington, D. C.: Island Press.

MA. (2005b) *Ecosystems and human well-being. Policy Responses*. Washington, D. C.: Island Press.

MA. (2005c) *Ecosystems and human well-being. Health synthesis*. Geneva: WHO.

MA. (2005d) *Ecosystems and human well-being: Biodiversity Synthesis*. Washington, D. C.: Island Press.

Maass, J., Balvanera, P., Castillo, A., Daily, G., Mooney, H., Ehrlich, P., Quesada, M., Miranda, A., Jaramillo, V., Garcia-Oliva, F., Martinez-Yrizar, A., Cotler, H., Lopez-Blanco, J., Perez-Jimenez, A., Burquez, A., Tinoco, C., Ceballos, G., Barraza, L., Ayala, R. & Sarukhan, J. (2005) 'Ecosystem services of tropical dry forests: insights from long-term ecological and social research on the Pacific Coast of Mexico', *Ecology and Society*, *10(1)*.

Mace, G., Norris, K. & Fitter, A. (2012) 'Biodiversity and ecosystem services: a multi-layered relationship', *Trends in Ecology and Evolution 27(1)*, p19-26.

Mayers, J., Batchelor, C., Bond, I., Hope, R., Morrison, E. & Wheeler, B. (2009) *Water ecosystem services and poverty under climate change: Key issues and research priorities. Natural Resource Issues No. 17*. London: International Institute for Environment and Development.

Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J & Rivington, M. (2013) 'Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering climate change impacts', *Current Opinion in Environmental Sustainability*, *Volume 5*, *Issue 1*, p67-71. Available at: http://dx.doi.org/10.1016/j.cosust.2012.12.001

OECD. (2008) *Natural Resources for Pro-Poor Growth*. Paris.

Paavola, J. & Hubacek, J. (2013) 'Ecosystem services, governance, and stakeholder participation: an introduction', *Ecology and Society 18(4)*, p42.

Ranganathan, J., Raudsepp-Hearne, C., Lucas, N., Irwin, F., Zurek, M., Bennett, K., Ash, N. & West, P. (2008) *Ecosystem services. A guide for decision makers*. Washington, D. C.: World Resources Institute.

Reid, H. (2011) *Improving the evidence base for ecosystem based adaptation. IIED Briefing Paper*. London: IIED.

Sudmeier-Rieux, K. (2013) *Ecosystem Approach to Disaster Risk Reduction*. Brussels: Council of Europe.

Sudmeier-Rieux, K., Masundire, H., Rizvi, A. & Rietbergen, S. (eds.) (2006) *Ecosystems, Livelihoods and Disasters: An integrated approach to disaster risk management*. Gland: IUCN.

TEEB. (2010a) *The Economics of Ecosystems and Biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB*. Nairobi: UNEP.

TEEB. (2010b) *The Economics of Ecosystems and Biodiversity for Business – Executive Summary*. Nairobi: UNEP.

UNDP. (2012) *The Future We Want: Biodiversity and Ecosystems—Driving Sustainable Development. United Nations Development Programme Biodiversity and Ecosystems Global Framework 2012-2020*. New York.

UNEP. (2014) *Integrating Ecosystem Services in Strategic Environmental Assessment: A guide for practitioners*. Proecoserv.

UNEP & SRC. (2008*) Ecosystems and Disaster Risk Reduction: Working Paper in Contribution to the Global Assessment Report*. United Nations Environment Programme/Stockholm Resilience Centre.

Vira, B., Adams, W., Agarwal, C., Badiger, S., Hope, R., Krishnaswamy, J. & Kumar, C. (2012) 'Negotiating tradeoffs: choices about ecosystem services for poverty alleviation', *Economic and Political Weekly*, *47(9)*, p9.

WBCSD. (2011) *Guide to Corporate Ecosystem Valuation*. Geneva. Available at: http://www.wbcsd.org/pages/edocument/edocumentdetails.aspx?id=104&nosearchcontextkey=true

WEDO. (2007) *Changing the Climate: Why Women's Perspectives Matter*. New York. Available at: http://www.wedo.org/wp-content/uploads/changing-the-climate-why-womens-perspectives-matter-2008.pdf

WHO. (2014) *Climate change and human health – Biodiversity* [accessed 31st May 2014]. Available at: http://www.who.int/globalchange/ecosystems/biodiversity/en/

World Resources Institute, United Nations Development Programme, United Nations Environment Programme & World Bank. (2008) *World Resources 2008. Roots of resilience – growing the wealth of the poor*. Washington, D. C.: WRI.

World Resources Institute, United Nations Development Programme, United Nations Environment Programme & World Bank. (2005) *World Resources 2005. The Wealth of the Poor: Managing Ecosystems to Fight Poverty*. Washington, D. C.: WRI.