The Social Dimension of Biodiversity Policy

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The Social Dimension of Biodiversity Policy

FINAL REPORT

by

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Together with

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EXECUTIVE SUMMARY

There has long been a recognised link between biodiversity and human well-being. Biodiversity and its related ecosystems provide vital services such as the provision of clean water, nutrient circulation and protection from natural disasters. It also creates opportunities for employment, either directly (e.g. through fisheries) or indirectly (e.g. the support of the tourism industry). A growing understanding of the benefits provided by nature is generating increased political interest, and provides an opportunity to garner more support for biodiversity conservation by finding common goals with other policy agendas.

This report sets out to investigate the social aspects of biodiversity conservation, in particular the links between biodiversity and employment, and the value of biodiversity for vulnerable rural people. The study maps the linkages between biodiversity, ecosystem services and employment and uses vulnerability-related indicators coupled with spatial mapping of biodiversity and ecosystem values for the EU to determine whether the poor and vulnerable rural communities are more strongly dependent on the provision of ecosystem services. A number of global case studies highlight a range of issues experienced by the rural poor in developing nations dependent on ecosystem services.

Links between biodiversity and employment

The relationships between biodiversity, ecosystem services and employment are significant and closely intertwined. Jobs are linked to biodiversity directly through management and conservation of protected areas, and through the direct provisioning services of ecosystems (supporting primary industries such as fisheries, forestry and agriculture) and indirectly through the provision of valuable ecosystem services such as nutrient cycling and water provision. The numbers of jobs provided directly and indirectly by biodiversity and ecosystem services is significant, both in the EU and in developing countries. A considerably larger proportion of jobs in developing countries (927 million, or 35% of jobs) are highly dependent on ecosystem services than in the EU. (14.6 million or 7%) (see Executive Summary Table 1).

As it is the primary industries which are most highly dependent on biodiversity and related ecosystem services, changes in biodiversity and the consequent effects on ecosystem services (and hence employment) will be felt significantly more in developing economies than in the EU. As a consequence, it is expected that EU employment will be less exposed to the impacts of changes in biodiversity. Those economies whose populations are largely composed of fishermen, subsistence farmers, and rural societies that face ecological degradation will be most at risk, although some communities in the EU will be faced with similar challenges (e.g. remote mountainous communities). In the EU, a relatively large number of service sector jobs are linked to biodiversity and ecosystem services, although these linkages are relatively weaker and opportunities for substitution greater, making them less vulnerable to ecosystem degradation.

Executive Summary Table 1: Quantifying Employment in EU and Globally According to Ecosystem Service Linkages

Type	Sector	EU		Developing economies	
		Employment (thousands)	% of total	Employment (thousands)	% of total
1. Primary Industries highly dependent on ecosystem services	Agriculture	11,223	4.9%	895,218	34.4%
	Forestry	2,988	1.3%		
	Fishing	400	0.2%	31,811	1.2%
	Water Supply	373	0.2%	21,049	0.8%
2. Processing and Manufacturing industries dependent on ecosystem services for inputs and processes	Energy Supply	1,233	0.5%		
	Mining	859	0.4%	31,696	1.2%
	Food, drink, and tobacco	5,635	2.4%	733,844	28.2%
	Textiles, clothing and leather	3,020	1.3%		
	Wood and paper	4,252	1.8%		
	Pharmaceuticals	548	0.2%		
	Other manufacturing industries	24,204	10.5%		
3. Services activities dependent on cultural services	Hotels and catering	10,598	4.6%	60,800	2.3%
	Media and creative industries	3,139	1.4%		
	Education	15,368	6.7%	132,923	5.1%
4. Services activities dependent on provision of raw materials and fuel	Construction	16,770	7.3%	140,171	5.4%
	Transport	26,154	11.3%	145,164	5.6%
5. Other activities	Other	103,985	45.1%	412,268	15.8%
Total		230,747	100.0%	2,604,943	100.0%

[Source: adapted from Laborsta: http://laborsta.ilo.org; OECD and Eurostat]

The report also examines the qualitative aspects of the relationship between biodiversity and employment, which are found to differ between the EU and developing world. In the EU, employment related to biodiversity often provides new and skilled employment opportunities for a population increasingly disconnected from the land. In developing economies, however, much of the employment linked to biodiversity is in poor quality, low paid subsistence jobs in the primary industries. Nevertheless, more sustainable farming and forestry practices offer potential both to maintain biodiversity and to enhance employment by supporting safer, more lasting jobs linked to local livelihoods rather than centralised systems of production. Nature conservation and ecotourism also offer opportunities for skilled, knowledge-based and sometimes relatively well paid employment, often helping to diversify local economies and the employment opportunities they provide.

The connection between biodiversity, ecosystem services and jobs

There is a lack of knowledge about the point (thresholds) at which changes in biodiversity will impact ecosystem services to such a degree that economic activity and jobs can no longer be sustained. The vulnerability of ecosystem services to changes in biodiversity varies considerably depending on the spatial scale, the type of ecosystem service, and the aspect of biodiversity being considered. For certain ecosystems, such as coral reefs, mangroves, or tropical forests, small changes in biodiversity can lead to dramatic and sometimes irreversible changes in ecosystem services. The degree of vulnerability of industries to biodiversity and ecosystem loss depends on the type of service relied upon and its substitutability (i.e. the degree to which a service can be replaced or reproduced technologically). A greater degree of substitutability can be expected from provisioning services while supporting services (e.g. nutrient cycling) are considerably more difficult to substitute by technologically generated alternatives.

There is also evidence that the sectors most dependent on biodiversity and related ecosystem services are also those that are causing the most damage to the very services and inputs that they are reliant upon (e.g. agriculture places pressure on water quality and quantity; commercial fishing in marine ecosystems exploits fish stocks and changes habitat structures). In most cases, such damages are caused by unsustainable resource management and the conversion of natural systems, which may create immediate wealth and short-term employment, but often result in degraded ecosystems, declining provision of ecosystem services and decreases in employment in the long run.

Trade-offs between biodiversity conservation and employment

The conservation of biodiversity, however, does not necessarily always lead to societal benefits. Substantial benefits have been gained from many of the actions that have caused the homogenisation or loss of biodiversity, such as land conversion for food production. The protection of biodiversity also has associated costs such as the management and running of protected areas, the loss of productive agricultural and grazing land, and displacement of populations. In the absence of compensation, protected areas often have a net cost at the local level which may be especially high in developing countries and in the case of the rural poor. In addition, employment opportunities arising from the conservation of biodiversity often go to the most affluent in society, increasing social inequalities. In particular, this is true where there has been inadequate consideration of local communities' involvement.

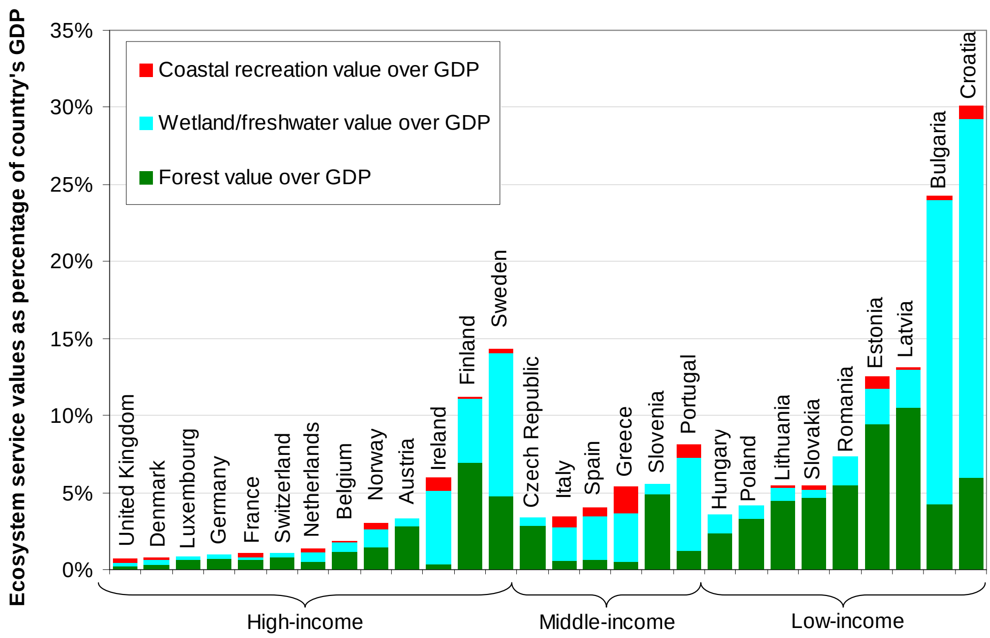
Nonetheless, it is equally important to acknowledge that the global benefits of protected areas are hugely significant, and in many cases, sufficient to justify their continued presence. In these cases, innovative (global) mechanisms which compensate communities for the costs incurred locally in return for global benefits should play an important role. It has been shown that conservation mechanisms can be a route out of poverty (e.g. community timber enterprises, nature-based tourism, fish spillover, protected area jobs, agroforestry and agrobiodiversity conservation; see Leisher, 2009). Furthermore, protected areas can provide a safety net which prevents the poor from falling further into poverty, indirectly acting as insurance from risks and shocks.

Valuing biodiversity benefits for vulnerable groups

It is apparent that developing nation economies are to a greater extent dependent on the provision of ecosystem services. However, large disparities exist in the degree of dependency on ecosystem services and in the levels of vulnerability to changes in biodiversity and the respective impacts on the provision of ecosystem services. There is also an imbalance between those most affected by, yet least able to respond to, the loss of ecosystem goods and services and the global distribution of derived benefits.

Vulnerability assessments were conducted based on a partial quantification of the economic dependency of local economies on ecosystem services. The provisioning, cultural, regulating and supporting services provided by ecosystems were evaluated based on their direct or indirect contributions to employment, non-market values and the welfare enhancement of local communities provided by extracting natural resources. The report found the rural poor to be the most directly dependent on ecosystem services as well as the most vulnerable to natural hazards, rapid resource depletion and biodiversity degradation. Approximately 70% of the world's poor live in rural areas and rely on benefits derived from environmental resources for at least 25% of their incomes.

The dependence of low versus high-income rural regions on the delivery of ecosystem services is explored in greater detail within the EU by using vulnerability-related indicators coupled with spatial mapping of biodiversity and ecosystem values for the EU. The analysis finds that communities living in remote regions are more vulnerable than populations in more accessible regions. This is largely due to their lack of access to, or the prices and affordability of, substitute products and services. Isolation additionally limits coping strategies to deal with a deterioration of environmental services. Furthermore, the location of rural households affects their potential to access markets or other sources of income from off-farm employment opportunities in neighboring urban areas. Although wealthy communities and households receive a higher total income from natural resources, poor households remain more dependent upon ecosystem health due to their often direct reliance on selling primary resources or labour (e.g. fishermen and foresters).



Executive Summary Figure 1. Contribution of forests, wetlands, freshwater and coastal ecosystem service values as a percentage of countries' GDP *(Source: Own estimation)*

The economic structure of poor, agricultural regions was found to be more strongly dependent on biodiversity and the provision of ecosystem services than that of richer areas, even when these wealthy areas are also remote and predominantly reliant upon agriculture. Moving from high-income countries to low-income countries, the socio-economic indicators show unemployment increases from 5.3% to 7.3%, the rural percentage of the population rises from 22% to 37% and dependence of GDP from the agricultural sector rises from 1.5% to 5.9%. Ecosystem services account for 11.8% of the GDP in low-income countries in comparison with 3.6% for high-income countries. Specifically, the highest levels of agricultural added value, unemployment rates, and ecosystem service value over GDP were all found in low-income countries. Executive Summary Figure 1 demonstrates the high contribution of ecosystem services to the EU's GDP, particularly in low-income countries. Forests and wetlands were found to make the largest contributions.

This is consistent with the finding from TEEB over the contribution of forests and other ecosystems to the livelihoods of poor rural households, and therefore the significant potential for conservation efforts to contribute to poverty reduction. TEEB reported that ecosystem services and other non-marketed natural goods account for 47 to 89 per cent of the so-called 'GDP of the Poor' (i.e. the effective GDP or total sources of livelihoods of rural and forest-dwelling poor households) in some large developing countries.

International case studies of the rural poor dependence on biodiversity

The issues surrounding the dependence of the rural poor on ecosystem services and biodiversity were explored in three global case studies. These studies illustrate how the inadequate consideration of the dependency of the poor on ecosystem services can threaten both livelihoods of the most vulnerable in society and valuable ecosystems. The reliance of the rural poor on ecosystem services and thus their vulnerability to biodiversity loss is exacerbated by existing inequities in power structures, poor land tenure rights and a difficulty to mitigate impending risks. The case studies are summarized below.

- Unclear land tenure rights and expansionist agricultural policies in Mexico resulted in an immense reduction (73%) of the country's dry forests. Although law revisions transferred ownership and management responsibilities to the rural communities, the lack of technical and organisational capacities in place has prevented the sustainable management of their forests. The poorest individuals in these communities remain the most heavily impacted by the loss of forest and soil fertility.
- The case of the Mekong River in South-east Asia, demonstrates how unsustainable fishing practices and hydroelectric schemes continue to threaten what is considered to be one of the world's most productive inland fisheries. The importance of the fish to the neighbouring communities has prompted locals to create conservation schemes and rules limiting fish catches. However, these require recognition in national legislation to secure permanence in the long-term.
- Mangrove destruction due to expanding aquaculture in Thailand has caused a collapse in the populations of commercially important fish species. Surrounding communities have a high dependency on the fish for nutrition and income due to their lack of education and access to other opportunities, highlighting the importance of protecting the remaining mangrove areas and fish populations.

Recommendations

Based on the policy needs shown above and the different policies on EU and international scale highlighted, the following priorities in EU policy actions can be derived for the consideration of social aspects in biodiversity and related policies. The actions should be understood as necessary steps in the short and medium term that would allow for better integration of biodiversity and its social dimension in future policy making. Rather then providing a roadmap for policy making, the list should support a broader thinking among decision-makers who seek to find the right elements for a strategy of integrated biodiversity policy.

1. **Increase efforts to raise the awareness of stakeholders and the wider public about benefits arising from biodiversity and eco-system services.** Changes in policies or cuts in subsidies can only be justified if their necessity is well understood by the stakeholders affected. More efforts are needed on the communication of the threats of biodiversity loss and ecosystem degradation, targeting both businesses and consumers, as well as communicating the solutions and benefits of overcoming these problems.
2. **Support regional approaches for payments for ecosystem services (PES) and investigate potential for wider application.** A clearer understanding of obstacles and

possibilities of PES approaches can only be gained if pilot projects in different regions and ecosystems are launched and evaluated. Examples from countries outside the EU can help design similar projects in the EU, funded by instruments such as LIFE+, and research and regional development funds.

3. **Determine a time-horizon by which subsidies and policy incentives harmful for biodiversity and vulnerable groups will be phased out.** The COP 10 of the CBD in Nagoya in October 2011 foresees the phasing out of harmful subsidies and incentives for biodiversity by 2020. Although voluntary, the EU should identify such perverse incentives and establish a phasing out model with a clear time frame, thus helping stakeholders affected to adapt to diminishing support over time.
4. **Adopt the "Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization" and take effective and quick action for its implementation.** The EU should pay particular attention to the rights of indigenous and local communities, and provide financial means to enable developing countries to implement the Protocol.
5. **Integrate the ecosystem-based approach in development aid policies and ensure a strong involvement of local communities in land-use decisions.** This would ensure a better consideration of local and traditional knowledge and greater local acceptance.
6. **Establish a monitoring process that highlights the contribution and the negative effects of EU polices to the achievement of the Millennium Development Goals.** Such an evaluation process may question policies that are currently not sufficiently debated regarding their impacts on natural resources and the rural poor in developing countries (e.g. trade, financial or agricultural policies).
7. **Complement current EU policies for nature protection with measures focussing on the connectivity of landscapes.** Policy-makers should consider how green infrastructure could be integrated in current policies, taking into account that it affects a wide range of policy fields such as regional policy, cohesion, nature protection, water, agriculture, forestry etc.

The international case studies represent contrasting environmental challenges and demonstrate the need for locally adapted solutions. However, several recommendations and paths of action can be outlined which are relevant for other environmental degradation cases threatening the livelihoods of vulnerable poor rural populations. These encompass policy shifts, including:

- **Perverse incentives** created by poorly developed management plans or governance regimes have to be eliminated and avoided in future policy design.
- **Short-term policy appraisals** benefitting only limited groups should be shifted to **long-term policies** that generate net benefits, involving respective stakeholder-groups from the start of the policy formulation and design.
- Access to crucial ecosystem services will be guaranteed for vulnerable groups by **safeguarding tenure and property rights** (e.g. by ABS and national law enforcement).

Local knowledge and experiences in maintaining ecosystems and biodiversity should be more seriously taken into account instead of creating overly broad solutions that cannot be adapted to local and regional conditions. Poor people should be **compensated and trained for alternative employment opportunities** if they are affected by regulatory measures to preserve biodiversity. While local communities often develop sustainable management plans and locally accepted regulations, these customs **need to be legally integrated into national legislation**, expanded to encompass additional threatened regions and enforced in order to be effective.

There should also be a greater **sharing of knowledge and development** of best practice examples where the long-term maintenance of ecosystems and biodiversity ensures stable livelihoods. Future evaluation and assessment methods for biodiversity and ecosystem services should **consider employment and poverty alleviation** to a higher degree.

TABLE OF CONTENTS

SECTION I:

THE LINKS BETWEEN BIODIVERSITY AND EMPLOYMENT

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1 LINKAGES BETWEEN EMPLOYMENT AND BIODIVERSITY - THE CONCEPTUAL MODEL

1.1 Employment and Biodiversity

Employment dependent on biodiversity conservation includes:

- Jobs directly concerned with the **conservation and management of biodiversity**. These include employment in land management, protection of sites and species, provision of advice, and scientific research and monitoring activities. These jobs are relatively small in number but their linkage to biodiversity is clear and direct.
- Jobs dependent on **ecosystem services**, which in turn are dependent to a large degree on the biodiversity within ecosystems. These include jobs and livelihoods which depend on the provisioning, regulating and cultural services which biodiversity plays a role in delivering. A much larger number of jobs fall into this group, but the role of biodiversity in supporting these jobs is often more indirect, uncertain and difficult to quantify.

These linkages are illustrated in Figure 1.1.

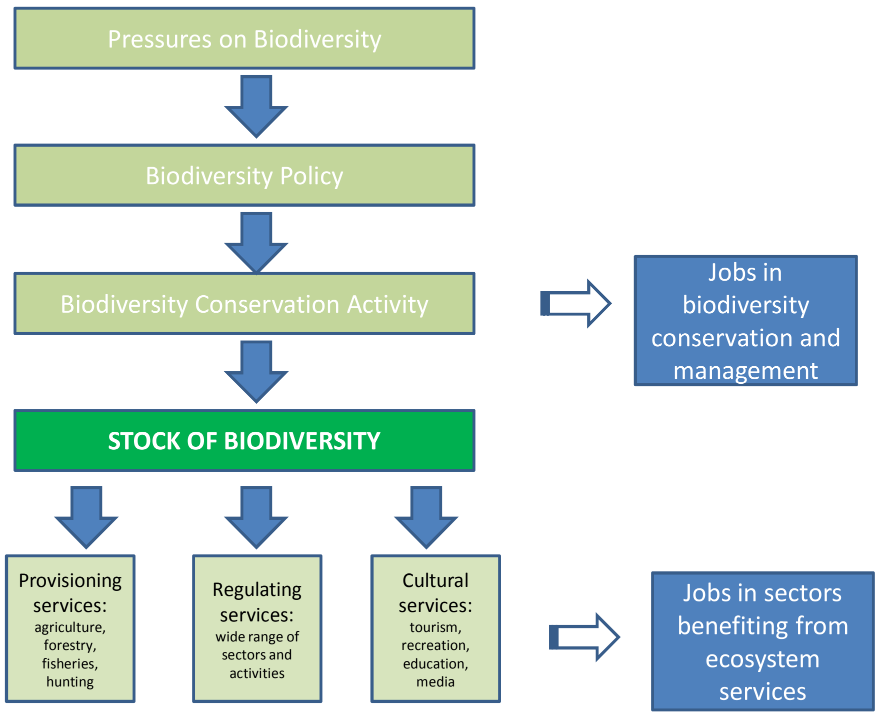

Figure 1.1: Links between Biodiversity and Employment

Figure 1.2 provides an illustration of the number of jobs in the economy which are linked to biodiversity in different ways. A small number of jobs in the economy are very directly concerned with the management of biodiversity, in nature conservation and related activities. However, a larger number of jobs in sectors such as fisheries, hunting and organic agriculture are strongly dependent on biodiversity conservation. Jobs in activities such as intensive agriculture, commercial forestry and water supply may be less intimately connected with biodiversity but still rely on biodiversity to maintain the functioning of ecosystems and the services they provide. More indirectly, jobs in a variety of manufacturing industries use raw materials of natural origin. Finally, all other jobs in the economy depend on biodiversity to the extent that it is an important component of ecosystems and, by contributing to their functioning, helps to maintain the ecosystem services which maintain human life, provide a reasonable living and working environment, and safeguard people and property from natural hazards.

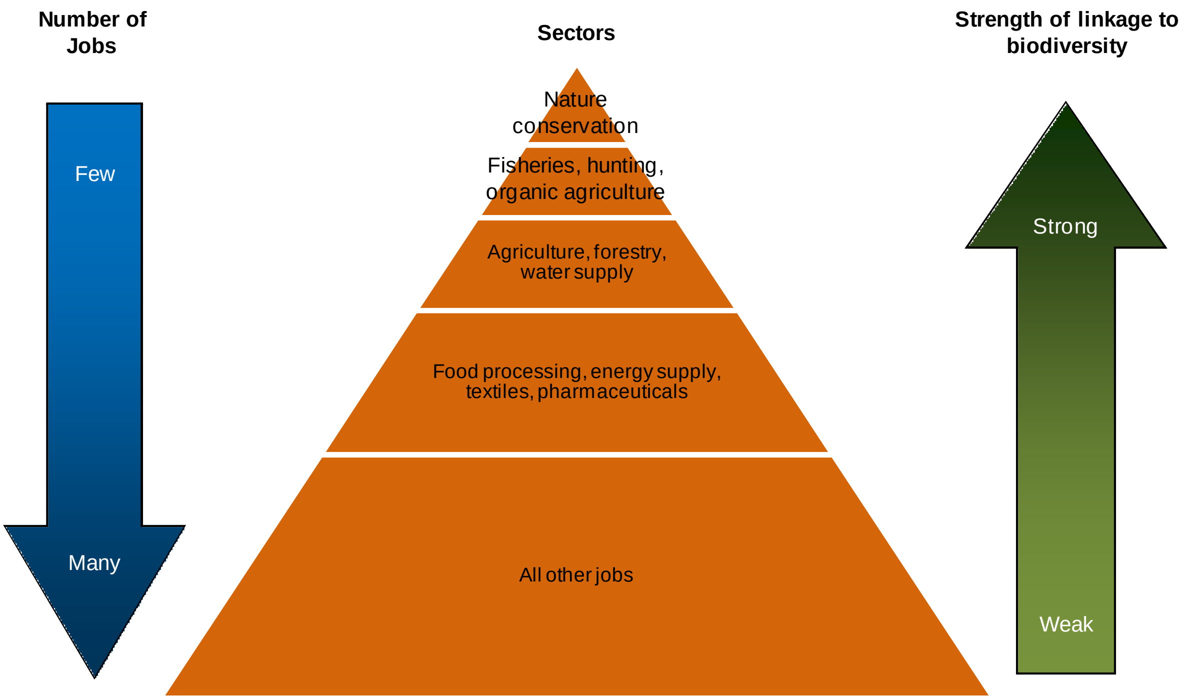

Figure 1.2: Illustration of numbers of jobs with different linkages to biodiversity

It is important to note that the strength of these linkages is likely to vary between developed and developing countries. In the developing world, a large proportion of employment is dependent on biodiversity and the ecosystem services it provides. In developed regions such as the EU, the provisioning role of biodiversity and ecosystems is now responsible for only a small proportion of livelihoods. However, direct employment in nature conservation is significant and growing, as a result of policies promoting biodiversity conservation, and there is also growth in employment in nature tourism and recreation.

1.2 Implications for the Study

The study has therefore examined employment directly concerned with biodiversity conservation, as well as employment in a variety of economic sectors which are indirectly dependent on biodiversity through their reliance on ecosystem services. These include sectors and activities dependent on:

- **Provisioning services** – e.g. agriculture, forestry, fisheries, pharmaceuticals, hunting;
- **Cultural services** – e.g. tourism, recreation, education, the media;
- **Regulating services** – this potentially includes a broad spectrum of economic activity dependent on the contribution that biodiversity makes to the regulation of climate, air, water and soil. Some activities are more directly dependent on regulating services than others. For example agriculture depends on pollination and prevention of erosion and flooding, but a wide

variety of activities depend on a liveable climate, healthy workforce and protection from natural hazards.

- **Supporting services** - such as nutrient cycling and soil formation - underpin all of the above services and to shape the stock of natural capital on which different sectors depend.

In quantifying biodiversity related employment it is important to distinguish between jobs that are very strongly and directly linked to biodiversity (e.g. in fisheries which depend on maintenance of healthy marine ecosystems and conservation of fish stocks), others that have a weaker relationship (e.g. in commercial forestry plantations, which depend on protection against pests and diseases and may benefit from new crop varieties) and others where the relationship is still more indirect (e.g. all jobs depend to some extent on the role of biodiversity in climate regulation and protection against natural hazards). It is therefore possible to identify a series of definitions of biodiversity-linked employment, enabling us to estimate the number of jobs dependent on biodiversity according to narrow or wider definitions.

It is important to note that the links between ecosystem services and employment are more easily identified and quantified than the linkages between biodiversity and employment. For example, it is clear that all employment in agriculture is directly dependent on ecosystem services, not just the role of provisioning services in delivering agricultural output, but also the provision of fresh water, genetic resources and other agricultural inputs, and the role of regulating services such as pollination, control of pests and diseases, and regulation of climate, water and soils. It is clear that all jobs in agriculture are dependent on ecosystem services, and it is therefore relatively straightforward to quantify employment in the sector that is dependent on ecosystem services.

However, assessing the linkages between biodiversity and employment is more challenging, because it is often less clear to what extent the delivery of ecosystem services on which jobs depend is influenced by the biodiversity within ecosystems. For example, food production is possible based on established varieties of crops and livestock; synthetic fertilisers and pesticides may be used to replace or enhance natural processes; and pollination may possibly be achieved by a limited variety of species. The loss of biodiversity may, however, adversely affect the functioning of ecosystems and impact negatively on ecosystem service delivery, potentially in unexpected ways and with unpredictable impacts.

The approach taken to assessing the linkages between biodiversity and employment has therefore been to:

1. Assess the extent to which jobs in different sectors are dependent on the delivery of ecosystem services (Section 2); and then
2. Assess the importance of biodiversity in the delivery of the ecosystem services on which different sectors depend (Section 3);
3. Assess the extent to which jobs in these sectors are dependent on biodiversity (Section 4);
4. Develop this understanding further through case studies (Section 5), and then;
5. Assess the implications for biodiversity conservation for employment (Section 6).

A sectoral approach is used in the analysis, as employment estimates are available by sector, while an assessment of the significance of ecosystem services, and the role of biodiversity in their delivery, can also be made on a sector by sector basis. This comprehensive approach is complemented by a selection of case studies which provide a more detailed understanding of the main types of ecosystem services and job typologies, their dependence on biodiversity, and the consequences of biodiversity loss (Section 5). Section 6 then assesses the significance of biodiversity policy for employment, now and in the future.

It is important to recognise that this approach depends on sufficient data and evidence being available at each stage of the analysis. In practice, evidence on the links between biodiversity, ecosystem services and economic activities is far from complete and often fragmented, making fully quantified and unqualified estimates of the relationship between biodiversity and employment impossible. The analysis therefore presents the available evidence at each of the five stages identified above, while recognising also the uncertainties and data gaps involved.

It should be noted that these uncertainties and gaps in evidence mean that the links between ecosystem services and employment (stage 1) are understood with greater confidence than the links between biodiversity and employment (stage 5).

Importantly, the use of the term 'biodiversity' in this study encompasses all its dimensions and is based on that used by the Millennium Ecosystem Assessment.[1] It therefore considers not just the typical species richness, but also the functional, ecological and genetic diversity and species abundance that encompasses 'biodiversity' as a whole.

It is also important to recognise that the loss of biodiversity can result in increases in some ecosystem services (for example increased food production resulting from deforestation), and that this may create employment, while also potentially causing job losses as a result of the decline in other ecosystem services.

[1] Defined as: "the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes diversity within species, between species and between ecosystems. Biodiversity may be described in terms such as richness, rarity, uniqueness, biomass and productivity"

2 MAPPING THE LINKS BETWEEN ECOSYSTEM SERVICES AND EMPLOYMENT

2.1 Ecosystem Services and Economic Activity

Ecosystem services support economic activities and therefore employment in different sectors in different ways. They support economic activity by directly influencing:

- Outputs – the output of natural resource based activities such as agriculture, forestry and fisheries is directly dependent on provisioning services;
- Inputs – many manufacturing activities use raw materials provided by ecosystems, including food, fibre, fuel, fresh water and genetic resources. Natural resource based activities also depend on a variety of these inputs;
- Processes – the primary sector depends on natural processes such as pollination and regulation of water, air, climate, pests and diseases, all of which influence the production process;
- Capital – ecosystem services maintain natural capital on which many economic activities depend. This includes productive assets such as soil and water, which are essential as the basis for primary production, as well as cultural assets such as landscape and wildlife which support tourism, recreation and cultural industries;
- Working Environment - all jobs depend on the role of ecosystem services in maintaining human health, preventing natural hazards and providing a liveable environment.

2.2 Links between Ecosystem Services and Different Sectors

Figure 2.1 provides an illustration of the importance of ecosystem services to different economic sectors. Primary sector activities such as agriculture, forestry, fisheries and hunting depend on a wide range of provisioning, regulating and supporting services which together shape the natural capital on which these sectors depend and determine sector inputs, processes and outputs. A variety of manufacturing activities depend on ecosystem services for the delivery of raw material inputs. Service sectors such as tourism, education and the media rely on the cultural services delivered by ecosystems. All sectors are dependent on ecosystem services indirectly in maintaining the health of the workforce, the living and working environment, and for providing protection from natural hazards.

	Food	Fresh Water	Fibre and Fuel	Genetic resources	Medicinal resources	Air quality regulation	Climate regulation	Natural hazard regulation	Water regulation	Waste treatment & water purification	Erosion regulation	Pollination	Biological control		
	Provisioning services					Regulating services								Cultural services	Supporting services
Agriculture	OI	I	IO	I	I	PC	PC	C	PC	PC	PC	P	P		CP
Forestry	E	I	O	I		PC	PC	C	PC	PC	PC	P	P		CP
Fisheries	O	C	I			C	C	C	C	C	E	E	C		C
Hunting	O	C	I			C	C	C	C	C	C	C	C		C
Water Supply	E	IO	I			E	CP	C	CP	CP	CP	E	CP		CP
Energy Supply	E	I	IO			E	CP	C	CP	E	E	E	E		CP
Mining	E	I	I			E	E	C	E	E	E	E	E		CP
Food, drink and tobacco	I	I	I	I		E	E	E	E	E	E	E	E		
Textiles, clothing, leather	E	I	I			E	E	E	E	E	E	E	E		
Wood and paper	E	I	I			E	E	E	E	E	E	E	E		
Pharmaceuticals	E	I	I	I	IO	E	E	E	E	E	E	E	E		
Other manufacturing industries	E	I	I			E	E	E	E	E	E	E	E		
Construction	E	I	I			E	E	E	E	E	E	E	E		
Hotels and catering	I	I	I			E	E	E	E	E	E	E	E	C	
Transport	E	IC	I			E	E	E	E	E	E	E	E		
Media	E	E				E	E	E	E	E	E	E	E	C	
Education	E	E				E	E	E	E	E	E	E	E	C	
Other services	E	E				E	E	E	E	E	E	E	E		

Figure 2.1: Dependence of Selected Sectors on Ecosystem Services

Key:

Strong link

Weak link

- O — Service delivers sector outputs
- I — Service provides sector inputs
- C — Service affects capital base
- P — Service influences production process
- E — Service influences sector environment and workforce

Building on this analysis, we propose the following typology of sectors according to their linkages with ecosystem services (Table 2.1).

Table 2.1: Typology of Sectors according to Linkage with Ecosystem Services

Type	Description	Sectors
1	Primary sectors dependent on provisioning services for outputs as well as inputs, and regulating and supporting services to determine productive capacity and production process	Agriculture Forestry Fisheries Hunting Water Supply
2	Processing and manufacturing activities dependent on ecosystem services primarily for provision of inputs and (in some cases) production processes	Energy supply Mining Food, drink and tobacco Textiles, clothing and leather Wood and paper Pharmaceuticals Other manufacturing industries
3	Service activities particularly dependent on cultural services provided by ecosystems, as well as inputs of food and other materials	Hotels and catering Media/creative industries Education
4	Service activities dependent on provision of raw materials and fuel from ecosystems	Construction Transport
5	Other activities dependent on ecosystem services for maintaining human health, living and working environment, and protection of people and property from natural hazards	All other industries

2.3 Quantifying Employment Linked to Ecosystem Services

Using the above typology, the number of jobs linked to ecosystem services in different ways in the EU and in developing economies can be quantified. Table 2.2 summarises the number of jobs according to the typology above for the EU, and in developing countries.

The varying categorisations used across the different regions have meant that both obtaining the necessary detail, as well as aggregating the data accordingly has been problematic. It was, for instance, particularly difficult to obtain data for developing countries with the same detailed categorisations used for the EU – accordingly there are some gaps in the these figures and aggregations have had to be made instead. Certain assumptions have had to be made to populate Table 2.2. A brief description of the methodology and the assumptions used are given in Box 2.1. For a more detail on the methodology and the original data, please see ‘ Referecne – section III’ for details on the assumptions used, the method of aggregation and other issues surrounding the data used.

Table 2.2: Quantifying Employment in EU and in Developing Economies According to Ecosystem Service Linkages

Type	Sector	EU		Developing economies	
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2. Processing and Manufacturing industries dependent on ecosystem services for inputs and processes	Energy Supply	1,233	0.5%	21,049	0.8%
	Mining	859	0.4%	31,696	1.2%
	Food, drink, and tobacco	5,635	2.4%		
	Textiles, clothing and leather	3,020	1.3%		
	Wood and paper	4,252	1.8%		
	Pharmaceuticals	548	0.2%		
	Other manufacturing industries	24,204	10.5%	733,844	28.2%
3. Services activities dependent on cultural services	Hotels and catering	10,598	4.6%	60,800	2.3%
	Media and creative industries	3,139	1.4%		
	Education	15,368	6.7%	132,923	5.1%
4. Services activities dependent on provision of raw materials and fuel	Construction	16,770	7.3%	140,171	5.4%
	Transport	26,154	11.3%	145,164	5.6%
5. Other activities	Other	103,985	45.1%	412,268	15.8%
Total		230,747	100.0%	2,604,943	100.0%

The figures estimate that a total of 55% of jobs in the EU and 84% of jobs in developing economies have a significant direct link to ecosystem services, falling within Types 1 to 4 of our typology. The remaining 45% of jobs in the EU and 16% in developing economies are indirectly dependent on ecosystem services for sustaining human life and health and a liveable, workable environment.

The data show that there is a definite difference in the dependence of employment in the EU and developing economies on ecosystem services (Figure 2.1). Overall, employment in the EU is less dependent on ecosystem services than is employment in developing economies. This is especially evident in the case of primary industries such as agriculture, forestry and fisheries, and to a slightly lesser extent in the case of manufacturing industries. Primary industries, which are highly dependent on ecosystem services, constitute more than a third of employment in developing economies, whereas only about 6% of workers in the EU are employed in these sectors. Manufacturing industries, which are reliant on ecosystem services for inputs and processes, constitute almost a further third in developing economies. In the EU this proportion is considerably less (only 17%). Overall, some 950 million jobs in the primary industries and a further 787 million jobs in manufacturing in developing economies are estimated to be reliant on ecosystem services for inputs and processes. These figures also reflect the much smaller share of primary industries in national income in the EU compared to developing countries.

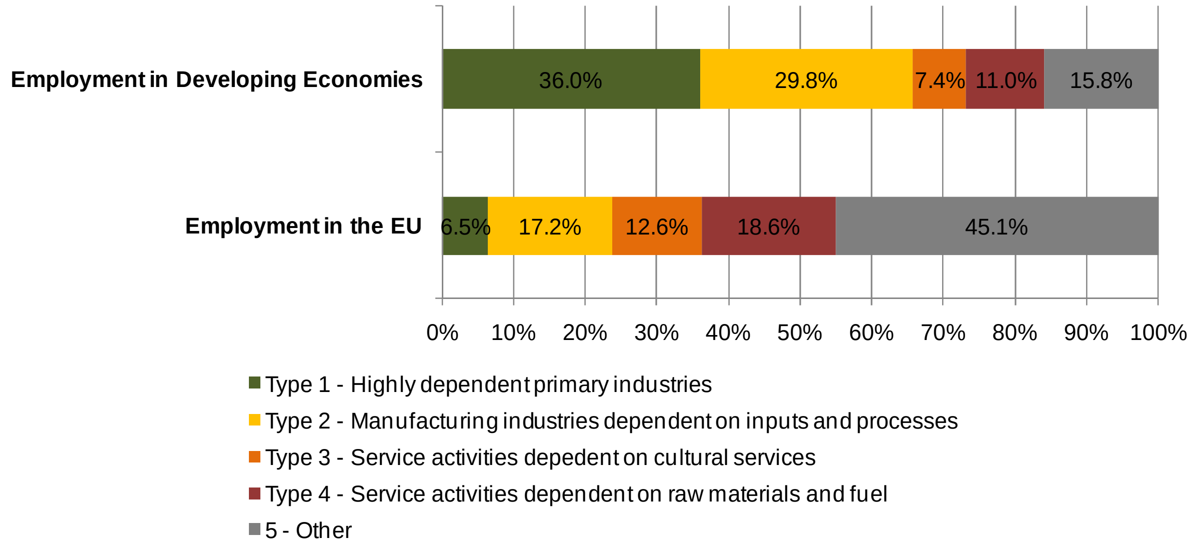


Figure 2.1: The extent to which employment in the EU and developing economies is linked to ecosystem services

However, the EU has a larger proportion of service sectors that depend on cultural services from ecosystem services than developing economies, such as hotels and catering, media and creative industries, and also education. Additionally, the EU has a larger proportion of service activities dependent on the provision of raw materials and fuel from ecosystems such as construction and transport than developing countries. In the EU, these two sectors provide a total of 31% of employment (72 million jobs) compared to 18% (480 million jobs) in developing countries. A variety of other activities dependent on ecosystem services and used to maintain human health, provide a living and working environment, and provide protection from natural hazards are indirectly linked to ecosystem services and make up the largest portion of employment activities in the EU and the remainder of employment in developing countries. These activities account for 45% of employment (104 million jobs) in the EU and 15.8% of employment (413 million jobs) in developing countries.

The analysis suggests that changes to ecosystem services will have varying impacts on employment in developing countries compared to the EU. However, there is a limit to which we can draw concrete conclusions from the analysis. Overall, we might expect the greater dependence of developing economies on ecosystem services to mean that employment and livelihoods are more sensitive to changes in ecosystem services in future. However, the loss of ecosystem services being observed across the world may lead to a loss of employment, a shift in employment between sectors, and/or more subtle changes as some jobs are able to adapt to the changes that take place. Overall, the effects on employment due to variations in ecosystem services are likely to vary across industries, sectors, and regions.

Box 2.1. Brief description of the methodology and assumptions used to derive employment data

Employment figures for developing economies were derived from Laborsta (http://laborsta.ilo.org). Reported statistics are presented by the different countries' statistical offices using different levels of detail, which created some inconsistencies. In order to ensure a minimum level of consistency for aggregation, some assumptions had to be made (e.g. averages from 1999-2008 were calculated and used for aggregation to achieve consistency between data for different years). For a full list see Annex A.

World Bank regions were used to aggregate data for employment in developing economies. However, employment data from Laborsta was limited to a subsection of those included in the World Bank regions; data was only available for 77 countries out of a possible 144 developing economies according to the World Bank's categorisation. In the case of some regions (for instance South Asia and Sub-Saharan Africa), the proportion of employment covered by Laborsta figures was low (as little as 10% in South Asia). In other cases however, Laborsta figures covered as much as 73% of the region's employment (in the case of Europe and Central Asia). As a whole, the Laborsta figures cover only 32% of all possible jobs in developing economies.

Consequently, a significant assumption has been made in order extrapolate the data to obtain employment figures for the entire World Bank regions, namely that the share of jobs for which Laborsta data was available were representative of the entire region. By multiplying the World Bank total employment per region by the percentages found for each sector according to the available Laborsta data for each region, it was therefore possible to obtain an indication of the total employment per sector, per region.

EU employment figures were derived from OECD Input-Output tables and Eurostat for the year 2008 (see Annex A).

For a more detail on the methodology and the original data, see '
References - Section III

' for details on the reference sources, assumptions used, the method of aggregation and other issues surrounding the data used.

3 DETERMINING THE LINKS BETWEEN BIODIVERSITY, ECOSYSTEM SERVICES AND EMPLOYMENT

3.1 Introduction

In this section we examine the links between biodiversity, ecosystem services and employment. The review first considers the degree to which different ecosystem services are dependent on biodiversity (Section 3.2), and discusses some of the caveats to be considered in the analysis (Section 3.3), before examining the implications for economic activity and employment in different sectors (Section 3.4).

Biodiversity, including the number, abundance, and composition of genotypes, populations, species, functional types, communities, and landscape units, strongly influences the provision of ecosystem services and therefore human well-being, livelihoods and employment. For example, as one of the most species-rich communities on Earth, coral reefs are responsible for maintaining a vast storehouse of genetic and biological diversity. Substantial ecosystem services are provided by coral reefs—such as habitat construction, nurseries, and spawning grounds for fish; nutrient cycling and carbon and nitrogen fixing in nutrient-poor environments; and wave buffering and sediment stabilization (MEA, 2005o) – and many human livelihoods depend on these (Box 3.1).

Box 3.1. The economic and ecological value of coral reefs

Coral reefs are responsible for providing several ecosystem services: they are a major source of fisheries products for coastal residents, tourists, and export markets; they support high diversity that in turn supports a thriving and valuable dive tourism industry; they contribute to the formation of beaches; they buffer land from waves and storms and prevent beach erosion; they provide pharmaceutical compounds and opportunities for bio-prospecting; they provide curios and ornamentals for the aquarium trade; and they provide coastal communities with materials for construction. Given this, it is unsurprising that 58% of the world's major reefs occur within 50 kilometres of major urban centres of 100,000 people or more, and that 31% of the world's population live within 50 kilometres of a coral reef system. Coral reefs are particularly valuable to some regions. Reef fisheries in Asia for instance, are estimated to produce net benefit streams of over $2 billion annually. Coral reefs play an especially significant role in tourism – much of the estimated economic value of coral reefs (annual net benefits are estimated at almost $30 billion) is generated from nature-based and dive tourism. In the United States alone, coral reefs and their associated nursery habitats support millions of jobs and billions of dollars in tourism each year. The natural reefs around Florida, for instance, support over 61,000 jobs in the region.[2]

However, despite their ecological and economic importance, coral reefs are also one of the most vulnerable and threatened ecosystems. The most intensive degradation is taking place in developing countries, where most tropical reefs occur. The latest estimates suggest that 20% of reefs have been destroyed and at least an additional 20% are badly degraded or under imminent risk of collapse. The impacts of this degradation on human well-being will be considerable given the large numbers of people who depend on coral reefs and the services they provide. For instance, in Jamaica and Barbados destruction of coral reefs caused dramatic declines in the number of visitors; loss of revenue streams consequently led to social unrest, resulting in further decline of tourist numbers.

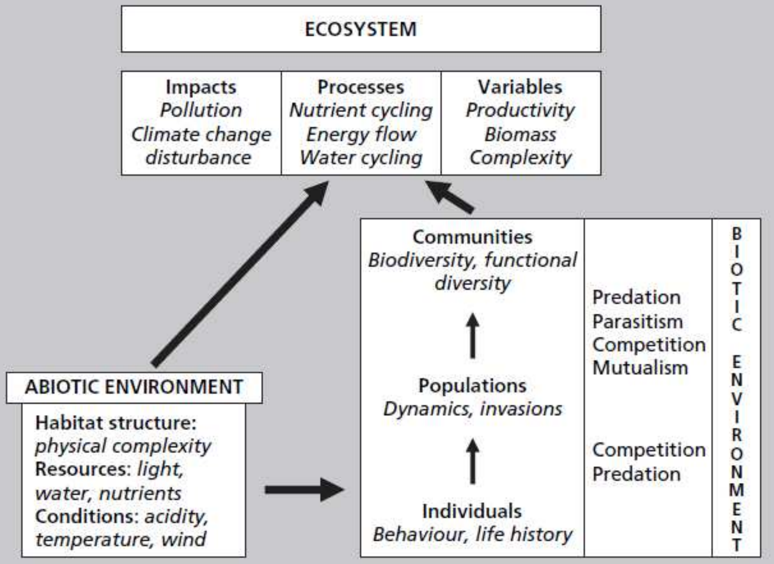
Source: MEA, 2005q

However, few studies link changes in biodiversity with changes in ecosystem functioning to changes in human well-being. Nonetheless, the link between biodiversity and the services which ecosystem deliver is

[2] http://www.allislandscorals.org/index.php?option=com_content&task=view&id=76&Itemid=9

clear. The importance of biodiversity to ecosystems is a consequence of the fact that it is at the different levels in the ecological hierarchy (see Figure 3.1) at which key processes such as carbon, water and nutrient cycling and productivity, and therefore the services ecosystems provide, are determined (EASAC, 2009). Overall biodiversity underpins the provision of ecosystem services to the point that local or functional extinction, or the reduction of populations to the point that they no longer contribute to ecosystem functioning, can have dramatic impacts on ecosystem services. Indeed, these impacts can be disproportionately large and irreversible (MEA, 2005o).

Figure 3.1: The Ecological Hierarchy – The importance of biodiversity in underpinning ecosystems and their services (EASAC, 2009)



The diagram represents the components of the ecosystem, which comprises the abiotic factors of the environment and the biological communities that live there. Communities are made up of populations of organisms whose individuals interact with each other and with those in other populations by competing for resources and preying on or parasitising others. It is the individuals that respond to the abiotic factors of the habitat. Processes in ecosystems, which underlie ecosystem services, are the result of the interaction of the organisms and the abiotic environment.

The ecosystem is one stage in a hierarchy of systems recognised by the science of ecology, from the population (the individuals of a single species in a defined area), through the community (the set of populations in that area), to the ecosystem, which brings in the abiotic elements. Although ecologists recognise landscape units such as forests and lakes as ecosystems, they also accept that ecosystems are not self-contained: they have porous boundaries and both organisms and materials move between systems, often with important ecological consequences. Above the ecosystem in this hierarchy, ecologists recognise biomes and the biosphere; both of these are at much larger scale, continental or global.

3.2 Links between Biodiversity and Ecosystem Services

Table 3.1 illustrates the significant links between biodiversity and the main ecosystem services. A fuller discussion is provided in Annex A – Details on the Employment Data.Angelsen, A. with Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. D. and Wertz-Kanounnikoff, S.

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ANNEX A – DETAILS ON THE EMPLOYMENT DATA

The following details the main issues arising from the EU and global employment data, as well as any assumptions that had to be made in order to aggregate the global data, and in the population of Table 2.

Global employment data

Global employment figures per main industry sectors were taken for each country from Laborsta (an International Labour Office database on labour statistics operated by the International Labour Organisation Department of Statistics - http://laborsta.ilo.org). Laborsta presents information on total employment by economic activity for all the world's economies. The data illustrates absolute figures on the distribution of the employed by economic activity, according to either the industry classifications ISIC-68 (http://laborsta.ilo.org/applv8/data/isic2e.html) or ISIC Rev.3 (http://laborsta.ilo.org/applv8/data/isic3e.html), or to both versions side by side, in cases where the latest revision of this international classification has been adopted during the 10-year time series covered in the Yearbook. Hence the figures used are the average over the 10-year time series period. Data sources employed by laborsta to compile employment statistics include either the population census and the Labour force survey.

Assumptions for data aggregation

There were some inconsistencies in the Laborsta data; reported stats are presented by the different countries statistical offices of each country using different levels of detail. Reporting requirements and level of detail shown on figures for each of the industry sectors under the international standard industry classifications (ISIC) differ between countries. Therefore, the following assumptions were necessary to ensure a minimum level of consistency for aggregation: i) ISIC-Rev 3 classification was employed, ii) only stats sourced from the Labour force survey were used and iii) averages from 1999-2008 were calculated and used for aggregation to achieve consistency between data for different years.

Employment figures are aggregated by World Bank region. The World Bank divides emerging economies into six different regions (South Asia, Europe & Central Asia, Middle East & North Africa, East Asia & Pacific, Sub-Saharan Africa and Latin America & Caribbean). Data for these regions are comprised of data for the following countries:

- **South Asia (SA)** – Bangladesh, Bhutan, Maldives, Nepal, Sri Lanka
- **Europe and Central Asia (E&CA)** – Armenia, Azerbaijan, Bulgaria, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, The former Yugoslav Rep. of Macedonia, Republic of Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Tajikistan, Turkey, Ukraine
- **Middle East and North Africa (MENA)** – Algeria, Egypt, Islamic Rep. Of Iran, Iraq, Morocco, Arab Rep. Syrian Arab Republic, West Bank and Gaza Strip, Rep. Of Yemen
- **East Asia and Pacific (EA&P)** – Cambodia, China, Indonesia, Malaysia, Mongolia, Papua New Guinea, Philippines, Samoa, Thailand, Tonga, Viet Nam
- **Sub-Saharan Africa (SSA)** – Botswana, Ethiopia, Lesotho, Madagascar, Mali, Mauritius, Namibia, Senegal, Sierra Leone, South Africa, United Republic of Tanzania, Uganda
- **Latin America and Caribbean (LA&C)** – Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Uruguay

A full breakdown of employment figures for the above regions is given below (employment figures are in thousands). Please note that further aggregation by industry sector is impossible as some countries have reported employment stats only in broad categories of the ISIC-Rev 3 classification (for example the A-C category covers jobs in Agriculture, fishing and manufacturing). There are some grounds to believe that some stats have been double counted between categories. As the totals in some cases are above a 100%.

Industry classification	Employment by Region (thousands)					
	LA&C	SSA	SA	MENA	E&CA	EA&P
Agriculture, Hunting and Forestry	30623.8	30261.3	29081.5	15169.9	29892.0	93971.3
Fishing	709.1	565.7	1091.3	297.3	251.8	4715.2
Mining and Quarrying	852.0	821.8	77.7	438.4	2128.6	6490.5
Manufacturing	27123.2	5435.6	6638.2	9063.8	24252.1	59705.5
Electricity, Gas and Water Supply	831.9	232.3	118.3	728.0	2952.9	3665.2
Construction	12132.5	2125.4	1912.2	7356.2	9512.4	19811.0

Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods	35411.0	6666.9	7936.1	9715.2	19976.4	40874.3
Hotels and Restaurants	7003.3	1546.1	887.9	1007.2	3013.7	8096.9
Transport, Storage and Communications	9789.2	1569.1	4058.7	5077.8	11602.0	16922.8
Financial Intermediation	2029.6	112.3	386.9	585.9	2181.7	5379.2
Real Estate, Renting and Business Activities	8894.1	256.7	249.7	1149.1	6751.8	8817.8
Public Administration and Defence; Compulsory Social Security	8103.3	1034.4	1525.6	6662.3	9981.8	19018.1
Education	9153.2	1007.3	1698.1	5104.7	12309.4	21615.2
Health and Social Work	9008.8	358.6	580.9	1604.0	9229.6	7272.9
Other Community,Social and Personal Service Activities	6489.5	1342.1	2645.7	1409.2	5101.1	5774.0
Households with Employed Persons	10236.8	2376.0	366.6	110.6	335.8	5165.8
Extra-Territorial Organizations and Bodies	39.0	80.7	8.2	19.9	22.1	15.2
Not classifiable by economic activity	885.9	547.2	315.6	312.8	21.2	3787.8

World Bank regions were used to aggregate data for employment in developing economies. However, employment data from Laborsta was limited to a subsection of those included in the World Bank regions; data was only available for 77 countries out of a possible 144 developing economies according to the World Bank's categorisation. In the case of some regions (for instance South Asia and Sub-Saharan Africa), the proportion of employment covered by Laborsta figures was low (as little as 10% in South Asia). In other cases however, Laborsta figures covered as much as 73% of the region's employment (in the case of Europe and Central Asia). As a whole, the Laborsta figures cover only 32% of all possible jobs in developing economies.

Consequently, a significant assumption has been made in order extrapolate the data to obtain employment figures for the entire World Bank regions, namely that the share of jobs for which Laborsta data was available were representative of the entire region. By multiplying the World Bank total employment per region by the percentages found for each sector according to the available Laborsta data for each region, it was therefore possible to obtain an indication of the total employment per sector, per region.

Employment by Region (thousands)

Industry classification	All regions			LA&C			SSA			SA			MENA			E&CA		
	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**
Agriculture, Hunting and Forestry	229000	27%	708754	30624	17%	45293	30261	54%	177616	29082	49%	299433	15170	23%	25641	29892	20%	41203
Fishing	7630	1%	23616	709	0%	1049	566	1%	3320	1091	2%	11236	297	0%	503	252	0%	347
Mining and Quarrying	10809	1%	33454	852	0%	1260	822	1%	4823	78	0%	800	438	1%	741	2129	1%	2934
Manufacturing	132218	16%	409216	27123	15%	40116	5436	10%	31904	6638	11%	68349	9064	14%	15320	24252	16%	33429
Electricity, Gas and Water Supply	8529	1%	26396	832	0%	1230	232	0%	1363	118	0%	1218	728	1%	1230	2953	2%	4070
Construction	52850	6%	163570	12133	7%	17944	2125	4%	12475	1912	3%	19689	7356	11%	12434	9512	6%	13112
Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods	120580	14%	373195	35411	20%	52373	6667	12%	39131	7936	13%	81713	9715	15%	16421	19976	13%	27535
Hotels and Restaurants	21555	3%	66713	7003	4%	10358	1546	3%	9075	888	1%	9142	1007	2%	1702	3014	2%	4154
Transport, Storage and Communications	49020	6%	151716	9789	5%	14478	1569	3%	9210	4059	7%	41790	5078	8%	8583	11602	8%	15992
Financial Intermediation	10676	1%	33041	2030	1%	3002	112	0%	659	387	1%	3984	586	1%	990	2182	1%	3007
Real Estate, Renting and Business Activities	26119	3%	80839	8894	5%	13155	257	0%	1507	250	0%	2571	1149	2%	1942	6752	5%	9307
Public Administration and Defence; Compulsory Social Security	46326	6%	143377	8103	5%	11985	1034	2%	6071	1526	3%	15708	6662	10%	11261	9982	7%	13759
Education	50888	6%	157498	9153	5%	13538	1007	2%	5912	1698	3%	17484	5105	8%	8628	12309	8%	16967
Health and Social Work	28055	3%	86830	9009	5%	13324	359	1%	2105	581	1%	5981	1604	2%	2711	9230	6%	12722
Other Community,Social and Personal Service Activities	22762	3%	70447	6490	4%	9598	1342	2%	7877	2646	4%	27241	1409	2%	2382	5101	3%	7031
Households with Employed Persons	18592	2%	57541	10237	6%	15140	2376	4%	13946	367	1%	3775	111	0%	187	336	0%	463
Extra-Territorial Organizations and Bodies	185	0%	573	39	0%	58	81	0%	474	8	0%	84	20	0%	34	22	0%	30
Not classifiable by economic activity	5871	1%	18169	886	0%	1310	547	1%	3212	316	1%	3250	313	0%	529	21	0%	29
TOTAL	841662	100%	2604943*	179316	100%	265211*	56340	100%	330679*	59579	100%	613447*	65812	100%	111238*	149516	100%	206091*
% represented			32%			68%			17%			10%			59%			73%

*Total employment numbers per World Bank region have been sourced from:
http://data.worldbank.org/about/country-classifications/country-and-lending-groups (Data downloaded 18-06-2010)
** Total employment figures per sector per region have been estimated by multiplying the percentages obtained for some countries by region in the Laborsta stat by the total figures obtained in the World Bank statistics.

EU employment data

EU employment figures were derived from OECD Input-Output tables and Eurostat for the year 2008. These figures had to be made consistent with the E3ME classification, which was more detailed, to obtain a total headcount employment. For more information, see Annex C of GHK 2007.

Assumptions for populating the typology table

Some assumptions had to be made in order to fit the figures into the typology laid down in Table3, as follows:

Type (from Typology)	Sector (from Typlogy)	**Combined sector categories on which the employment figure is based** (in some cases these are identical)
1. Primary Industries highly dependent on ecosystem services	Agriculture, forestry, fisheries	Agriculture, forestry, fisheries
	Water Supply	Water supply
2. Processing and Manufacturing industries dependent on ecosystem services for inputs and processes	Energy Supply	Electricity Supply ; Gas Supply
	Mining	Coal ; Oil and Gas ; Other Mining
	Food, drink, and tobacco	Food, Drink and Tobacco
	Textiles, clothing and leather	Textiles, Clothing and Leather
	Wood and paper	Wood and Paper ; Printing and Publishing
	Pharmaceuticals	Pharmaceuticals
	Other manufacturing industries	Manufactured fuels, Chemicals nes; Rubber and Plastics ; Non-metallic Mineral Products ; Basic Metals ; Metal Goods ; Mechanical Engineering ‘ Electronics ; Electrical Engineering and Instruments ; Motor Vehicles ; Other Transport Equipment ; Manufacturing nes.
3. Services activities dependent on cultural services	Hotels and catering	Hotels and Catering
	Media and creative industries (Communications)	Communications
	Education	Education
4. Services activities dependent on provision of raw materials and fuel	Construction	Construction
	Transport	Distribution ; Land Transport ; Water Transport ; Air Transport
5. Other activities		Retailing ; Banking and Finance ; Insurance ; Computing Services ; Professional Services ; Other Business Services ; Public Administration and Defence ; Health and Social Work ; Miscellaneous Services

Annex B – Links between Biodiversity and Ecosystem Services', which provides the basis for the general overview presented below. Based on available evidence, a judgement has been made on the strength of the linkage, the extent to which the service is likely to change in importance in the future, as well as the extent to each service may be subject to thresholds or tipping points (where a small change in nature has disproportionate effects).

In many cases, the likely increased importance of the service being delivered is due to the resilience that biodiversity provides, rather than the actual diversity per se (noted in the table below as 'R' and 'D' respectively). This is largely a consequence of the increased likelihood of systems being subject to shocks, both in terms of absolute numbers and their degree (e.g. climate change, general environmental pollution, disease, natural hazards). For instance, the strength of the linkage between food provision and biodiversity is quite weak (with lower biodiversity actually being associated with increased productivity in some cases). The sensitivity of the system to decreases in biodiversity therefore appears to be low, until the system is subject to a disturbance, when the resilience that biodiversity confers (rather than actual productivity) is needed. A case in point would be the potato famine in Ireland, where the low genetic diversity of the potatoes cultivated is thought to have made the entire crop susceptible to potato blight fungus, a problem resolved by using resistant varieties from original gene pools in South America.

Table 3.1: The extent to which ecosystem services depend on biodiversity

Ecosystem Service	Link to biodiversity	Strength of linkage	Likely trend in importance	Risk of abrupt changes in service delivery
Provisioning services				
Provision of genetic resources	Genetic resource provision, for example provision of genes and genetic material for animal and plant breeding and for biotechnology, is directly related to the current level of biodiversity.	***	▬	Low to Medium (but High in the case of one-time use benefits)
Provision of food and fibre	Only 30 crops provide an estimated 90% of the world population's calorific requirements. Fewer than 14 species account for 90% of global livestock production. Trees planted in Europe tend to be grown at high densities in large-scale monocultures with limited scope for biodiversity. However, new crop and livestock varieties could be important for future production and to improve the resilience of existing production to disease and disruption.	*	▲ (R)	Low to Medium (mostly localised effects)
	Regulating services			
Pollination and seed dispersal	80% of angiosperms are pollinated by animals. However, most plants attract and can be pollinated by a range of pollinators. Nonetheless, the diversity and abundance of pollinators influences the quality of the pollination services, and therefore the quantity and quality of plant productivity. The diversity of plants also influences the health and survival of pollinators. Given the reliance on the domesticated honeybee and its current precipitous decline highlights the importance of pollinator diversity to improve the resilience of crop production.	**	▲ (R)	Medium to High
Invasion resistance	Although areas of high species richness (such as biodiversity hot spots) are more susceptible to invasion than species-poor areas, within a given habitat the preservation of the natural species pool can increase resistance to invasions. Key native species are very competitive and can act as biological controls to the establishment of aliens. Species-rich communities are more likely to contain highly competitive species and fewer vacant niches, and are	**	▲ (R)	Medium to High

	therefore more resistant to invasions.			
Climate Regulation	The functional characteristics of dominant species, and hence the type and distribution of habitats across landscapes, are a key element in determining climate regulation. These characteristics affect climate by influencing albedo, evapotranspiration, temperature, fire regimes, and the capacity of ecosystems to sequester carbon. Overall, the current evidence suggests that biodiversity has a moderate impact in climate regulation	**	▲ (R)	Medium to High
Pest Control	Evidence indicates that the spread of pathogens is less rapid in more biodiverse ecosystems, in that high species richness can slow down the spread of pests and pathogens. Genetic diversity also reduces density of hosts for specialist pests, and thus their ability to spread. The maintenance of natural pest control services is therefore strongly dependent on biodiversity.	***	▲ (R)	Medium to High
Disease control and human health	Human health, particularly risk of exposure to many infectious diseases, may depend on the maintenance of biodiversity in natural ecosystems. Over 60% of human pathogens are naturally transmitted from animals to humans. However, greater diversity of wildlife species might be expected to sustain a greater diversity of pathogens that can infect humans. Nonetheless, intact ecosystems play an important role in regulating the transmission of many infectious diseases due, for instance, to the dilution effect. Overall evidence indicates that human health is supported as an ecosystem service by biodiversity in some cases, but the generality of this service is poorly known.	*	▲ (D)	Low to Medium
Water purification and waste treatment	Fresh water services are the result of interactions among the ecological components within ecosystems and those in the catchment; biodiversity influences that ecological character and therefore the services provided. Soil micro-organisms are especially important in purification. The capacity for an environment to assimilate wastes is highly dependent upon local conditions. Wetlands play a key role in treating and detoxifying a variety of waste products. In turn, these abilities are determined by the ecological characteristics of wetlands. The role of species diversity is unclear given that many of the processes can be performed by a wide variety of species ; there seems to be high functional redundancy in the effects of species on the provision and regulation of freshwater water.	*	▲ (D)	Medium to High
Water cycling and regulation	Fresh water services are the result of interactions among the ecological components within ecosystems and those in the catchment; biodiversity influences that ecological character and therefore the services provided. Natural processes play key roles: vegetation is a major determinant of water flows and quality, whilst soil state and vegetation both act as key regulators of the water flow and storage and microorganisms play an important role in the quality of groundwater. However, the relationship of water regulation to biodiversity is poorly understood. Nonetheless, changes in species composition can have significant impacts, and native flora may be more efficient at retaining water.	**	—	Medium to High
Regulation of natural hazards	The extent to which ecosystems mitigate the effects of natural hazards is still unclear. However, ecosystem integrity is important in providing protection from hazards, but less so to localised, geological hazards. Overall, biodiversity seems to play a relatively small part, although vegetation itself is very important.	*	▲ (R)	Medium (dependent on extent of the relationship)
	Supporting services			

Nutrient cycling	Nutrient cycling requires a large number of different organisms from diverse functional groups; specific forms of biodiversity are critical to the performance of the buffering mechanisms that ensure the efficient use and cycling of nutrients in ecosystems.	***	▼ (D) (except for agricultural systems in poorer countries)	Low to Medium
Soil formation	Soil formation is fundamental to soil fertility, especially where processes leading to soil destruction or degradation (erosion, pollution) are active. Biodiversity of soil organisms plays a major part in creating soil and maintaining soil function.	***	▬	Low to Medium
Ecosystem resilience	There is established but incomplete evidence that reductions in biodiversity reduce the resilience of ecosystems. A reduction in biodiversity reduces overall fitness and adaptive potential, and it limits the prospects for recovery of species whose populations are reduced to low levels. The impacts of reductions in biodiversity on ecosystems can be both spatially and temporally displaced.	***	▲ (R)	Medium to High
	Cultural services			
	Biodiversity has considerable intrinsic, aesthetic and spiritual values. Cultural services based on biodiversity are most strongly associated with less intensively managed areas, where semi-natural biotopes dominate. Maintenance of diverse ecosystems for cultural reasons can allow provision of a wide range of other services without economic intervention. Biodiversity provides a resource for tourism, recreation, education and the creative industries, both in itself and through its effect on landscape.	**	▬	Medium to High (localised effects)

Compiled by GHK from various sources: see Annex A-B for further details

3.3 Caveats to the Links between Biodiversity and Ecosystem Services

3.3.1 The Vulnerability of Ecosystem Services to Changes in Biodiversity

It is crucial to note that there are essentially two main links between biodiversity and ecosystem services - the influence of biodiversity on the amount of the service being delivered, as well as its influence on the stability of that provision over time. In the case of the former, the relationship is far from straightforward, in that more biodiversity does not necessarily mean more of an ecosystem service is provided.

The extent to which changes in biodiversity affect the amount of services being delivered varies considerably depending on the spatial scale, the type of ecosystem service, and the aspect of biodiversity being considered (e.g. species richness, species abundance, functional diversity, trophic interactions, and compositional characteristics). As has been noted above, small changes in biodiversity can lead to dramatic and sometimes irreversible changes in ecosystem services. For instance, some systems—including coral reefs, glaciers, mangroves, boreal and tropical forests, polar and alpine systems, prairie wetlands, and temperate native grasslands—are particularly vulnerable to climate change because of limited adaptive capacity and may undergo significant and irreversible damage (MEA, 2005h). The loss of particular species could have a substantial impact on ecosystem functioning. Such ‘‘keystone species’’ or ‘‘ecosystem engineers’’ may not necessarily be identified in advance, which makes preventive mitigation policy difficult (MEA, 2005h).

Box 3.2. Examples illustrating the links between biodiversity, marine ecosystem services and livelihoods

There have been several cases in the past where changes to biodiversity have led to the degradation (or collapse) of ecosystems, with subsequent impacts on livelihoods. This is particularly obvious in the case of marine environments. Some examples are given below:

- In the late 1980s, the invasion of the Black Sea by a comb jellyfish and the subsequent collapse of the fishing industry led to 150,000 jobs being lost. Additionally, the degraded state of the environment led to a reported loss of $300 million in revenues from the tourist industry (Lubchenco, 1997).
- The Canadian cod fishery in Newfoundland, Canada, provided between 80 and 100% of income in some communities, and 20% of the population was employed in the fishery. Its collapse led to more than 40,000 people losing their jobs, including 10,000 fishermen (Vilhjálmsson, H. et al., 2010; WWF, undated)
- The number of fishermen across the EU has been steadily declining as a result of the deterioration of major commercial fish stocks in the last decade. In the harvesting sector, 22% of jobs have been lost (66,000 jobs), whilst the processing sector has experienced a 14% decline in employment. The absence of suitable alternative employment means small coastal communities are particularly vulnerable (IEEP, 2006).
- The degradation of the former Lake Karla in Greece and the consequent impact on commercial fisheries has meant that 1,300 fishermen have lost their jobs. The impact was especially severe given the lack of alternatives (IEEP, 2006).
- The bleaching of Palau’s coral reefs in 1998 led to a 5-10% decline in the number of tourists visiting the area. The total losses to the Palau tourism industry in the 2 years following the bleaching are estimated to be as high as $750,000 (Pratchett, et al., 2008).
- Recent coral bleaching in the Philippines, is thought to result in economic losses ranging from $6 million up to $27 million, depending on the coral reef’s recovery. Over the next 20 years following the 1998 bleaching event in the Indian Ocean, the total economic damages could reach $8 billion, including $1.4 billion in lost food production and from fisheries, $3.5 billion in lost tourism revenue and $2.2 billion in lost coastal protection (Pratchett, et al., 2008).

Nonetheless, in other instances ecosystem services can be relatively stable regardless of changes in biodiversity. For example, the functionality of microbial communities is rarely impaired by ecosystem degradations in spite of decreases in microbial diversity reported in some cases. The most sensitive function may be nitrification, since it is operated by a relatively small, diverse group of microbes. The risk to this function seems to be very limited, although it is speculated that threshold effects might be observed in some conditions (MEA, 2005g).

The existence of different levels of buffers at nested scales also has the potential to reduce the vulnerability of nutrient cycling services, since different options exist to support the services. However, although vulnerability may appear to be relatively low as a result, disturbances that have multiple effects that accumulate over time and space can nonetheless cause the system to collapse (MEA, 2005g).

The same applies to some provisioning services. For instance, increases in the productivity of some fishery systems have been observed despite dramatic declines in diversity; catches from Lake Victoria increased from 30,000 million tonnes to an average of 500,000 million tonnes since the 1970s, despite the loss of roughly half the native species. The introduced Nile Perch now makes up around 90% of the landing’s volume and value (Balmford & Rodriguez, 2008).

It is worth noting that while some ecosystems and the services derived from them are quite stable regardless of changes in their biodiversity, changes to those services through human manipulation can have a significant impact on the ecosystems and the biodiversity which underpins them. This can be seen in the case of climate change (see above) and nutrient cycling. For example, the human manipulation of nutrient cycling services has greatly affected all ecosystems. Dysfunctions in nutrient cycling, leading, for example, to eutrophication, have severe negative effects on biodiversity (MEA, 2005g).

As the discussion above shows, the sensitivity to the which changes in biodiversity affect the provision of a specific ecosystem service varies. However, the extent to which changes in biodiversity influences the stability of that provision over time is much more straightforward; more biodiversity means that a system is more resilient, and therefore its delivery is more stable over time. This resilience is becoming increasingly important, partly because the effects of anthropogenic and environmental changes are becoming more prevalent. Crucially, this is arguably one of the most important and directly attributably benefits which biodiversity confers. It is therefore unfortunate that biodiversity is being lost at unprecedented rates, at a time when the ability of biodiversity to help ecosystem services resist and recover from disturbances is becoming more significant.

3.3.2 Substitutability

Part of the debate around the substitutability of ecosystems and their services is the idea that ecosystems represent a form of capital (defined as a stock yielding a flow of services), and that this stock of ‘natural capital’ must be independently maintained in order to assure ecological sustainability (known as ‘strong sustainability). The alternative view is that human-made capital can substitute for natural capital, so that, in other words, only the total of all capital stocks need to be maintained (known as ‘weak sustainability’). This debate plays a central role in the field of ecological economics. Ecological economists hold the view that the stock of natural resources and ecological functions are irreplaceable, while neoclassical economists tend to maintain that man-made capital can, in principle, replace all types of natural capital. The latter view is based largely on the benefits of technological advances, in that every technology can be improved upon or replaced by innovation, and that there is a substitute for any and all scarce materials.

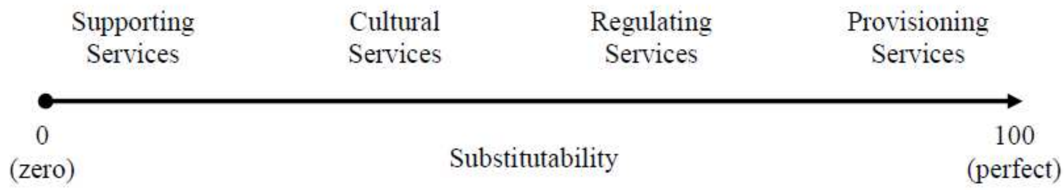
However, ecological economists point out that substitution is, for instance, limited by the laws of thermodynamics in the production process. The laws of thermodynamics, for instance, place limits on the ability of technical change to offset the depletion or degradation of natural capital. Although human capital may be a substitute in individual processes in the short run, natural capital and human-made capital ultimately are complements because both manufactured and human capital require materials and energy for their own production and maintenance. As such, weak sustainability is based on the erroneous premise that ‘self-generating technological change’ can maintain a constant output with ever-decreasing amounts of energy and materials as long as ever-increasing amounts of human capital are available.

Additionally, there are irreducible thermodynamic minimum amounts of energy and materials required to produce a unit of output that technical innovations cannot change. For instance, in sectors concerned with processing and/or constructing materials, technical change is subject to diminishing returns as it approaches these thermodynamic minimums. Essentially, no amount of substitution of capital for resources can ever reduce the mass of material resource inputs below the mass of the outputs, given the law of conservation of matter–energy (Perrings, 1999).

Nonetheless, there are degrees to which ecosystem services are substitutable, whether by natural alternatives, or man-made ones. Ecosystem services vary in the extent and in the ease with which they can be substituted. Provisioning services are most easily substituted, mostly because they are associated with market prices and good (and sometimes better) technological substitutes are well established. On the other hand, supporting services as a whole are considerably less substitutable.

The substitutability of regulating and cultural services varies depending on the service and context. As such, it is possible to place ecosystem services on a continuum of substitutability (Figure 3.2).

Figure 3.2: The varying substitutability of different types of ecosystem services[3]



Substitution of provisioning services

Although biodiversity is of high importance to certain sectors (e.g. agriculture, fisheries, forestry), there are some caveats to consider. Increasingly, the inputs that the sectors used to rely on heavily have become substitutable, decreasing to some extent the dependence of the various activities on biodiversity as a continued resource. For example, there is a decreased reliance on wild services in favour of those delivered through cultivation - nearly one third of the fish and timber supplied to markets comes from farming (MEA, 2005p). Aquaculture in particular contributed approximately 27% of fish harvested and 40% (by weight) of all fish consumed as food in 2002. However, the variety of supply from aquaculture is well below that of capture fisheries: only five different Asian carp species account for about 35% of world aquaculture production, and inland waters currently provide about 60% of global aquaculture outputs (MEA, 2005c). In forestry, plantations are providing an increasing proportion of timber products. In 2000, plantations were 5% of the global forest cover, but they provided some 35% of harvested roundwood, an amount anticipated to increase to 44% by 2020 (MEA, 2005d).

This trend towards cultivated rather than wild inputs has been accompanied by a substantial reduction in the genetic diversity of domesticated plants and animals in agricultural systems (MEA, 2005o). The losses of crop genetic diversity due to modern agricultural methods have been well documented. In China, for example, only 10% of the 10,000 wheat varieties present in 1949 were available in the 1970s, while in Mexico only 20% of maize varieties planted in the 1930s remain and in the United States only 15–20% of apple, cabbage, maize, pea, and tomato varieties grown in the nineteenth century are available today (MEA, 2005e). In Europe, 50% of livestock breeds that existed 100 years ago have disappeared (MEA, 2005c). The loss of varieties has for the moment not had a major influence on agricultural output at a global scale. However, there are dangers of a loss of genetic diversity to agriculture and also a danger of basing agriculture on only a minority of crop varieties. In Ireland in 1845, for instance, a mildew epidemic destroyed the entire potato crop for two consecutive years. Because potatoes were the basis of the local diet and there was only one variety on the island, over one million Irish died and another one million emigrated to North America to escape starvation (GHK, 2007).

Some of these on-farm losses of genetic diversity have been partially offset by genetic tools, such as the maintenance of genetic diversity in seed banks, and yields have continued to increase in many sectors (MEA, 2005o). Plant breeding for example has been complemented by deliberate programs of genetic enhancement or ‘‘base broadening’’ in order to incorporate genetic variation into plant breeders’ stocks, which has enabled, *inter alia*, the maturity period for annual and perennial crops to be shortened and drought resistance and nutrient use efficiency to be increased (MEA, 2005c). With regard to timber, gains in production will also come from insect and disease-resistant trees,

[3] Taken from “COPI Task 3: Potential for Substitution”. Available from: http://ec.europa.eu/environment/enveco/biodiversity/pdf/ieep_alterra_report.pdf

genetically improved trees with higher yields and improved fibre characteristics. There is therefore a reduced harvest from natural forests in most regions (MEA, 2005d).

Other examples include:

- The substitution of a variety of other materials for wood, such as steel, vinyl, and plastics, has contributed to relatively slow growth in global timber consumption in recent years (MEA, 2005c; MEA, 2005d).
- In the paper industry, plastics and other materials have replaced some paper bags, packing papers, and paperboard (MEA, 2005d)
- Competition from non-cellulosic fibres has increased significantly in recent years; total world fibre production has grown by 63% in the last two decades, while the proportion of natural (cellulosic) fibres has declined from almost two thirds to under one half (MEA, 2005d)

This has meant that in some sectors, constraints or losses in biodiversity as inputs will be unlikely to affect the outputs. This is due both to production from natural forests being replaced by production from plantation forests, as well as the impact of competing materials. The future availability of wood supplies in the United States for instance, is likely to be related more to growth and productivity of managed and planted forests than to the area of natural forests or gross forest stock (MEA, 2005d)

It is important to note two related characteristics of substitution. Firstly, substitution is quite often costly. Secondly, and consequently, richer groups of people are often less affected by the loss of biodiversity and the related ecosystem services because of their ability to purchase substitutes or to offset local losses by shifting production and harvest to other regions. Examples which demonstrate the socio-economic limits to substitutability are given in Box 3.3.

Box 3.3. Socio-economic limits to the substitutability of provisioning services

The two examples below illustrate that in some cases, although substitutes are available, these are often associated with prohibitive costs that mean they are not accessible by all. Additionally, the impacts on livelihoods can be significant.

Technological substitution – the case of genetic modification

In the past, natural breeding was used for increasing yields by drawing upon the natural pool of genetic resources. Biodiversity also improves an ecosystem's natural resistance and resilience to pests and disease, and to the establishment of invasive species (see Table 3.1). More recently, genetic modification (GM) has become a technological tool to increase yields and protect crops against pests and disease. However, it is has been argued that the characteristics of GM, namely high costs and patenting practices, introduce an anti-poor bias.

The patents that biotechnology companies place on their seeds mean that farmers using that seed are prohibited from saving, reselling or exchanging that seed. However many farmers, especially poorer ones, depend on saved seed and its re-use from one year to the next. Perhaps more importantly, GM seeds are significantly more expensive than traditional seeds. Combined with the cost of other inputs (e.g. the associated herbicides with herbicide-tolerant seeds), and "technology use payments", this makes the technology often prohibitively expensive. In India for example, farmers could buy a kilogram of local seed for as little as Rs7 or Rs9 in 1991. By 2003, a 450g bag of hybrid seed cost Rs350 (US$7). By 2004, a 450g bag of Bt cotton seed (which was modified to protect a cotton crap against bollworm infections), was selling at between Rs1,650 and Rs1,800 ($33 to $36). In addition, the costs of pesticides for farmers increased from Rs921 million to Rs13,264 billion in the same period (a 13 fold increase). Bt cotton seeds also require double the amount of water to traditional seeds (ISIS, 2010).

However, state support and marketing campaigns highlighting improved yields meant farmers in some Indian regions adopted GM seeds despite the higher costs. In some cases, farmers are said to have become heavily indebted through the need to borrow money to buy the seeds. Unfortunately, rains failed for two years, leading to extensive crop failure. Some believe that this, combined with the indebtedness caused by the widespread adoption of GM crops, contributed to a wave of farmer suicides (ISIS,2010). One journalist reported an estimated 125,000 farmers had committed suicide as a direct result of the debt incurred by choosing to purchase and grow GM crops (Malone, 2008).

Nonetheless, the International Food Policy Research Institute found that suicides among Indian farmers have not increased as a result of the introduction of GM crops. Although it was found that there were some catastrophic failures of Bt cotton varieties for some farmers after their initial introduction, conventional varieties were found to have been equally affected because of the drought. Since then, they report that the adoption of GM varieties have led to increases in yield and a 40% decrease in pesticide use (IFPRI, 2008).

Geographical substitution – the mobility of fishing fleets

Many factors, including technological advances have led to the over-exploitation and depletion of numerous fish stocks. It is estimated that 52% of all fish stocks are fully-exploited and a further 17% over-exploited. The depletion of fish stocks in some areas has led to fishing fleets moving further afield and replacing an over-fished stock with another situated somewhere else. This allows the same service to be obtained from the same type of ecosystem, but only in a different location (geographic substitution). Critically however, this is far easier for larger, international fishing fleets but small-scale traditional fleets exploiting local resources are limited in their ability to substitute the fish stocks in their area for another.

For example, as fish stocks have been depleted in the north Atlantic, European and other commercial capture fisheries shifted their fishing to West African seas, but this has adversely affected coastal West Africans who rely on fish as a cheap source of protein (MEA, 2005o). In the case of Senegal, fisheries are characterised by artisanal and traditional fishing, a low-technology approach, low initial investment and a large workforce. The fish stocks in the area support 47,000 artisanal fishermen, constituting more than 7% of the active population and landing more than 70% of the total volume of fish caught. With the progressive overfishing of European waters, European fishing fleets have moved to places like Senegal in search of new fishing grounds. Fishing stocks in the area have become increasingly affected, with knock on impacts on the marine environment and the local fishing communities which dependent on it. As a consequence, artisanal fishermen are having to travel further out to sea. Those unable to afford the additional equipment and fuel required to do so are instead fishing to supply European or Asian boats (who use local fishermen to obtain access to coastal resources).

Despite the apparent relative abundance of substitutes for provisioning services, the dependence on biodiversity and the relevant genetic resources as an input is still critical. Aquaculture, for example, is still extremely dependent on marine fisheries for its inputs (cultured fish are fed on fish meal and fish oil that comes largely from fishing) and, looked at from a global perspective, it may not be reducing the actual dependency on wild marine fisheries (TEEB, 2008).

Furthermore, it is likely that the need for biodiversity as an input in some sectors might increase. For instance, as traditionally used inputs are depleted, non-natural substitutes might not be suitable or readily available. Consequently, other natural inputs might need to be found as replacements from the stock of available biodiversity; about half of the wild marine fish stocks for which information is available are fully exploited and offer no scope for increased catches. However, 25% are underexploited or moderately exploited (MEA, 2005c) and therefore provide scope for diversification. Nonetheless, at the global level, fishery substitution potential will decrease with time (TEEB, 2009a).

The emergence of new and changing needs might also increase the dependence on biodiversity as an input in some sectors. Alarming levels of antibiotic resistance in many human pathogens for instance, are likely to provoke an increase in pharmaceutical bio-prospecting (MEA, 2005e). Moreover, hundreds of medicinal plant species, whose naturally occurring chemicals make up the basis of over 50% of all prescription drugs, are threatened with extinction (TEEB, 2008). Consequently, other options may have to be found, for which biodiversity might prove significant.

The importance of biodiversity stocks might also become more important as the need grows to improve a sector's resilience in the face of environmental shocks.

Substitution of regulating and supporting services

The substitution of regulating and supporting services is considerably more difficult. The degree to which ecological services can be replaced by technologically generated alternatives is very uncertain. In some cases, substitution of services can happen by natural means: the services lost from the original ecosystem may be (partly) substituted for by exploiting another, similar ecosystem in some other location (TEEB, 2009a). For instance, the case of mining along the Kafue River in Zambia, Zambians have traded off the quality of upstream wetlands while retaining the properties of drinking water and food (provisioning services) provided by the lower portions of the watershed (MEA, 2005k). In other cases, substitution of ecosystem services can be by artificial means: their loss may be substituted by technical solutions (artificial substitutes) (TEEB, 2009a).

Replaceability depends upon what services people want to replace, what technologies are available, and what other ecosystem services are (intentionally or accidentally) traded off by the technological replacement. There are limits to substitution potential, with very important implications for society (TEEB, 2009a). For some services and groups of society, there are:

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

As noted already in the discussion of the substitutability of biodiversity, the substitution of ecosystem services, where possible, is often costly. The effects are therefore often regressive, leaving vulnerable populations without access to the substitutes even where these are available. This point is illustrated in Box 3.4, which considers the case of substituting fresh water. Finding substitute sources of services - water, fuel wood, food provision - or creating substitutes - e.g. water purification - can lead to higher social costs, to higher economic costs beyond the reach of some social groups and to potential loss of quality. Substitution is also potentially limited by timescale and geography, as well as wealth (TEEB, 2009a). Table 3.2 gives some examples of the financial costs associated with the implementation of evaluated artificial substitutes for the following ecosystem services: (i) water regulation, (ii) water purification and (iii) carbon storage. These relate to specific cases and are therefore not necessarily representative.

Table 3.2: Financial costs associated with the implementation of artificial substitutes in the case of some regulating ecosystem services[4]

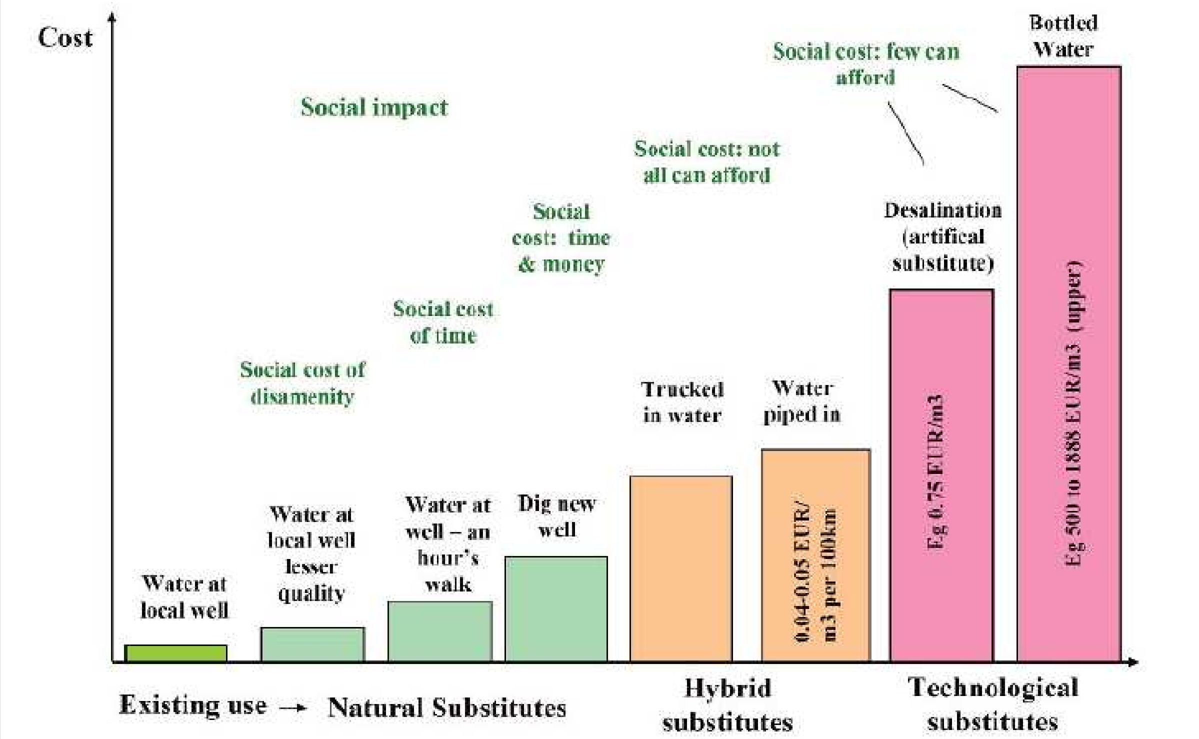
Artificial Substitute	Associated costs
Water Regulation	
Runoff Diversion	Negligible
Agricultural practices	Low, but very much correlated to the region and the respective production system
Embankments	€4 million per km
Flood reservoirs	€2490 - €3670 per m^3
Groundwater infiltration	€0.75 - €7.50 per m^3
Water purification	
Agricultural practices	€1 - €23 per kgN (depending on the production system and the intended reduction level)
Sewage treatment plant	€15.8 million at 49 million litres per day For nitrogen removal, marginal costs of €6 - €25 per kgN and for phosphorous removal costs of €20 - €35 per kgP are reported in Germany
Water purification plant	€365 million (construction costs) and €17.2 million (O&M) per year: €0.29 per m3
Carbon storage	
Carbon capture and storage	€0.5 - €1.1 billion per plant; €35 - €50 per tonne of carbon abated

Box 3.4. The potential for fresh water to be substituted

The pollution of natural freshwater resources may require substitutes for drinking water. The potential substitutes are illustrated in Figure 3.3 below. As the Figure shows, the cost of these substitutes varies. While some options can be implemented at little or no extra cost, other substitutes can be associated with significant costs. For instance, bottled water (the most expensive substitute for drinking water) can cost as much as 10,000 times that of tap water, amounting to €1.88 per litre. Such high prices often lead to social problems in developing countries, where the poor cannot afford the cost of the substitute. Besides the social impact, bottled water also has a much higher environmental impact than other natural options, given the carbon intensity of its production and transport. Additionally, huge amounts of packaging waste are associated with the consumption of bottled water. A similar situation exists in the case of desalination, which is also accompanied by high financial costs and energy-consuming production.

[4] Taken from: "COPI Task 3: Potential for substitution" Available from: http://ec.europa.eu/environment/enveco/biodiversity/pdf/ieep_alterra_report.pdf

Figure 3.3: Substitution potential for ecosystem services – The case of freshwater (TEEB, 2009a)



Source: IEEP (2009) COPI Task 3: Potential for substitution. Available from: *http://ec.europa.eu/environment/enveco/biodiversity/pdf/ieep_alterra_report.pdf*

Overall, future technologies may allow feats that are impossible or prohibitively expensive today. On the other hand, formerly unknown or unimportant ecosystem services may be discovered to be fundamental to people or the maintenance of other ecological services. An example of this type of dilemma is provided by water management. Humans have always altered rivers to regulate water levels. While these interventions were often successful, changes in rivers and their floodplains decreased their ability to provide regulating and supporting services, resulting in water contamination and floods. People have begun to realise that it may be less costly to enhance flood control and water quality ecosystem services via ecosystem protection rather than construct artificial water control and purification systems (MEA, 2005k).

Unfortunately, past ecological engineering efforts have frequently produced surprising consequences, which suggests that we still lack the sophistication or necessary understanding to engineer ecosystems (MEA, 2005k). Indeed, true restoration to prior states is rarely possible, especially at large scales, given the array of global changes affecting biota everywhere and that 'novel' ecosystems with unprecedented assemblages of organisms are increasingly prevalent (TEEB, 2009b).

This is illustrated, by for example, the fact that scientific evidence questions the effectiveness of large dams to replace the role of natural wetlands for flood mitigation. Wetlands and floodplains act as natural sponges; they expand by absorbing excess water in time of heavy rain and they contract as they release water slowly throughout the dry season to maintain stream-flow. The large scale conversion of floodplains and wetlands (some of it through dams) has resulted in declines in the natural mechanism for flood regulation (MEA, 2005b).

In fact, many services can usually be more efficiently provided by ecosystems than by artificial structures or processes. These include fire protection by native vegetation, maintaining natural soil fertility and safeguarding genetic diversity (including crops and livestock breeds) as insurance for future food security. Investing in ecological infrastructure can be cheaper than investing in man-made technological solutions. For instance, natural solutions for water filtration and treatment forests, wetlands and wetlands provide filtration for clean water at a much lower cost than man-made substitutes like water treatment plants (TEEB, 2009a):

- The Catskills Mountains (United States): $2 billion natural capital solution (restoration and maintenance of watershed) versus a $7 billion technological solution (pre-treatment plant);
- New Zealand: in Te Papanui catchment, the central Otago conservation area is contributing to Dunedin's water supply, saving the city $93 million;
- Venezuela: the national protected area system prevents sedimentation that would reduce farm earnings by around $3.5 million/year.

Substitution of cultural services

The substitutability of cultural services depends on the context, the location and specific nature of the service in question. Tourism offers an interesting case in point.

Arguably, certain (charismatic) species may not be substitutable. If, for instance, the Komodo dragon or any of the ‘big five’ African mammal attractions disappeared, many might be deterred from visiting a particular park. However, increasing rarity and risk of extinction may increase tourism demand for certain sites and species (e.g. the mountain gorilla, tiger and giant panda). Perhaps most importantly, tourism is not currently limited by availability of natural attractions. Increasing availability of nature-based tourism attractions (for example due to the establishment of new protected area destinations) increases choice, substitutability and competition between destinations. Changes in the biodiversity of some areas therefore may mostly only alter the geographic distribution of economic benefits from tourism as new destinations capture a portion of the market. However the overall value of tourism at global scales may not necessarily increase, and may eventually decrease to some degree.

The value of tourism as a justification for ecosystem conservation is limited by the size of the global market, despite its current growth. In the short term, tourism is unlikely to be constrained by a general reduction in biodiversity and availability of recreational sites, up until such point as access, overcrowding or species disappearance cause a tipping point to be reached (usually at the local level). In theory, if sites for outdoor recreation decline, overall welfare will not decline as long as substitutable opportunities are available elsewhere. These will generally be more abundant in the case of longer-distance wildlife tourism than for more general outdoor recreation; most tourists will simply choose a different destination (Balmford & Rodriguez, 2008).

These differences have implications for developed and developing countries. People in developed countries are much more mobile, and therefore may be able to substitute losses in their own cultural services by travelling to destinations where cultural services have been better preserved. However, people in developing countries might not have the opportunities to seek out alternatives if cultural services that are accessible to them are degraded.

Table 3.3: Overview of some possibilities for the substitution of different ecosystem services[5]

Service	Product	Technologies or Technological Systems
PROVISIONING SERVICES		
Food	crops	high yield agriculture, precision agriculture, GM crops
	livestock	cloning, breeding, artificial insemination, GM animals, fortified feeds, high lysine feed
	capture fisheries	aquaculture, fish hatcheries, genetically modified fish, crop-based feeds
	wild foods	agriculture
Timber	wood	high yield tree crops, GM trees, aluminum, steel, plastics,
Natural fiber	cotton, silk, jute, flax, coir, hemp	synthetic fibers, plastics
	furs, skins	synthetic fibers
Fuel	wood, hydropower, wind	fossil fuels, photovoltaics, higher efficiency wind and solar, geothermal , nuclear, high yield biofuel crops, cellulosic ethanol
Transportation and work	beasts of burden	bicycles, mechanized transport (i.e., trucks and cars), airplanes, tractors
Genetic resources		polymerase chain reaction, gene banks, zoos, botanical gardens
Biochemicals, medicines, pharmaceuticals		synthetic drugs and pharmaceuticals, GM pharms, biofactories
Fresh water		Water purification and treatment, recycling and reuse technologies, desalination, water pricing and marketing, property rights for water
REGULATING SERVICES		
Air quality regulation	Traditional air pollutants	scrubbers, fabric filters and electrostatic precipitators for traditional air pollutants; emissions trading;
Climate regulation at local, regional and global scales		carbon sequestration on land, oceans, geologic formations; conservation tillage; geoengineering; modification of land cover and albedo
Water regulation		water purification and treatment, recycling and reuse technologies, desalination, water pricing and marketing, property rights for water
Erosion regulation		no- or low-till agriculture, hydroponic cultivation, cover crops
Water purification and waste treatment		chlorination, waste water treatment, filtration, reduction in oxygen demand
Disease regulation		chlorination, drugs and pharmaceuticals, insecticides
Pest regulation		insecticides, integrated pest management, GM crops
Pollination		Managed pollination via non-native/cultured pollinators (e.g., European honeybee in the US), hand/mechanical pollination, electrostatic enhancement
Natural hazard regulation		Artificial or restored wetlands and mangroves, dams, sea walls, levees, dykes, concrete and steel houses

[5] Taken from: "Technological Substitution and Augmentation of Ecosystem Services". Available from: http://goklany.org/library/Goklany%20Technological%20substitution%20in%20ecosystem%20services.pdf

CULTURAL SERVICES		
Spiritual/religious values		Photographs, movies, videos, HD and holographic television, virtual reality
Aesthetic values, recreation and ecotourism		Man-made or augmented landscapes and ecosystems, artificial reefs, zoos, arboretums, photographs, movies, videos, HD and holographic television, virtual tourism

Note: Most substitutes are imperfect (some more imperfect than others)

3.4 Implications for Sectoral Economic Activity and Employment

Table 3.4 summarises the main links between employment in different sectors and biodiversity, through the dependence of various sectors on ecosystem services. For more detail on a select number of sectors, see 'Annex C – Detailed Examples of Links between Employment, Ecosystem Services and Biodiversity in Some Sectors'. The implications of biodiversity loss on employment is discussed more fully in section 6.2, where, for instance, the impacts of increased investment in natural or technological capital on labour intensity is considered, as well as the sensitivity to jobs of changes in biodiversity.

Table 3.4: The importance of biodiversity to different sectors

Sector	Links to biodiversity	**Strength of linkage** (Dominant ecosystem service)	Substitut-ability[1]
Primary industries highly dependent on ecosystem services			
Agriculture	Agriculture relies only to a limited extent on the inputs from genetic resources, which are increasingly limited to a small subset of available resources. The remainder are increasingly substitutable, e.g. through genetic breeding techniques. Agriculture is hugely dependent however on regulating services, most notably that of pollination, biological control, water regulation and waste treatment. These are significantly influenced by biodiversity. Supporting services are also important, especially nutrient cycling, soil formation and maintaining an agro-ecosystem's resilience in the case of disturbances. These ecosystem services are much harder (and in some cases, impossible) to substitute successfully. Such supporting services are highly dependent on biodiversity.	*** (R, S)	*
Forestry	Similarly to agriculture, forestry depends less on the inputs of genetic resources (given the growing prevalence of large-scale monoculture plantations), than on regulating and supporting services. These include nutrient cycling, soil formation, waste treatment, biological control and seed dispersal. The role of these in supporting the sector is hugely significant.	*** (R, S)	*
Fisheries	Fisheries are more dependent on inputs from genetic resources than forestry or agriculture, given their continued reliance on wild inputs as opposed to cultivated inputs. Nonetheless, aquaculture is increasing the substitutability of these (the extent of which is however limited – aquaculture is still extremely dependent on marine fisheries for its inputs). Regulating and supporting services which critically support fisheries include climate regulation, waste treatment, biological control, and ecosystem resilience.	*** (P, R, S)	
Water Supply	Significantly dependent on certain regulating services, including the regulation and supply of water, the moderation of extreme events, and waste treatment. These are all influenced by biodiversity,	** (R)	*

	although the extent to which is still poorly understood.		
Processing and Manufacturing industries dependent on ecosystem services for inputs and processes			
Energy Supply	Mostly dependent on provision of history raw materials. Substitutability is relatively low at present, although this is increasing with the growth of wind, water and other renewable energy sources; these are heavily dependent on regulating services.	** (P)	*
Mining	Mostly dependent on provision of historical and current raw materials. The potential for substitutability for these inputs is moderate. The sector is also dependent on certain regulating services such as the supply and regulation of water, as well as waste treatment.	* (P)	**
Food, drink, and tobacco	Significantly dependent on primary production, however the role of biodiversity in providing those inputs might be limited as substitutability is high. However, the continued provision of these inputs are dependent on the same regulating and supporting services as agriculture and other such primary production sectors, although this reliance is significantly weaker.	** (P, R, S)	**
Textiles, clothing and leather	Significantly dependent on raw materials, however the role of biodiversity in providing those inputs might be limited as substitutability is high.	* (P)	**
Wood and paper	Although the provision of fibre and forest products depends on certain ecosystem services, their reliance is considerably weaker than that of the actual forestry sector. For instance, there appears to be little evidence to suggest that changes in forest ecosystem condition will materially affect the availability of wood pulp globally in the foreseeable future. Instead, evidence suggests that the increase in competing materials and the increased harvest of young plantations will continue to keep supplies ample and prices low.	** (P, R, S)	*
Pharmaceuticals	Pharmaceuticals are most dependent the inputs from genetic resources, which have historically played, and still continue to play, a significant role in pharmaceuticals through bio-prospecting; over 50% of modern prescription medicines were originally discovered in plants. However, there has been a withdrawal of companies from bio-prospecting of late due to investments yielding relatively few lead compounds.	** (P)	**
Other manufacturing industries	Significantly dependent on raw materials, however the role of biodiversity in providing those inputs might be limited as substitutability is high.	*	**
Services activities dependent on cultural and provisioning services			
Hotels and catering	Somewhat dependent on the cultural services provided by biodiversity, whose substitutability in localised cases is limited, although scope for substitutability is much higher when considering all available cultural services (e.g. travellers have other destinations they can go to if cultural services are degraded in any one area). However, the sector is also highly dependent on certain regulating services such as waste treatment and the regulation of climate, air and water quality, and natural hazards, which are much less substitutable than the cultural services themselves.	** (C, R)	*
Media and creative industries	Significantly dependent on the cultural services provided by biodiversity, however the potential for substitutability is also considerably higher than in the hotels and catering sector and the sector is less dependent on regulating and supporting services.	* (C)	**
Education	Significantly dependent on the cultural services provided by biodiversity, however the potential for substitutability is also considerably higher than in the hotels and catering sector and the sector is less dependent on regulating and supporting services.	* (C)	**
Services activities dependent on provision of raw materials and fuel			
Construction	Mostly dependent on provision of history and current raw materials. The potential for substitutability is moderate.	* (P)	**
Transport	Mostly dependent on provision of history and current raw materials. The potential for substitutability is moderate. The sector is somewhat dependent on regulating services such as the regulation	* (P, R)	**

	of climate, and natural hazards.		
Other activities			
	Dependent on ecosystem services indirectly in maintaining the health of the workforce, the living and working environment, and for providing protection from natural hazards	* (R)	*

[1] Substitutability: *** - largely substitutable; ** - somewhat substitutable; * - difficult to substitute; none – not at all substitutable.

Most sectors, and therefore most jobs, are in some way dependent on the regulating and supporting services that biodiversity underpins. Cultural services also play a significant role, albeit the dependence is limited to a small number of service sectors. Provisioning services appear to play a less significant role, largely due to the increasing substitutability of inputs.

The above analysis suggests that employment in primary sectors will be most significantly affected by changes in biodiversity. This is due primarily to these sectors' dependence on biodiversity in its role in delivering regulating and supporting services, not actually through direct provisioning services. As has been shown in the discussions above, biodiversity loss can actual mean increased productivity and so there is no obvious relationship between biodiversity and provisioning services in primary industries. Thus, the effects will be felt most in terms of the impacts biodiversity loss has on regulatory and supporting services and so these impacts might not be felt immediately, or might only become apparent after the system has suffered a severe disturbance. Overall, these sectors rely mostly on biodiversity to the extent that biodiversity increases the resilience of natural systems, and their ability to recover from disruption. For instance, the impacts on employment may only become apparent as these sectors become vulnerable to disease and invasive species, if the ability of the system to resist such episodes has been compromised by a reduction in biodiversity. Even then, the number of jobs that are affected will depend on the severity of the disturbance to the sector.

In some cases, the characteristics of the primary industry might mitigate the effects on employment. For example, following the outbreak of Foot and Mouth disease in the UK in 2001, it was estimated that 15,000-20,000 jobs would be at risk of being lost (equivalent to 6-8% of the area's employment). In reality, the number of people that registered as unemployment amounted to less than 700. The effect of the outbreak was apparently absorbed through reduced recruitment of summer workers and an increased 'under-employment' of workers who were not eligible for unemployment benefit or did not register as unemployed for other reasons. This was partly possible due to the characteristics of the sector – many who work in agriculture (and hospitality) are self-employed, freelance, part time, or casual seasonal workers whose employment is flexible. Additionally, a high proportion of businesses are 'family concerns' where it is preferable to reduce hours rather than lay people off. An interesting consequence of the outbreak was the creation of as many as temporary manual jobs were created as a consequence of the disease-control and 'clean-up' procedures, and these would have absorbed some excess labour capacity from agriculture (Cumbria FMD Task Force, 2002).

Fisheries are the one area of economic activity which relies heavily on the provisioning services of biodiversity, since substitutability in this case is more limited. Past experience has already shown that jobs in this area are at high risk of being lost if biodiversity is also lost. Crucially the extent of employment in these, more vulnerable, sectors is greater in developing countries than in the EU, where primary sectors employ a relatively limited number of people.

Regarding manufacturing and processing industries, jobs are at lower risk of being affected by changes to biodiversity given that the dependence is largely based on provision of raw materials, where the ability to substitute inputs is significant, and arguably increasing. Nonetheless, these sectors are still indirectly reliant on the regulating and supporting services that ensure that inputs are consistently made available. However, the nature of the dependence is more indirect than that of the primary industries. It is likely therefore that any effects resulting from biodiversity change will have a more delayed impact on employment in this area of economic activity. As with the primary industries, employment in manufacturing and processing industries is greater in the rest of the world than in the

EU. As a consequence, EU employment will be less exposed to the impacts of changes in biodiversity.

However, EU employment is perhaps more vulnerable in the case of the service sector. Proportionally, more people are employed in the service industry in the EU compared to the figures for developing countries. Employment in the hospitality industry is perhaps most at risk, given its high reliance on cultural services, and the limited ability of these services to be substituted. In the case of the outbreak of Foot and Mouth disease in the UK, by far the greatest loss to employment was not in the agricultural sector, but to the hospitality sector (CRE, 2001). In the other service sectors which use cultural services, it is likely that changes to biodiversity will have a much smaller impact. Although the cultural services provided by ecosystems are not easily substitutable, the sectors affected are not solely dependent on these services as an input. For example, the loss of ecosystem cultural services may lead to the growth of other forms of tourism (e.g. based on the built environment). Therefore while there may be changes in patterns and locations of employment, with adverse impacts on some communities, overall levels of tourism employment will not necessarily change.

In the case of construction and transport, the situation is similar to some of the manufacturing and processing industries, in that the provisioning services that play a role in supporting these sectors are increasingly substitutable. It is therefore unlikely that changes in biodiversity will have a major impact on their employment.

Nonetheless, as noted before, all jobs depend to some extent on the regulating and supporting services that sustain the natural systems which allow the continuation of all economic activity. However, it is less clear at what point changes to biodiversity will impact these services to the extent that economic activity may longer be sustained and jobs will be lost.

4 ANALYSIS OF JOBS DEPENDENT ON BIODIVERSITY

4.1 Jobs in Biodiversity Conservation

4.1.1 In the EU

Biodiversity conservation directly supports a small but growing number of jobs in the EU.

BirdLife International has estimated that in the EU-15 125,000 jobs are supported in nature protection related activities, while in the same countries Ernst and Young (2006) has estimated that employment in Natura 2000 sites alone amounts to the equivalent of 83,530 full time jobs. Direct employment in the natural environment sector in the UK is estimated at 18,000 jobs. Local employment attributable solely to protected areas managed by RSPB (the BirdLife partner in the UK) is estimated at more than 1,000 jobs. This includes both direct and indirect local employment. Significantly, nature conservation is a growth sector, unlike agriculture and forestry which have shed many jobs in the last decade.

A recent report for DG Environment estimated that the full implementation and management of the Natura 2000 network can be expected to directly support 122,000 FTE jobs[6] and Gross Value Added of €3.05 billion in the regions in which sites are located, helping to provide a new source of income for land owners and managers and to diversify the rural economy. Taking account of indirect and induced effects (through purchased inputs and employee expenditures), the total impact at the EU level is estimated to be to support 207,400 FTE jobs and GVA of €5.2 billion at the EU level[7].

There are additional benefits to the tourism sector, through opportunities to market locally distinctive and environmentally beneficial produce, and through the delivery of ecosystem services. Some examples are given in Box 4.1.

Box 4.1: Examples of Employment Linked to Biodiversity

- The pond complex of Central-Limburg (Belgium) supports employment of between 65 and 85 full time jobs directly and indirectly (GHK et al., 2010);
- The Natura 2000 site of Lille Vildmose (Denmark) was estimated to support 68 direct jobs in 2002 with 167 expected in the following 5-10 years (GHK et al., 2010);
- The Salaca river, Latvia, supports 21 jobs directly, 11 indirectly, and generates further employment through tourism (GHK et al., 2010);
- Successful development of wildlife tourism in the Prespa wetlands, Greece, has created 50-60 new jobs and extended the season year-round (GHK et al., 2010);
- In the UK, it is estimated that around 18,000 people are directly employed in nature conservation, which also contributes to significant indirect employment (The Royal Society for the Protection of Birds, 2010)).
- In Germany approximately 1.8 million or 4.5% of jobs were related to environmental protection in 2006, up from an estimated 3.8% in 2004 (Umwelt Bundesamt, 2008).

[6] GHK et al (2010) Economic Benefits of Environmental Policy. Report for DG Environment. Based on estimate that wages comprise 50% of the costs of the network and an average wage rate of 25,000 euro per FTE job (from MS responses to EU questionnaire survey on costs of managing N2K sites)

[7] Based on a multiplier of 1.7 (direct + indirect + induced to direct effects) for natural resource based activities from modelling work in the GHK et al (2007) study on the links between the environment, economy and jobs

More widely, based on the core natural resource definition[8], environmental protection and management and environmental quality, the total turnover in the European economy linked to the environment is €405 billion, supporting 4.4 million jobs. Of this:

- around €144 billion in turnover and 1.6 million jobs is associated with? tourism that depends on environmental quality so, for example, recreational fishing or tourism where the natural environment influences the choice of destination. Visits to the seaside are excluded from this estimate.
- around €100 billion in turnover and 960,000 jobs are associated with? organic agriculture, sustainable forestry, renewable energy and water extraction and supply
- around €160 billion in turnover and 1.8 million jobs are associated? with environmental protection and management. Adding in induced and indirect effects would increase the totals to €1,130 billion in turnover and 8.6 million jobs.[9]

High standards are important in sectors such as tourism and leisure, which rely on an attractive physical environment to win customers. In England, economic activities connected with the management of the natural environment support an estimated 2.68 million full time equivalent jobs[27]. In Wales an estimated 1 in 6 of the workforce depends on the environment for employment, whilst in Scotland nearly as many people are employed in natural heritage related activity as are employed in biotechnology, call centres and electronics combined. Across the EU as a whole, it has been estimated that almost one job in every ten jobs is somehow linked to the environment. If indirect effects are included, this figure rises to one in six (GHK *et al.*, 2007). However, the links are often weak as the typology used in the study is wide[10] and includes a large number of jobs broadly dependent on natural resources.

4.1.2 Outside the EU

There are already more than 120,000 designated protected areas covering around 13.9% of the Earth's land surface. Marine protected areas still cover only 5.9% of territorial seas and 0.5% of the high seas but are increasing rapidly in number and area (TEEB, 2009e). These areas have significant potential for creating and maintaining employment. For instance, it has been estimated that conserving 20-30% of global oceans in MPAs could create a million jobs (TEEB, 2009e).

Some examples of jobs related to nature conservation are provided in Box 4.2.

Box 4.2. Examples of jobs related to nature conservation in countries outside the EU

- Economic activity in conservation lands within the West Coast Region of New Zealand's South Island led to an extra 1,814 jobs in 2004 (15% of total jobs), and extra spending in the region of US$ 221 million a year (10% of total spending), mainly from tourism (TEEB, 2009c).
- In Bolivia, protected area tourism generates over 20,000 jobs, indirectly supporting over 100,000 people (TEEB, 2009c).
- In South Africa, the ecosystem restoration programme 'Working for Water' combined control of invasive alien species with rural economic and social development. The project treated 3,387 ha

[8] Activities where the environment is a primary natural resource or input into the economic process – organic agriculture, sustainable forestry, renewable energy and water extraction and supply (a broader definition would includes all agriculture and forestry, fishing, mining and quarrying, all electricity generation and water supply and extraction)

[9] http://ec.europa.eu/environment/enveco/industry_employment/pdf/ghk_study_wider_links_summary.pdf

[10] The typology used includes activities where the environment is used as a resource input, activities related to the management of the environment (including environment protection and resource management , as well as economic activities dependent on environmental quality

of land and created 91 person years of employment. Contracting costs up to 2001 were R 2.7 million, with an estimated total cost of R4.9 million (including project management costs and all other transaction costs). The action prevented losses of between 1.1 and 1.6 million m³ of water annually (TEEB, 2009c).

- In New Zealand, the DOC West Coast/Tai Poutini Conservancy manages 1.9 million ha of land that in 2003 generated economic activities estimated to be worth 15% of the 12,341 full-time job equivalents in the area[11].
- In Namibia, community-managed conservation areas generated 547 full-time and 3,250 part-time jobs (mostly to women) by the year 2004.[12]
- According to the Bureau of Labor Statistics, in the US fish and game wardens accounted for 7,530 full-time jobs in 2009 while forest and conservation workers account for 5,840 full-time jobs. In 2008 conservation scientists accounted for 18,300 full-time jobs and foresters accounted 11,500 full-time jobs (United States Department of Labor: Bureau of Labor Statistics).[13]
- An estimated 4.97 million jobs across the US were related to environmental protection in 2003 (Beydek, et al, 2007).
- The Namunyak Wildlife Conservation Trust in northern Kenya is a non-profit community owned wildlife initiative which contributes to local economic development and biodiversity protection of the area. The trust has 43 permanent employees and 200 temporary employment opportunities available (Craig, and Wamithi, undated).
- In the Cape Tribulation section of Daintree National Park (in the Wet Tropics World Heritage Area), Australia, it is estimated that annual visitor expenditure amounts to more than $100 million. 2,778 jobs in the local area rely on tourist expenditures, which comprise 39.5% of local jobs (compared to a national average of 6.0% employment in tourism) (Griffin et al. (2004)).
- In South Africa, the Sabi Sabi Private Game Reserve, adjacent to Kruger National Park, is an 800 ha private game reserve and environmentally friendly sewage management facility. It supports 130 employees and their families (Eagles et al, 2002).
- The Wakatobi Marine National Park in Indonesia contains 1.39 million ha of marine, coastal and tropical forest environments. It is estimated that the park provides 60 local families all or a significant proportion of their income through employment, contract work or by purchasing supplies from them (Eagles et al, 2002).

4.2 Wider Links between Employment and Biodiversity

Based on the analysis in the previous sections, the numbers of jobs linked to biodiversity to varying degrees can be quantified. Based on the analysis in Section 3, a typology has been established outlining the extent to which different sectors (and therefore employment) depend on biodiversity. The typology takes into consideration the extent to which biodiversity impacts on the ecosystem services on which the sector's activity depends (strength of linkage to biodiversity), as well as the extent to which the role that biodiversity plays can be substituted by other (either natural or artificial)

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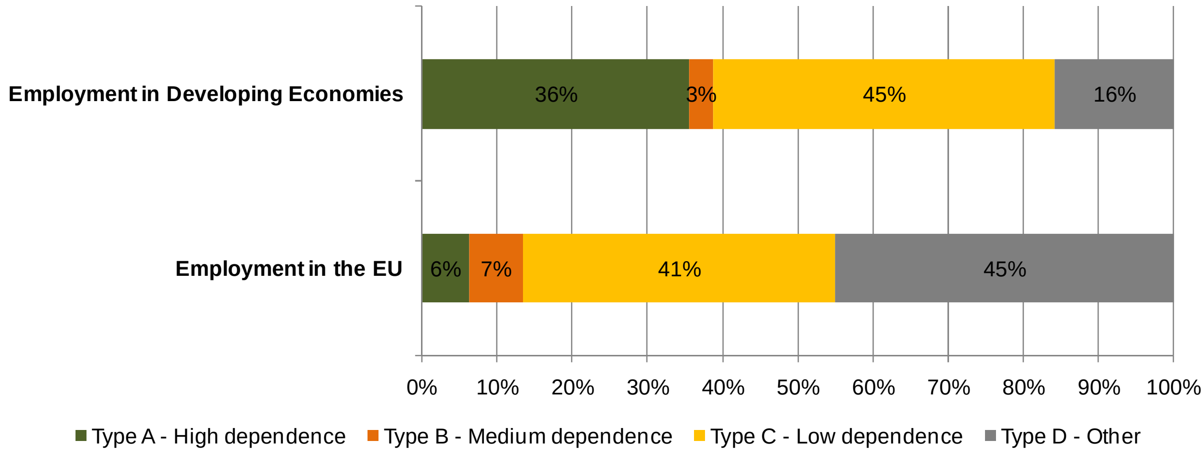
[11] http://www.consvalmap.org/
[12] Ibid.
[13] Employment as a warden entails patrolling an assigned area to prevent fish and game violations as well reporting on damage to the area and gathering biological data. Forest and conservation workers supply manual labour to develop, maintain, or protect forested areas and woodland areas through activities such as planting trees, combating insects, pests and disease harmful to trees as well building structures to protect against water erosion. Conservation scientists manage, improve, and protect natural resources, they work with landowners and governments to devise ways to use and improve the land while safeguarding the environment. Conservation scientists advise farmers, farm managers, and ranchers on how they can improve their land for agricultural purposes and to control erosion. Foresters have a wide range of duties and oversee forests and direct activities on them for economic, recreational, conservational, and environmental purposes.

alternatives (potential for substitution), which is detailed in Table 3.4 above. This is combined with estimates of employment in each sector, as set out in Table 2.2 and "**Errore. L'origine riferimento non è stata trovata.**". Needs updating. Due to the data limitations (discussed further in Annex A), it has only been possible to use very broad categories of sectors, which does hide some of the more detailed and nuanced implications for employment based on biodiversity and ecosystem services. Manufacturing, for instance, is a particularly broad sector within which particular jobs may be especially dependent on services and inputs from the environment. As such, the analysis only attempts to provide a general overview of the dependencies and linkages between employment and biodiversity. The results are shown in Table 4.1, and represented graphically in Figure 4.1.

Table 4.1: Extent to which employment in the EU and developing economies depends on biodiversity

Type	Sector	EU		Developing economies	
		Employment (thousands)	**% of Total**	**Employment (thousands)**	**% of Total**
A. High dependence - very strong linkage, limited potential for substitution	Agriculture	11,223	4.9%	895,218	34.4%
	Forestry	2,988	1.3%		
	Fisheries	400	0.2%	31,811	1.2%
B. Medium dependence - medium strength of linkage, limited potential for substitution	Water supply	373	0.2%	21,049	0.8%
	Energy Supply	1,233	0.5%		
	Wood and paper	4,252	1.9%		
	Hotels and catering	10,598	4.6%	60,800	2.3%
C. Low dependence - some potential for substitution, and EITHER medium OR low strength of linkage	Food, drink and tobacco	5,635	2.5%		
	Pharmaceuticals	548	0.2%		
	Mining	859	0.4%	31,696	1.2%
	Textiles, clothing and leather	3,020	1.3%		
	Other manufacturing industries	24,204	10.6%	733,844	28.2%
	Media and creative industries	3,139	1.4%		
	Education	15,368	6.7%	132,923	5.1%
	Construction	16,770	7.3%	140,171	5.4%
	Transport	26154	11.4%	145,164	5.6%
D. Other - low strength of linkage	All others	103,985	45.4%	412,268	15.8%
Total		230,747	100.0%	2,604,923	100.0%

Figure 4.1: Extent to which employment depends on biodiversity (taking into account the strength of linkage to biodiversity, and the potential for substitution)



The above analysis indicates that a considerable number of jobs in developing countries are highly dependent on biodiversity (927 million), much more than in the EU (14.6 million). However, a roughly equal proportion of jobs in developing economies (1,266 million), and in the EU (112 million) are either somewhat or slightly dependent on biodiversity (about 50%). A larger proportion of employment in the EU however, falls into the category of jobs that have only indirect links to biodiversity (104 million jobs), and are only reliant on it as far as biodiversity underpins the regulating and supporting services that determines our natural systems. Changes in biodiversity, and the consequent effects on ecosystem services, are therefore likely to be felt less in the EU than in the developing countries.

It is clear that the effects of biodiversity loss will vary depending on the region, and even country, in question. The impact will depend on the level of endowments of biodiversity and the degree to which resources are exploited. It is likely however that the consequences of biodiversity loss will be felt most acutely in countries whose population are largely composed of fishermen, subsistence farmers, rural societies and communities that face this degradation and disruption, given that developing countries are richest in biodiversity, whilst their regulation and enforcement is less stringent. Nonetheless, some local communities in the EU will also be faced with the same challenge (OECD, 2010).

4.3 Qualitative Aspects of Biodiversity/Employment Links

4.3.1 The Quality of Jobs

The above analysis indicates that a significant number of people are employed in industries related to, or directly dependent on biodiversity. This is especially the case in developing countries, where those employed in the primary sector are the most dependent on biodiversity. Biodiversity therefore underpins a significant number of "green jobs", which are jobs in agriculture, industry, services and administration that contribute to preserving or restoring the quality of the environment.

However, although the quantity of jobs is important, the quality of jobs is increasingly being recognised as a key consideration. This recognition is evidenced by the emergence of the Decent Work Agenda, developed by the ILO, which emphasises fair and sustainable working opportunities (Box 4.3). Decent work is conceptualised as requiring four interdependent and mutually reinforcing aspects:

- Access to productive employment and income opportunities;
- Rights at work, particularly with respect to the core labour standards;
- Systems of social protection; and

- A voice at work through social dialogue.

There is an increasing appreciation for the fact that green jobs should also be good jobs (UNEP, 2008; IPPR, 2010). Unfortunately, this is not always the case. Whilst there is very little research available across the EU Member States on the quality of green jobs (EEO, 2009), evidence from developing countries shows that green jobs do not automatically constitute decent work. Work in the primary industries, where the dependence on biodiversity is especially high, is particularly precarious, vulnerable, and often characterised by low incomes and low skill levels.

Box 4.3: Decent work

Decent work is defined as opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. Decent work sums up the aspirations of people in their working lives – their aspirations for opportunity and income; rights, voice and recognition; for family stability and personal development; for fairness and gender equality. Ultimately these various dimensions of decent work underpin peace in communities and society. Decent work is central to efforts to reduce poverty, and is a means for achieving equitable, inclusive and sustainable development (ILO definition).

Source: http://www.ilo.org/global/About_the_ILO/Mainpillars/WhatisDecentWork/index.htm

Agriculture

Agriculture is a particularly labour-intensive sector, especially in developing countries. However, a variety of issues call into question the quality of jobs in the sector. For instance, agriculture accounts for 70% of all child labour globally (UNEP, 2008). Moreover, agriculture is one of the most dangerous industries (UN CSD, 2000) . Those employed in agriculture are twice as likely to die at work than in any other sector. Among these fatalities are an annual 40,000 deaths from exposure to pesticides, while millions more are severely poisoned.

Furthermore, ILO has found that "decades of neglect and deteriorating farm-gate prices have led to unsustainable land-use practices and to bad jobs and low incomes" (ILO, 2007: p.11). Consequently, farmers and agricultural workers are the largest contingent of poor people in the world. Most of the three out of every four people in developing countries— 900 million individuals— who live below the $1 per day poverty line in rural areas depend directly or indirectly on agriculture for their livelihoods (UNEP, 2008). This is exacerbated by the precarious nature of the work and recent trends in the sector. Three trends in particular have contributed to increasing inequalities in the food system: the shift towards fewer farmers and landowners; a growing share of the work being done by landless labourers; and increasing flexibility in employment. These trends have been driven by technological innovation and particularly by the restructuring of the upstream and downstream sections of the supply chain as result of consolidation in food retailing. Consolidation has meant that large businesses are able to place great pressure on producers to satisfy a range of customer demands (Food Ethics Council, 2010). This pressure to meet these demands is often too great for small holders, which are being excluded from participation in the market (FAO, 2004). For example, the number of Kenyan small holders producing fresh fruits and vegetables for export markets declined from 75% in the early 1990s to a mere 10-20% by the late 1990s (Posthumus, 2007).

Smaller "greener" farmers are therefore increasingly losing out to large capital-intensive producers and suppliers. Coupled with productivity improvements throughout the global food system, this further contributes to rural unemployment and accelerated urbanization, where migrants often find themselves in cities where conditions are frequently worse than the ones they left behind. Some smallholders and entrepreneurs are responding to these trends by moving into higher-value, "new agriculture" products. However, these generally require more environmentally damaging inputs and are also characterised by low-quality and precarious employment.

Producers are able to meet the increasing demands created by the globalisation of the agricultural marketplace by transferring the risk onto their workers through less favourable conditions, such as reducing their permanent employment positions and increasing the use of temporary workers, or by outsourcing the production completely. As such, agricultural workers are amongst the first to bear the cost of cutbacks and restructuring of agricultural production as flexible labour practices enable exporters to drive down wage and social benefit costs (e.g. sick pay), while shifting the risks of production and the costs of maintaining the labour force onto workers and their families ((Posthumus, 2007; Food Ethics Council, 2010).

This has meant that the number of permanent employees in the agricultural sector is decreasing. For example, 75% of workers in the Ugandan cut flower industry are now employed on a temporary basis, with associated wages being lower than permanent positions (Posthumus, 2007). This trend towards the ‘casualisation’ of the waged agricultural workforce means the instability that is already inherent in agricultural employment is being increased further, at the same time as larger growers are benefiting from increased flexibility.

Whilst these trends have affected European farmers as well as those in developing countries, there are fundamental differences between the quality of jobs of the two. While European farmers are also vulnerable to volatilities and suffer from job insecurity, there are benefits associated with farming in Europe which means the quality of the job might be considered higher than other, perhaps more stable employment. For instance, whilst some might see the exposure to the elements as a drawback, most farmers prefer working outdoors to working in an office. Rural living is also considered safer and is associated with a greater sense of community. The job also provides considerable flexibility, despite the long working hours (Faires, 2010).

Agriculture remains the world’s second largest source of employment and this serves to emphasise the importance of improving the quality of work in agriculture. Fortunately there are some indications that improvement is possible and in some places, already occurring. For instance, small farms using more sustainable methods are both labour intensive and are associated with fewer of the risks associated with agricultural work outlined above. This kind of sustainable farming tends to be knowledge intensive. The process of developing farmers’ ecological literacy could therefore also create significant employment. Furthermore, whilst agricultural restructuring has had some negative impacts, it has also created some opportunities, such as increasing access to new markets and value chains for producers through the rising number of global value chains touching ground in developing economies.

Organic farming and local food systems also show significant potential. Organic farming, for instance, has been shown to employ one third more full-time equivalent workers compared to conventional farming (UNEP, 2008). Nonetheless, any growth in alternative, decent agricultural employment would have to confront or adapt to powerful trends to reduce labour inputs in the name of efficiency, productivity, and profitability.

Forestry

The forestry sector is generally a significant source of wealth and employment, especially in developing countries. Jobs in the sector however, are usually under-reported. Consequently, self-employed or informal workers are often overlooked in national statistics. Estimates of informal forestry workers vary significantly (from 30 million to 140 million), but all underscore the importance informal workers in the forestry sector. Even these estimates however do not consider that the vast majority of those who depend on forests for their livelihoods are not wage earners, but people who rely on the forest for subsistence.

The challenges for those employed in forestry in developing countries are particularly great, especially for those in lower income groups who are often not able to take advantage of higher value products. Higher value products often require more skills or equipment, and are therefore exploited by those who are already more affluent and able to make the necessary investment. For example, non-timber forest products (NTFPs) are often used for subsistence purposes but some of these do have market values. The harvesting and use of NTFPs is labour intensive, requires few skills and little capital. This makes collection attractive to the poorest, but this also means that the poor frequently have poor prospects for market or price growth, making them a safety net rather than a means of poverty reduction. Crucially, the highest value products tend to be managed more intensively, by specialised producers (WWF, 2008).

Forestry is characterised both by a few large multinationals, and a multitude of small and medium-sized forest enterprises (SMFEs). SMFEs are generally labour intensive. However, the industry is also associated with very low wages. Most jobs in the sector are also increasingly sporadic, part-time, and seasonal, as global forestry corporations come under increasing pressure to improve their competitiveness. Costs are often reduced by reducing the number of formal employees. Workers are often paid by 'piece rate', requiring long hours under harsh working conditions to surpass poverty-level wages. Existing hazardous working conditions are being exacerbated as these trends bring additional health and safety concerns. Jobs in the forestry sector, especially logging jobs, are in the top three most dangerous jobs in almost all countries. In the case of woodworking for instance, workers have to constantly depend on their own "skills to avoid injuries, rather than on any prevention measures" (BWI, 2010).

Many believe that REDD+[14] schemes will benefit rural populations by increasing employment and income. However, unequal structures of land ownership and corruption may prevent the benefits from reaching the intended recipients. Currently there are few examples of REDD schemes, consequently their impacts on employment and incomes are still unclear. Sustainable forestry management and certification schemes have some employment benefits. By ensuring the longevity of forests, the schemes provide long term employment opportunities. Some schemes are also associated with specific standards for employment. However, evidence on the actual economic and employment consequences of certification is mixed (UNEP, 2008).

On the other hand, projects which focus only on afforestation and reforestation are usually dominated by seasonal, contract work given the short time span of the planting season. Tree planting is also generally low paid, with little associated benefits. The extent to which tree planting is mechanised also has a significant impact. Mechanisation decreased the need for labour inputs, but does generally increase safety and the ability of companies to pay higher wages.

Overall, it is likely that REDD+, and other sustainable land use changes may lead to immediate losses of jobs, but that long term positive effects on employment are likely as jobs are sustained in the sector over a longer time period.

Fisheries

As with forestry, employment in fisheries tends to be characterised by low incomes. Many rely on fisheries for subsistence purposes. The sector is also characterised by significant challenges. For example, market rigidities mean that those employed in the fishing sector face a particularly difficult situation. Fishers usually have low education levels and sector-specific abilities, and tend to be elderly. Consequently, options for employment elsewhere are limited. There are also cultural factors (such as attachment to the sector) and the distance from other labour markets that increase adjustment costs should a fishery collapse (OECD, 2010). Workers are often geographically isolated and specifically skilled, making them especially vulnerable in the case of any disturbances.

As fishing takes place in often hostile marine environments, it is of little surprise that it is one of the most dangerous professions in the world. Fatality rates are exceedingly high, with the worldwide fatality rate being estimated at 80 per 100,000 workers (roughly 24,000 deaths per year). Additionally, there are also 24 million non-fatal accidents annually (ILO, 1999). In the UK for instance, fishing by far the most dangerous job, with fishermen being 50 times more likely to die while working compared to any other job.[15] Drowning is the leading cause of death among fishermen.

[14] Reducing Emissions from Deforestation and Forest Degradation (REDD) - is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

[15] BBC (2002) "Fishing 'most dangerous job'". Available from: http://news.bbc.co.uk/1/hi/health/2195847.stm

Characteristics of the job mean that there are numerous possibilities of fire, sinking, collision or grounding. Where accidents do happen, the effects can be exacerbated as it can take a long time for aid to reach the vessel. Additionally, working conditions such as cramped crew accommodation can increase stress as well as facilitate the passage of contagious diseases. Fishermen also have 'indefinite workdays', with exceedingly long hours. Crew member are often expected to work between 18 and 22 hours a day without a break. Many fishermen also suffer from skin and respiratory diseases, as well as from the effects of noise and vibration (ILO, 1999).

Conservation and eco-tourism

There is very little information available on the skills profiles in nature protection, biodiversity conservation and natural hazards prevention sectors (Ernst & Young). Most information on the quality of green jobs is limited to primary industries such as those detailed above, and emerging eco-industries such as those relating to renewable energy and energy efficiency.

From the limited amount of information available however, it appears that those involved in the management of protected areas tend to be employees from national authorities or non-governmental organisations. It is therefore likely that these jobs are at least somewhat skilled, and certainly not as low paid as those in the primary industries. Those employed in protected areas tend to be the moderately poor, to the better off. The poorest rarely have the basic skills or connections needed to secure themselves a job (Leisher et al., 2009).

For those who are hired by protected areas, however, significant benefits can be reaped. For instance, the average wage for an employee in a South African national park earns four times more than the minimum wage in the South African forestry sector. Nonetheless, employment in nature conservation is not generally considered financially rewarding. This is one of the reasons why career opportunities are considered limited, especially by younger generations. Another reason is the limited number of entry-level opportunities available to young people (CBD, 2004). Indeed, while analysis of the quality of work in conservation is scarce, anecdotal evidence suggests that relatively low rates of pay and a lack of opportunities for work progression seem to be associated with jobs in conservation (IPPR, 2010). Many protected area jobs that do go to local people, including positions that require a knowledge of the local area, such as guides and guards, often pay too little to lift a local person out of poverty (Leisher, 2009). Furthermore, although training is necessary, the quality of the training is often inadequate. A report by the WWF found that staff across 200 forest protected areas in 37 countries reported serious shortfalls in training and capacity building (WWF, 2004).

The potential for local people to be employed in aspects related to the management of protected areas (for example in related jobs such as park rangers, tourist guides, interpretive centres, infrastructure provision and maintenance) is significant. Many of these jobs would involve some training, which could complement their traditional knowledge, especially in such tasks as environmental/social/cultural impact assessments, biodiversity monitoring, parataxonomy, habitat rehabilitation and species surveys (CBD, 2004). Local jobs associated with protected areas can reduce poverty; while the number of jobs and the pay may be modest, benefits to the local rural economy from multiplier effects can be significant (Leisher, 2009)

Some insights into qualitative aspects of jobs in the UK nature conservation sector are given in Box 4.4.

Box 4.4: Qualitative Aspects of Jobs in Nature Conservation in the UK

Rayment and Dickie (2001) in a study of the UK nature conservation sector, summarised evidence on qualitative as well as quantitative aspects of employment. They found that:

- The majority of jobs are in the public sector - in national government, agencies and local authorities.

- Employment in conservation involves a wide range of occupations requiring different skills, such as countryside management, biological and environmental sciences, visitor services and environmental education, as well as managerial, administrative and support functions.
- Conservation organisations often find it difficult to recruit local people with the specialist skills and experience required, and therefore jobs are frequently filled by incomers.
- Employment in nature conservation is widely distributed across the UK, reflecting regional variations in natural landscape, habitats and biodiversity. Many of the jobs associated with conservation-related activities are located in remote rural areas suffering from declining employment in agriculture and with a shortage of alternative job opportunities. In these areas, conservation plays an important role in promoting the diversification of the rural economy.
- Qualification levels are high, with one Scottish study finding that 83% of employees had a university degree.
- Survey evidence suggests that job satisfaction is high among conservation sector employees.
- There are examples of land managed for nature conservation supporting higher levels of employment than under previous uses.

More information is available on the quality of jobs in eco-tourism, which are usually linked to nature conservation areas. Tourism is relatively labour intensive, with proportionally higher than average job opportunities for women and in unskilled jobs. There are low barriers to entry, high multipliers into the local economy, and often opportunities in remote areas where other income opportunities may be limited. However, working in tourism is also characterised by high risks, as the sector is susceptible to rapid changes. External factors, which are outside the control of those working in the sector, also have a significant impact (e.g. dependence on cheap airfares or cheap fuel prices).

Eco-tourism presents significant opportunities for local employment. For instance, the Indonesian government ensured that 80% of tourism staff in the marine Bunaken National Park came from the local community. In five years, the project generated 1,000 jobs and helped hundreds to increase their skills and incomes (Lewis, 2010). In Costa Rica, local guides from Tortuguero village led 72% of all night walks to see turtle nesting (WWF, 2008)

Thus, although eco-tourism represents one of the main opportunities for job creation with respect to protected areas, there are several caveats to consider. For instance, eco-tourism may be associated with seasonal activity, and hence year-round, stable employment opportunities may be limited. On the other hand, in many regions ecotourism may be less seasonal than traditional forms of tourism (e.g. beach holidays), and opportunities to watch wildlife or engage in outdoor recreation linked to the natural environment may extend the tourism season.

For example, in the UK, Rayment and Dickie (2001) argued that wildlife tourism can help to extend the tourism season and therefore mitigate some of the problems of seasonal unemployment associated with the mainstream tourism sector. For example, in the Scottish islands of Islay and Jura, much of the expenditure that wildlife tourism brings into the local economy is in the winter months, when many people visit Islay to watch the large flocks of barnacle and Greenland white-fronted geese. In the Isles of Scilly, an influx of birdwatchers each October helps to extend the tourism season by an extra month. Growing populations of geese in Scotland benefit the tourism industry by attracting winter birdwatchers and goose shooters. It was estimated that birdwatchers and goose shooters spend a total of £5.4 million in the local economies around goose sites each winter, of which £3.6 million can be attributed to the presence of geese themselves. This spending was estimated to support more than 100 FTE jobs in 1997/98.

Furthermore, jobs in eco-tourism are especially vulnerable to natural risks and conflicts. If local communities become highly dependent on tourism and associated industries as a source of income (especially if their previous income has been restricted with the establishment of a protected area), they are at risk if environmental or political factors mean tourist numbers decrease. For example, extreme weather patterns can have significant impacts on livelihoods related to tourism. The consequences can be severe for both developed, and developing countries. Hurricane Katrina, for instance, meant that 40,000 people employed in tourism in New Orleans lost their jobs. Meanwhile, sea level rise in the Maldives will significantly affect the tourism industry, which provides 18% of GDP (ILO, 2004). Eco-tourism is also becoming a fashionable trend, hence demand for eco-holidays is growing. However, fashions are fickle and can change rapidly.

Benefits generated by eco-tourism are also sometimes unfairly distributed across local communities. A report from the WWF shows that in many cases, the number of people actually benefiting from eco-tourism remains small; "while many jobs are created through tourism, often unfortunately those employed are not necessarily the rural poor most in need of the jobs" (WWF, 2008). For instance, only 1% of income from visitors to Indonesia's Komodo National Park is estimated to reach local communities. Thus, the poorer members of a community are rarely able to take advantage of the opportunities provided by eco-tourism as much as those who are already better off. However, since benefits are concentrated on the semi-skilled sectors of a community, tourism can be a means out of poverty and can offer relatively secure livelihoods to these individuals. Nonetheless, the indirect benefits of eco-tourism, such as improvements in infrastructure, may be important to the poor.

Eco-tourism that is badly planned can also have a significant, detrimental impact on the environment it is trying to promote. There are concerns therefore around the sustainability of eco-tourism, both socially and environmentally, as an option, for communities looking for alternative livelihoods in and around protected areas. Overall, tourism is rarely shown to generate significant benefits on a large scale or to deliver sustainable alternative livelihoods (UNEP Working Paper, 2008).

Conclusions on Qualitative Aspects of Employment

The qualitative aspect of the relationship between biodiversity and employment differs between the EU and developing world. In the EU, employment related to biodiversity often provides new and skilled employment opportunities for a population increasingly disconnected from the land. In developing economies, however, much of the employment linked to biodiversity is in poor quality, low paid subsistence jobs in the primary industries. Nevertheless, more sustainable farming and forestry practices offer potential both to maintain biodiversity and to enhance employment by supporting safer, more lasting jobs linked to local livelihoods rather than centralised systems of production. Nature conservation and ecotourism also offer opportunities for skilled, knowledge based and sometimes relatively well paid employment, often helping to diversify local economies and the employment opportunities they provide.

5 CASE STUDIES TO ILLUSTRATE BIODIVERSITY/EMPLOYMENT LINKS

5.1 European Case Studies [16]

5.1.1 Amvrakikos Case Study - Greece

Introduction

The Amvrakikos National Park is a site of 1800 km² area consisting of the marine waters of the Amvrakikos Gulf (approx. 400 km²) and the adjacent coastal lagoons, salt marshes and freshwater marshes, hills and remnants of riverine forests. This area plays an important role as a spatial buffer zone with the nearby agricultural land and villages. The Socio Ecological System (SES) of the Amvrakikos National Park is considered as the total area related to the municipalities that are stakeholders of the Park (approx. 100,000 ha of land) and 35,000 ha of sea. The terrestrial component comprises 20 municipalities from the prefecture of Arta with 39,000 inhabitants and an area of 31,430 ha, 11 municipalities from the Prefecture of Preveza with 23,000 inhabitants and an area of 18570 ha in the north, and 6 municipalities from the Prefecture of Aetoloakarnania with 15,500 inhabitants and an area of 54690 ha in the east and south part of the Gulf. These social and ecological characteristics of Amvrakikos National Park demonstrate that this site interacts substantially with the livelihoods of local communities. Today, the area is facing a number of major environmental problems that disturb the health of ecosystems and affect the associated human welfare.

The Significance of Biodiversity for Employment

The ecosystems in the Amvrakikos area provide an array of ecosystem services to the region, including agriculture, cattle farming, fisheries, clean water, flood prevention, sedimentary balance, refuge for wildlife species, tourism, research, environmental education and nutrient cycling. These ecosystem services bring various job opportunities to the inhabitants around the Amvrakikos National Park. Statistics have shown that in the period 1988-1991, 70.5 % of the inhabitants worked in the primary sector, 10.3 % in the secondary sector, and 19.2% in the tertiary sector. Some economic sectors, in particular, agriculture and fisheries, generated substantial revenues to the local population. Table 5.1 summarises the employment in the marine and inland water fishery industries between 1983 and 1991. Although the data do not extent into the present, overall, for the lagoon fisheries there appears to have been a reduction in yields of between 10-15% over the period 1980-1995, along with a decline in the yield of fisheries associated with inland waters.

Table 5.1: Total number of fishermen in marine and inland water fishery

[16] Source: The European case studies in this section are adapted from EEA technical report No 3/2010 'Ecosystem accounting

YEAR	Total Number of Fishermen in boats less than 19 hp - Marine fishery	Total Numbers of Fishermen in the water catchment area
83	231	1127
84	283	1144
85	292	1116
86	297	1200
87	307	1153
88	324	1058
89	328	1097
90	296	1200
91	352	1184

Today, the major environmental problems that the Amvrakikos National Park is facing include: (1) dead fish incidents in the lagoons and the sea; (2) lack of freshwater input to the lagoons and the sea; (3) contamination in molluscs; (4) river water pollution incidents; (5) algae blooms; (6) changes of wetland vegetation patterns; and (6) decreased populations of endangered bird species. For instance, the recorded fishery yields for Tsoukalio lagoon suffered a dramatic fall from 162.5 tonnes in 1977 to 84.4 tonnes in 1995, which affected local fisheries employment.

Lessons and policy implications

In 2003, ETANAM, beneficiary of a LIFE – Nature project - proposed a set of investments for the sustainable development of the area. These proposed investments included combined actions targeting more than one function or service of the ecosystems, including food provisioning, nature conservation, tourism and research. Some of these proposals are already included in the Operational Programme for the environment 2007-2013 of the Ministry of Environment (Table 5.2). These actions aim at restoring some of the ecosystem functions in both lagoons and marine waters.

Table 5.2: Summary of the most important conservation, research and restoration budgets invested in Amvrakikos

Aim of the project	Description	Investment expenditure €	Years	Source
Conservation	LIFE –Nature project (For the northern coastal part)	1,945,400.00	1999-2003	LLFE –Nature project application to European Commission
	Protection and monitoring of biodiversity (Total of operations of the National Park management Authority)	1,024,400.00	2007-2013	Ministry of Environment, Operational Programme for the Environment
Research	Hydraulic works for pollution and sedimentation control	410,000.00	2007-2013	Ministry of Environment, Operational Programme for the Environment
	Fresh water input and restoration management in the lagoons	7,000,000.00		Final report of Life-nature project (already submitted for financing)
Maintenance and restoration costs of natural resource	Removal of dead fish	340,000.00	2008	Press reports

and the cost of biodiversity losses: The case of coastal Mediterranean wetlands': ISSN 1725-2237.

5.1.2 Danube Delta Case Study - Romania

Introduction

The Danube Delta social-ecological system (SES), situated in South–East Romania, covers 5800 Km² of which 3500 Km², belong to the delta proper while the remaining area is shared between the upstream Danube floodplain in natural regime (Isaccea-Tulcea sector 102 km²), the Razim-Sinoie lagoon complex (1,145 km²), the marine waters up to the 20m isobaths (1,030 km²), and the Danube river between Cat's Bend and Isaccea (13 km²). These units are embedded by the Danube Delta Biosphere Reserve (DDBR, Figure 5.1). This reserve was created through the Decision of the Romanian Government No. 983 of August 1990 and is listed within three international environmental protection networks: the International Convention for the Protection of the World Cultural and Natural Heritage (1990), the Convention of Wetland Zones of World Importance (RAMSAR Convention - 1991) and the International Biosphere Network (UNESCO - M&B program).

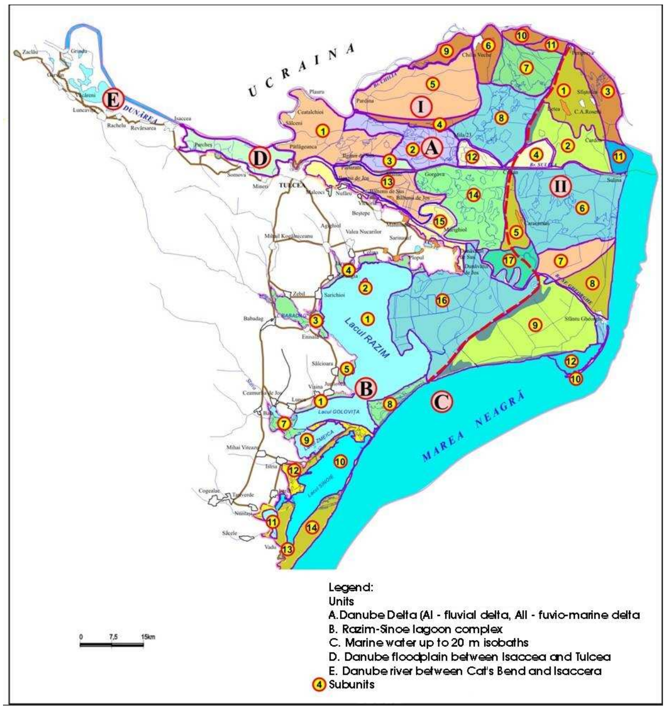


Figure 5.1: The geographical units within Danube Delta Biosphere Reserve (Source: DDNI-Danube Delta National Institute)

The Significance of Biodiversity for Employment

The Danube Delta SES embeds 26 settlements that are divided into seven communes and one town (Sulina), summing 14 295 inhabitants. The largest village in each commune serves as a centre for social services. The local economy and well-being of the population in all of these municipalities largely depend on the ecosystem services provided by the Danube Delta ecosystems. Since ancient times, fishing has been the main occupation of the inhabitants of Danube Delta. Although today the supply of fish has diminished and changed in quality, this occupation continues to be a basic one. The second main occupation has been (and still is) sheep and cattle breeding, which has developed in recent decades from a temporary activity (practiced by the shepherds bringing flocks from the eastern Carpathians and the Moldavian tableland each winter), to a permanent occupation.

Table 5.3: Economically active population in DDBR, according to the 2002 Census

Locality	Total unemployed population	Total employed population	Main employment in %			
			Fish aquaculture	Agriculture, silvi-culture	Public and social services	Other
Sulina	342	1516	11.1	1.4	23.6	63.9
C.A.Rosetti	12	757	7.9	76.2	6.5	9.4
Ceatalchioi	47	176	0.6	72.7	9.7	17.0
Chilia Veche	240	594	11.6	34.5	31.1	22.7
Crisan	144	318	47.8	5.0	17.0	30.2
Maliuc	81	245	18.4	30.2	16.7	34.7
Pardina	46	237	2.1	69.2	16.0	12.7
Sfantu Gheorghe	30	266	48.1	3.0	24.8	24.1
Total	942	4109	15.3	29.0	19.7	36.0

Source: DDNI

Fishing - both professionally and for subsistence use - is the single most important livelihood in the DDBR. 2004 statistics indicate that 1375 professional fishing permits were issued in the Delta. Also, almost all households living in the delta (except professional fishermen) have family fishing permits, for family consumption. In 2000 there were approximately 4500 family fishing permits (DDBR). Apart from fishing, agriculture is a major source of income to the rural villagers living in the delta area – Table 5.3.

Lessons and Policy Implications

Delta villages, located within the delta tributaries and channels, suffer from isolation and poor infrastructure. The lack of road transportation to the neighbouring towns of Tulcea and Sulina is widely considered a major obstacle in the development of the Delta localities. Therefore, the need for improved transportation and communications has been identified, as has the opportunity to develop sustainable tourism based on the area's natural resources and landscape. New developments in tourism will bring in new employment opportunities in related sectors, but requires compliance with existing legislation regulating fishing and hunting activities.

5.1.3 Doñana Case Study - Spain

Introduction

The Doñana social-ecological system (SES) (South-West Spain) covers an area of 3,120 Km², more than one third of which is protected. Doñana formerly encompassed two protected areas, which were unified in 2005 to form the Doñana Natural Area (Figure 5.2). It embeds other smaller protected sites and is also protected through international agreements (Ramsar Site, Biosphere Reserve). Doñana consists of a wide system of marshes, dunes and beaches, associated with the coastal dynamics of the Guadalquivir River mouth, sometimes referred to as the Doñana fluvio-littoral system (Montes et al., 1998). It embeds four main types of ecosystems at the eco-district scale: the coastal system, the aeolian sheets of sand dunes and two wetland ecosystems: the Guadalquivir River Estuary (36 Km²; 77 km long; tidal influence: 110 km from the river mouth) and the Doñana marsh (original surface: 1.663 Km²), which is the flood plain of the Guadalquivir River.

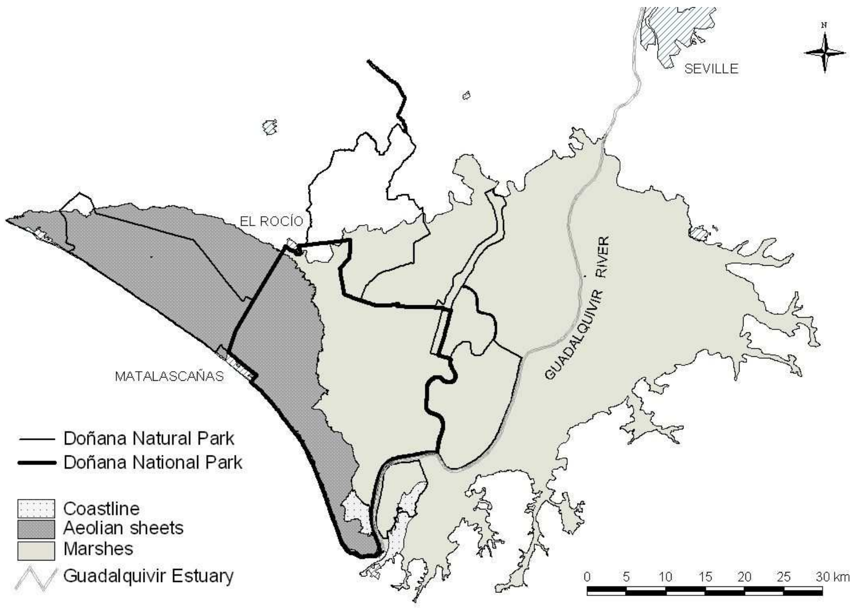


Figure 5.2: The Doñana fluvio-littoral Ecosystem of Doñana: ecodistrict and main protected areas.

The Significance of Biodiversity for Employment

The ecosystems of Doñana provide a diversified flow of ecosystem services, from the local (sense of place, hunting, picking up goods, local ecological knowledge) to the national and international scale (carbon sequestration, refugee for biodiversity, research and tourism). Economic activity in the Doñana SES has been continuously growing from the 1980s to the present. In Doñana, agriculture and aquiculture, beach and nature tourism, science and environmental education are major economic sectors that supplement provisioning services to provide both direct and indirect incomes to the local population. In addition, non-marketed socio-cultural services, such as spiritual and religious services, are also an important source of income in Doñana. The El Rocío pilgrimage attracts 2 million visitors every year. Employment in Doñana, which until a few decades ago depended completely on nature, is still strongly dependent on the natural capital and ecosystem services of the marsh, estuary, coast, and dunes ecosystems. The main economic sectors depending on ecosystem services are agriculture, fishing and aquiculture, cattle farming, forestry, salt production and tourism. Nevertheless, more recently industry and housing are gaining weight as economic sectors in Doñana.

Lessons and Policy Implications

In recent years, Doñana has faced a number of environmental disturbances from floods, disease outbreaks, droughts, and oscillations of agricultural subsidies and markets. The previously intensive agricultural and fishery development policies in the 1960s and 1970s are responsible for the degradation of marshes and estuaries in the Doñana wetlands ecosystem, which is threatening the target commercial fish species (incl. eels and sturgeon) in the market. In particular, a clear decline of the fish stocks such as eels and sturgeon is observed during the last 50 years. This causes dramatically socio-economic impacts on the livelihoods of thousands of families living around the Guadalquivir estuary.

5.2 Global Case Studies

5.2.1 Cod Fishing – Eastern Canada

Introduction

The closing of northern cod (Gadus morhua) fishing in the eastern Canadian Provinces around the Gulf of St. Lawrence illustrates how one particular industry was directly impacted by a loss of biodiversity. The local ecosystem shifted from one of a variety of medium sized species (demersal) and small-bodied forage species to one dominated primarily by small-bodied forage species. This shift resulted in the cod-fishing moratorium of 1992. Eastern Canada, particularly the province of Newfoundland, had been dependent upon fishing for decades and was one of the poorest areas of Canada.[17] To maintain employment the industry then transformed, no longer targeting cod, but focusing on other resources, i.e., invertebrates (shrimp).

The Importance of Activity for Employment

In Newfoundland and Labrador, many families and individuals living along the Canadian coastline were either directly or indirectly connected to the cod fishing industry (Table 5.4). During the 1980s, cod stocks provided an estimated 300,000 tons of fish per year to Newfoundland and Labrador's fishing industry.[18] Employment connected to the cod fishing industry includes fishers, fish plant workers, fish sellers, transporters or related industries. In many cases entire families were employed in jobs related to the cod fishing industry. The fishing industry as a whole (fishing, processing and aquaculture) combine to account for less than 1% of Canada's GDP (2004), however, the importance of fishing to regional and small coastal communities particularly in Novia Scotia, Newfoundland and Labrador is much greater.[19] Labrador and particularly Newfoundland in the 1980s and 1990s had strong informal economies by which inhabitants supported themselves through a number of different means. Fishing, because it is seasonal, allows, or requires fishermen to acquire additional income through diverse measures. In 1986, six years prior to the collapse of the cod industry, a household survey of Newfoundland estimated the personal income, by source for full-time and part-time fisherman. Fishing accounted for 40% of personal income for full-time fisherman and 20% of personal income for part-time fisherman.[20] In 1991 Newfoundland's population was estimated around 568,000.[21]

[17] Hamilton and Butler (2001)
[18] Fisheries and Oceans Canada (2005)
[19] DFO (2004)
[20] House, Hanrahan and Simms (1986) cited by Hamilton and Butler (2001)
[21] Hamilton and Butler (2001)

Table 5.4: Employment in Fishing Industry in Newfoundland and Labrador (Annual Averages, 1987 to 2009, in thousands)

Year	FISHING INDUSTRY			Employment, All Industries
	Fishing [1]	Seafood Product Preparation and Packaging	Total Fishing Industries	
	(NAICS 1141)	(NAICS 3117)	(NAICS 1141, 3117)	
1987	12.6	11.9	24.5	190.3
1988	12.3	13.4	25.7	199.7
1989	10.1	13.0	23.1	206.3
1990	10.6	10.5	21.1	206.9
1991	11.2	9.7	20.9	204.7
1992	9.3	7.8	17.1	194.9
1993	10.4	7.1	17.5	193.8
1994	10.5	3.7	14.1	193.5
1995	8.2	3.8	11.9	194.4
1996	8.8	4.2	13.1	187.5
1997	8.4	5.0	13.4	188.3
1998	9.2	5.9	15.1	192.4
1999	8.3	8.1	16.5	201.0
2000	8.3	6.0	14.3	198.0
2001	6.8	6.9	13.7	203.8
2002	7.6	7.2	14.8	207.2
2003	7.9	6.0	13.9	212.3
2004	8.3	7.8	16.1	214.3
2005	8.8	7.0	15.7	214.1
2006	8.2	6.7	14.9	215.7
2007	7.4	5.8	13.2	217.1
2008	6.5	5.5	12.0	220.3
2009	5.6	4.7	10.3	214.9

Source: Statistics Canada, Labour Force Survey (Special Tabulations)

The Significance of Biodiversity for Employment

The chief driver behind the collapse of the cod fishing industry in eastern Canada was overfishing, while environmental changes, and specifically record low temperatures from 1984 to 1998, also played an important role.[22] The environmental conditions slowed growth rates of northern cod and accelerated the impacts of overfishing. In addition, advances in technology enabled fishermen to catch increasing amounts of fish compared to previous years. The combined socio-economic and ecological conditions drastically reduced stocks of northern cod.[23] Some predictions estimated that eastern Canadian cod stocks, around Newfoundland alone were once more than 400,000 tons and had been depleted to around 5,500 tons.[24] A reduction in cod stocks was witnessed around the world in the late 1980s and early 1990s, though nowhere were the changes so profound as in eastern Canada.[25]

The removal of larger-bodied fishes (through fishing and environmental changes) caused an overall change in the ecosystem because the cod, being at the end of the food chain, competed with other large species for the same prey. Therefore the change at this top level led to changes in all lower levels.[26] The loss in cod fish stocks resulted in loss of income, employment, and caused a shift in fishing tactics, known as ‘fishing down marine food webs’, away from cod to invertebrates such as northern shrimp, American lobster and snow crab. In addition, the numbers of the invertebrates in the

[22] Hutchings and Myers (1994); Sinclair and Murawski (1997); Drinkwater (2002) cited by Hamilton, Haedrich and Duncan (2004)
[23] Hamilton, Haedrich and Duncan (2004)
[24] Casert (2009)
[25] Hamilton and Butler (2001)
[26] Savenkoff et al. (2007)

ecosystem were rising as their natural predators from the area were removed. The pressures of fishing remain an ecological concern and further depletion of natural resources remains an issue.[27]

The closure of the cod fishing industry resulted in the loss of the main source of income for many individuals. Gien (2000) estimate that 10,000 fishers and 12,400 plant workers in 400 coastal communities in Newfoundland and Labrador alone lost their main source of income.[28] Other reports[29] suggest that 19,000 fishers and plant workers were directly affected while some 20,000 additional jobs were lost or damaged as a result. Gien (2000), studying changes in health linked to the collapse of the cod fishing conducted household surveys in 1995. The survey determined that the unemployment rate (defined as, 'looking for a job') for the affected coastal area was approximately 42.7%, while the overall unemployment rate in Canada at the time was 8% and for Newfoundland, 18.6%. The employment rate might have actually been higher when including individuals who were forced to retire, gave up looking for a job, or were 'keeping house'. The survey also concluded that those unemployed clearly had less income and less education. In addition, more men were unemployed, and therefore more women working in the area.

Lessons and Policy Implications

Cod fishing in eastern Canada is an example in which a number of influential factors, socio-economic and environmental, combine causing a loss in biodiversity and ultimately a shift in an ecosystem. In this case, signs of changes in the ecosystem were noticeable years prior to actually being officially acknowledged.[30] The complexity of ecosystems, being both a whole and a part, suggests that comprehension of the ecological systems, such as top-down and bottom-up variables, is crucial. A comprehensive understanding of the ecosystem may lead to an increased ability to detect 'early warning signs' or small changes in the ecosystem which therefore increase the ability of policy makers to react and reduce affects upon the ecosystem.[31]

As outlined by the Canadian Government, strategies intending to rebuild cod stocks and reduce further impacts on the environment necessitate long-term commitment by government, industry and other stakeholders to initiate and maintain a number of approaches. Furthermore, an approach to rebuild fisheries requires a more collaborative and inclusive management framework, and cooperation is required between levels of government, industry, fishing communities and other stakeholders.[32]

5.2.2 The Maldives

Introduction

Biodiversity plays a major role in the Maldives' two largest industries, tourism and fishing, and the case study gives a clear example of an island nation impacted and threatened by changes to its ecosystem. The two industries directly or indirectly employ the majority of the nation's inhabitants. Threats to biodiversity, such as erosion of beaches and coral reefs due to improper waste disposal and coastal development practices, pose an immense danger to the nation's economy. The Maldives possess an area of great biodiversity with a total coral reef area of 3,500 km^2, over 1,100 species of reef fishes and 250 species of reef corals. In 2007, the Maldives had an estimated population of 304,869, inhabiting 194 of its 1,192 islands with more than a third of its population living in the capital

[27] Hamilton, Haedrich and Duncan (2004)
[28] Storey and Smith (1995) cited by Gien (2000)
[29] Steele, Andersen and Green (1992) cited by Mason (2002)
[30] Hamilton and Butler (2001)
[31] Fisheries and Oceans Canada (2005)
[32] Fisheries and Oceans Canada (2005)

city Male. In 2008, the GDP per capita of the Maldives was US$ 2,804, with a GDP growth rate of 19.1% in 2006 and 6.6% in 2007.[33]

The Importance of Activity for Employment

The two major industries of the Maldives, tourism and fishing, extensively contribute to present day economic activity as well as future growth of the country. These two industries are directly important to the national economy and also contribute to a number of supporting industries. Tourism is linked to economic activity in construction, financial services, manufacturing, transport, food, restaurants and entertainment sectors. The fishing industry is related to processing, canning, drying, as well as the fish meal and fish oil production industries, and also boat building and maintenance. The Maldives' tourism industry (2007) directly employs 32,000 people and employs another 32,000 people indirectly, accounting for 58% of national employment. Fisheries directly employ an estimated 10,500 people and another 4,000 are estimated to work in related sectors, accounting for about 20% of national employment. The national economy of the Maldives is underpinned by biodiversity, with biodiversity-based sectors contribute 71% of national employment (78,500 jobs); 49% of public revenue (Rf 2.5 billion); 62% of foreign exchange (US$ 435 million); 98% of exports (Rf 1.7billion); and 89% of GDP (Rf 135 billion).[34]

The Significance of Biodiversity for Employment

The importance of biodiversity for the Maldives' economy is immense. The biological resources and natural ecosystems of the Maldives supply the base stock or natural capital which enables the functioning and growth of the economy. The marine and coastal areas of the Maldives provide a flow of goods (i.e., food, medicines, building materials, handicrafts, etc.) and services (i.e. tourist destinations, cultural services, habitat for wildlife, coastline protection, etc.) which generate economic benefits and cost savings for the government, businesses and households.[35]

The degradation, over exploitation or irreversible conversion of the Maldives biological resources and services poses an immense threat to the Maldives' economy. Improper waste disposal and unsustainable coastal development practices have damaged coral reefs and increased pollution. Furthermore, a number of coral fish and other species have been overexploited due to unsustainable practices. The Maldives is at risk both from local activities, but also impacts of global warming. Because the Maldives is comprised of many small islands of low elevations, it is more vulnerable to environmental threats than many other nations. Moreover, due to the narrow focus of the Maldives' economy and the country's small population, spread over multiple islands, conserving biodiversity is necessary to maintain economic growth.

Consequences of Biodiversity Change for Employment

With 71% of national employment coming from biodiversity-based sectors, a majority of the Maldives' inhabitants are at great risk from changes or loss of biodiversity. Most notably, risks include losing employment such as in the tourism or fishing industry or losing a percentage of income because of reduced numbers of visitors to the island or decreased stocks in fish. The large percentage of employment, and national income, stemming from these two industries means that losses incurred by them are likely to spread throughout supporting industries, thus causing additional losses (e.g. fish processing or restaurants). Rising sea levels cause coastal erosion and loss of landmass through submersion. Continually higher sea levels in the future combined with salt water intrusion of aquifers pose the risk of damaging small islands to the point where they are no longer inhabitable or destinations for tourists. The coral reefs surrounding the islands ensure that they remain intact, and the growth of the reefs fluctuates in response to variations in the sea. Small changes (1 or 2℃) in

[33] Emerton et al. (2009)
[34] Emerton et al. (2009)
[35] Emerton et al. (2009)

ocean temperature can damage, or kill, coral reefs leading to a loss of habitat for native species, the removal of natural barriers which protects against flooding, and also a major tourist attraction.[36] A 1997 study estimated the costs of losing 58% of the worlds coral reefs at $US 140 billion.[37]

Lessons and Policy Implications

The influence of both local activities and global climate change on biodiversity in the Maldives presents a highly complex scenario threatening the Maldives' economy as well the island nation itself. The future of the islands and the livelihoods of their inhabitants depend on an appropriate combination of economic and environmental policies, to conserve biodiversity and the economy that it underpins. The large number of users of biological resources in the Maldives, combined with the various threats to biodiversity, suggest that policy measures need to address the situation as a whole while also responding to specific pressures, drivers and problems.

Emerton et al. (2009) suggest a number of modes by which policy can aid in conserving biodiversity. They propose that planners and decision makers need to adequately value biodiversity and view it as an economically productive sector so that its contribution does not go overseen. Moreover, mainstreaming conservation goals into development policies, strategies and plans at all levels as well as creating incentives that reward for biodiversity conservation, or penalise for activities that lead to biodiversity loss, are also suggested. They propose that economic and environmental instruments (i.e., environmental protection acts, environmental controls, environmental action plans, etc.) should be transformed to support biodiversity conservation. Targeting specific measures to the local users and managers of biological systems also has the potential to make a large impact. Measures targeted to local managers and users include: financing local initiatives that conserve biodiversity, support for investments in environmental technologies, and developing incentives and payment systems which directly reward for the provision of environmental goods and services through conservation at the local level. In addition, they propose improving the financial sustainability of marine and coastal biodiversity conservation in the Maldives through contributions from overseas, local citizens and other sources, because current financial resources are not enough to cover conservation.

5.2.3 Lake Victoria's Fishing Industry

Introduction

Lake Victoria, Africa's largest lake, is shared by Kenya (possessing 6% of the total 68,800 km^2), Uganda (45%) and Tanzania (49%). The lake basin is one of the most highly populated and poorest rural regions worldwide, having an average human population density of over 170 people/km^2.[38] Due to its range of uses, e.g. transportation, water supply, recreational activities, fisheries, waste disposal and tourism,[39] the lake ecosystem plays an important economic role for the riparian communities. The fisheries sector is particularly significant, acting as a vital source of employment, export earnings and income.[40]

In the late 1950s five exotic fish species were introduced in the Lake Victoria as a response to declining endemic fish populations. Since then, Lake Victoria's fishing industry underwent a dramatic transformation. Nile perch, one of the introduced species, acclimated particularly well and established itself fully within a decade; catches increased from around 100,000 tons per year in the 1960s to

[36] Viner and Agnew (1999)
[37] Bryant et al. (1998) cited by Viner and Agnew (1999)
[38] LVFO (2008)
[39] Odada et al. (2004) and LVFO (2008)
[40] Matsuishi et al. (2006)

approximately 400,000 t/y by the 1980s[41] and laid the foundation for a thriving export market. Presently, Lake Victoria's fish catch is estimated to be approximately one million tons annually of which approximately 95% is Nile perch, Nile tilapia and the endemic dagaa.[42] With increased economic activity, however, came ecological consequences; more than 200 other species have been driven to extinction[43] and the remaining species are being overfished, thereby endangering the very ecosystem upon which the area's economic prosperity rests.

The Importance of Activity for Employment

Employment opportunities centred around the Lake Victoria fisheries are both of a direct (e.g. fishermen, fish traders, processors, transporters and consumers) and indirect nature (e.g. boat builders, net and hook manufacturers, outboard engine providers, fish vehicle providers and repairers, fuel suppliers, fish bait suppliers, ice suppliers and providers of containers and packaging materials).[44] Demand for an assortment of other services has also been created in the newly formed 'boom towns' along the shoreline, including restaurants, bars and boarding facilities; these services are all dependent on cash flows from the fisheries.[45]

Over the past several decades, these jobs have become increasingly important to the economies of the three countries as the value of the fish catch now surpasses US$ 350 million/year and the number of fishermen alone reached 196,426 in 2006.[46] In Kenya, for instance, around 560,000 people were already employed in the fishing industry by 1995, accounting for 25% of the country's employment in the informal sector and 14.5% of the total employment.[47] Currently, the fisheries provide direct support for the livelihoods of an estimated 2 million of the 30 million lake basin residents.[48]

The Significance of Biodiversity for Employment

Maintaining high stocks of the three fish species in Lake Victoria around which the fishing industry revolves is integral to preserving the hundreds of thousands of affiliated jobs. Although additional fish species perhaps seem peripheral as compared to the commercial species, maintaining their populations and thus the lake's biodiversity is integral to ensuring the overall health of the ecosystem and enabling the survival of the desired fish species and contingent fishing industry.

Degradation of the basin as a result of unsustainable natural resource use, algal blooms, water hyacinth infestations, oxygen depletion and the introduction of alien fish species are threatening the ecosystem health[49] and, consequently, the job security of those directly or indirectly employed in Lake Victoria's fisheries. Other issues affecting the sustainability of the basin relate to overexploitation, industrial pollution, eutrophication, poor governance and sedimentation problems.[50] Further ecological threats such as water quality deterioration, receding water levels, declining fisheries and loss of biodiversity are also becoming increasingly significant[51] and have already begun to evoke considerable damage within the fishing industry.

With the proliferation of Nile perch and more recently of dagaa, Lake Victoria's predominantly small scale fishing operations were transformed into an internationally influenced sector dominated by export demands and a resultant inflow of capital. This shift in scale enabled many previously unemployed people to find work, for example in the harvesting, processing and distribution areas of

[41] LVFO (2008)
[42] LVFO (2008)
[43] Matsuishi et al. (2006)
[44] LVFO (2008)
[45] Geheb et al. (2008)
[46] LVFO (2008)
[47] Bokea and Ikiara (2000)
[48] LVFO (2008)
[49] Odada et al. (2004)
[50] Geheb and Crean (2003) and Odada et al. (2004)
[51] LVFO (2008)

the fishing industry[52] while also encouraging others to migrate to the basin area.[53] In fishing alone, there was an increase from 84,000 jobs in 1991 to about 122,000 in 2000[54] and 196,426 in 2006.[55]

Although historical trends in Lake Victoria's employment have been predominantly positive to date, a decline in the lake's ecological condition could harm the Nile perch population and cause an estimated US$ 270-520 million in lost revenue to the riparian communities.[56] Other negative consequences could also result in the loss of incomes and livelihoods, unemployment, food and nutritional insecurity as well as conflicts over fish between the local, national and international communities.[57] Decreasing stocks and resultant low catch rates have already forced several fish processing factories to close and left the dependent fishermen struggling to maintain their incomes.[58] The lack of alternative employment opportunities further exaggerates the centrality of maintaining healthy fisheries.[59]

Lessons and Policy Implications

Lake Victoria's history illustrates a complex situation in which interference with an ecosystem's biodiversity resulted in substantial economic benefits to surrounding communities, in turn increasing the exploitation of and dependence on the resource and subsequently placing it at risk. Currently, the fisheries are at a critical developmental stage in which productivity is decreasing and catches are being reduced,[60] threatening the jobs of affiliated individuals and calling for changes in behaviour both within and external to the fishing industry. These trends show that sustainable use of a renewable resource from ecosystems (such as fish)depends fundamentally on the health of ecosystems. However, it also shows that, due to complexity of nature, changes in ecosystems as a result of human activities can be difficult to anticipate. As also demonstrated in other contexts, heavy changes in an ecosystem's integrity, as has taken place in Lake Victoria, rarely lead to stable conditions for human welfare and biodiversity in the long run. Furthermore, the significance of these relationships is strongly linked to the dependency of people (and sectors) on natural resources (see section 4).

Given the economic importance of this industry for the riparian nations and surrounding communities, Matsuishi et al. (2006) recommends a precautionary approach regarding the intensification of the fisheries as well as increasing the distribution of information about possible consequences of destructive fishing practices.[61] They also highlight the need to address several governance aspects in order to ensure the sustainability of the ecosystem, including enforcing existing regulations on resource use and access rights, devolving responsibilities to the communities and improving data collection and the general knowledge of the basin.[62] Without changes in behaviour, the original decline in fishery productivity which prompted the introduction of alien species in the first place may reoccur, resulting in massive job losses and the endangerment of local communities' livelihoods.

5.2.4 Miombo Woodlands - Africa

Introduction

The Miombo Woodlands in several African countries (Mozambique, Malawi, Tanzania, etc.) demonstrate the importance of a large inland forest for local inhabitants. The forest occupies an area

[52] Jansen et al. (1999)
[53] Odada et al. (2004)
[54] Odada et al. (2004)
[55] LVFO (2008)
[56] Odada et al. (2004)
[57] LVFO (2008)
[58] LVFO (2008)
[59] Bokea and Ikiara (2000)
[60] Geheb and Crean (2003)
[61] Matsuishi et al. (2006)
[62] Matsuishi et al. (2006)

of about 2.7 million km^2 and constitutes the largest more-or-less contiguous block of deciduous tropical woodland forests in the world.[63] The woodlands can be divided into dry and wet areas and provide a home to over 40 million people as well as being the source of products to over 15 million urban dwellers.[64] However, the Miombo Woodlands are rapidly being lost due to changes in climate, deforestation and to make way for other development activities. Despite protection efforts by past and present government authorities to preserve the forests, degradation and depletion is occurring at a steady rate.

The Importance of Activity for Employment

The World Bank (2008) reports that there is a high level of dependence on the Miombo Woodlands though this varies largely between countries. Inhabitants often use a number of activities to support their livelihoods. The forest is used to provide fodder for livestock and swidden agricultural systems depend on woodlands for nutrients, in addition, inhabitants harvest timber, medicine, fuel wood, charcoal and hunt wildlife. The livelihoods of both rural and urban dwellers, in a variety of occupations, are dependent on the natural resources of the Miombo Woodlands.

According to the World Bank (2008) forest income[65] from different sites ranges from less than 10 percent to 50 percent.[66] In Zimbabwe, the forests contribute about 15%[67] of total income while in Zambia it is more than 50%.[68] In a study of southern Zimbabwe it was determined that a higher percentile of total income (30%) is forest based for the lowest wealth quartile, while it is less than 10% for the top quartile.[69] The Miombo Woodlands are also used as a form of insurance. In other words, when households may be experiencing difficult times, they tend to depend more on the woodlands for food and to subsidise their incomes.[70]

The Miombo Woodlands are important for many national economies and the people they employ. In Tanzania (2005) the apiculture industry provides some portion of income to about 2 million people.[71] In Mozambique timber sales from the woodlands accounted for US$ 65 million in 2005 accounting for 4% of total national exports.[72] The charcoal industry (2007) in the four largest urban areas in Malawi has an estimated yearly value of about US$ 41.3 million.[73]

The caterpillar industry is a traditional source of income for people in some areas, providing to both local markets and for export. Caterpillar harvesting is often performed by women, in South Africa, harvesters can earn around US$ 715 in seven weeks, almost 95% of the average farm workers income in this area.[74]

Campbell et al. (1991), studying the Miombo Woodlands in Zimbabwe, assigned values to woodland use on the basis of consumption levels derived from other literature and local market trading prices. The results suggest that products and services had an imputed gross value of about US$ 320 per house hold per year, which was considerably higher than the median income for households according to other studies.[75] This figure, however, is argued as most likely an overestimate.[76]

[63] Campbell et al. 1996 cited by Abdallah and Monela (2007)
[64] Abdallah and Monela (2007)
[65] Forest income includes the value of forest products consumed or used by households and cash income from sales of forest products.
[66] Jumbe et al. cited by the World Bank (2008)
[67] Cavendish (2002) and Campbell et al. (2002) cited by the World Bank (2008)
[68] Jumbe et al. cited by the World Bank (2008)
[69] Campbell et al. (2002) cited by the World Bank (2008)
[70] World Bank (2008)
[71] Mwakatobe and Mlingwa (2005) cited by the World Bank (2008)
[72] FAO (2007) cited by the World Bank (2008)
[73] Kambewa et al. (2007) cited by Dewees et al. (2010)
[74] Styles (1995) cited by Campbell (1996)
[75] Campbell et al. (1991) cited by Campbell (1996)
[76] Cavendish (1996) cited by Campbell (1996)

According to Campbell (1996) Miomobo Woodland resources contribute significantly to household total incomes in Zimbabwe. Averaged across all households, woodland resources contribute to about 22.9% or about US$ 115 per household per year of total income, and vary according to household income levels.[77] Studies in Mozambique also suggest that income from woodland resources vary across household income levels.[78] This has also been shown in studies in Zambia.[79]

The Significance of Biodiversity for Employment

Biodiversity is significant in the Miombo Woodlands, though richness and diversity of faunal species is low; it has an estimated 8,500 species of higher plants, with over 54 percent endemic.[80] Deforestation of the woodlands is driven by land clearing for agriculture uses and wood extraction for energy sources. Many times, an area of wood extraction is then followed by agricultural use. It is not clear what the main driver of deforestation is across the Miombo Woodlands, and it is likely to vary by region. In Tanzania, for example, some sources[81] determine about 91,200 hectares are lost each year, while others[82] suggest the figure is actually somewhere between 130,000 and 500,000 hectares per year.

As reported by the World Bank (2008), climate change is likely to intensify poverty associated with the Miombo Woodlands. Volatile seasons, such as strong seasonality of rain and warmer dry seasons will likely undermine productivity for agriculture and forest activities. The poorer sections of rural society, who are most dependent upon the Miombo Woodlands, both to subsidise their income and to provide an insurance mechanism, are likely to be the first and most devastated due to biodiversity changes. However, because most inhabitants' income is not completely dependent on the Miombo Woodlands, as resources in one area become scarce, it is likely that activities will shift to new areas or altered (i.e., using inferior wood for heating or walking longer distances to find fuel wood).[83]

Lessons and Policy Implications

The Miombo Woodlands provide an example where a loss of biodiversity, through deforestation, poses real risks to rural household incomes. Those most likely affected are the poorest groups, who are most dependent on the woodlands. The sheer size of the woodlands and the large number of resources that they provide means that many economic activities are tied to them. In many cases individuals are dependent on various resources, which may ultimately conceal the problem because inhabitants can shift to alternative or lesser quality options by which to provide or subsidise an income. According to the World Bank (2008) continued loss of the Miombo Woodlands suggests that governments will be pressed with increasing economic and financial burdens to provide alternative safety nets to those affected. The World Bank (2008) suggests various options as possible ways forward such as improving management opportunities in Miombo regions, improving governance related problems and also renovating forest institutions and other agencies to the realities of local users.

Possibilities for improving management opportunities in Miombo regions include; devolving rights and responsibilities for woodland management to the local level, organising transfer payments to individuals and communities in exchange for providing environmental services, and increasing the value of woodland production through market development (i.e., increased value addition and new products). The World Bank (2008) asserts that improved relevance of forestry institutions, policy and

[77] Campbell (19969
[78] Hegde, R. and Bull, G (No Date)
[79] Jumbe et al. cited by the World Bank (2008a)
[80] World Bank (2008)
[81] FAO 2000 cited by Abdallah and Monela (2007)
[82] The National Forest Policy (1998) cited by Abdallah and Monela (2007)
[83] Scholes and Biggs (2004) cited by the World Bank (2008)

legal reforms as well as building capacity in local organisations is crucial. To improve governance related issues in the Miombo Woodlands, the diversity and size of the region will need consideration; tailoring and prioritising to local conditions is therefore most likely necessary. 'Revitalising forestry organisations' and 'getting forestry onto the poverty agenda' are areas suggested for the improvement of governance by the World Bank, because they are 'cross-cutting' and will encourage support and acceptance through all intervention areas. In addition, 'redistributing woodlands' to local users is advocated because local woodland use and management practices have the potential to adjust in response to resource constraints, and therefore stay within sustainable harvesting limits. 'Enhancing forest-based markets for products and services' is also suggested because of a history of local markets and products showing low returns as well as the difficulty of developing new successful products. By establishing simple regulatory frameworks and supporting producer organisations the World Bank (2008) predicts that a reduction of transaction costs and an increase in value for local users is possible. The opportunity to gain from economies of scale from reducing transport costs, increased quality standards, improved market recognition, improved supply chain capability and protection against corrupt regulators is also possible.

The policy implications suggested by the World Bank (2008) cover a number of various organisational and market-based options selected to improve governance and management related issues of the Miombo Woodlands. Ultimately, it is expected that improved organisational structures and markets of the Miombo Woodlands would help to safeguard the forests and therefore employment and household incomes dependent upon them.

6 IMPLICATIONS OF BIODIVERSITY CONSERVATION FOR EMPLOYMENT

6.1 Synergies and Trade-offs – Overall Evidence of Whether Biodiversity Conservation Supports Jobs or Constrains Job Opportunities

There has been considerable debate regarding the links between conservation, employment and poverty reduction. Although many have made assumptions regarding the ability of the former to reduce the latter, there are actually a very limited number of studies that generated hard evidence of impacts. Simplistic views are increasingly being replaced by an understanding that the links between conservation, livelihoods and poverty are complex and uncertain. The complexity of the issue means that the evidence is often contradictory, as the results depend on the local and specific context investigated in each of the studies. Some studies find that there are significant trade-offs associated with protecting biodiversity, especially at the local level. However, others find that there are also considerable opportunities for synergy, especially when local communities are compensated for the benefits foregone from, and the costs associated with, conservation. Overall, a general conclusion can be made that the spatial distribution of the costs and benefits from biodiversity conservation is uneven; the evidence seems to indicate that the costs are often most significant at the local level, while the most significant benefits are usually accrued at the national and global level.

6.1.1 The Trade-offs Associated with Protected Areas

Although protected areas are associated with many benefits in that they protect and conserve many of the ecosystem services discussed above, there are also some associated costs. These include:

- Costs of managing and running the protected area in question
- Loss of productive agricultural and grazing land
- Costs associated with crop raiding and livestock losses
- Restrictions on plant and animal resource utilisation
- Displacement of populations

There have been a few studies which compare both the net benefits and net costs of establishing protected areas. Although they are limited in number, some have found that the costs to local communities of protected areas may outweigh the benefits (see Box 6.1). However, most studies find that the benefits of conservation do outweigh the costs, especially if measured at the global level. For example, one study found that conserving 60,000 hectares of lowland rainforest in Madagascar would result in net global benefits of US$20million (the benefits included wildlife habitat (US$ 2.7 million in net present value terms), hydrological regulation (US$ 760,000) and carbon storage (US$ 26.7 million), and potential eco-tourism (US$ 2.5 million). However, while most of these benefits would accrue globally, the costs associated with restricted access would mainly be borne locally (TEEB, 2010). Similarly, another study assessing the case for Madagascar's entire protected area network found that benefits from biodiversity conservation, ecotourism and watershed protection were mainly felt at the regional to global scale, whereas the management and opportunity costs were incurred at the regional to local scale. In the absence of compensation, or community conservation programmes, the literature therefore suggests that protected areas, whilst providing significant net global benefits, often have a net cost at the local levels which are especially high in developing countries and in the case of the rural poor.

Several studies have shown that the opportunity costs for local communities of establishing protected areas are significant where the use of agricultural or productive land is foregone (UNEP/WCMC, 2008). Limiting access to resources also worsens the situation of those who depend the most on biodiversity for their livelihoods, as "fencing off such areas is like cutting off access to their bank account" (WWF, 2008). The establishment of conservation areas is often associated with a decrease in economic output as measured by market values. For instance, the forest available for timber production has been declining for this reason in some parts of the world, including Europe. Some 21 million hectares of productive forestland have been set aside in conservation reserves (parks, wilderness, and so on) in the United States (MEA, 2005d). Even though protected areas tend to occupy land with lower agricultural potential, their opportunity costs often remain significant. In Cameroon, resource use restrictions imposed on residents by the creation of Bénoué National Park led to the loss of about 30% of agricultural income and 20% of livestock-derived income (TEEB, 2009e).

Box 6.1: Examples of the opportunity costs of protected areas

- In 1995, Peter Howard showed that Uganda's protected area system resulted in a net financial benefit of $8.5million, representing a net present value of $120.6 million. However, the net economic impact (including non-marketed benefits and costs), results in an annual net loss of $76.4 million (roughly $1 million a year in net present value) (IUCN, 1999).
- Analysing the benefits and costs of the protected area system in Kenya shows that Kenya bears an annual net cost of $2.8 billion (taking into account tourism, forestry, watershed, biodiversity and carbon sequestration benefits, and opportunity costs opportunity in terms of the value of protected area land if it were converted to agricultural or other uses). However, global benefits clearly outweigh the costs borne by Kenya itself, amounting to $11 billion (IUCN, 1999).
- Lamerton (1999) illustrates the net costs of Lake Mburo National Park in Uganda far outweigh the financial benefits accruing from resource utilisation, tourism and contributions from external sources. The annual value of benefits amount to UGX 685 million, compared to a loss in excess of UGX 742 million. Direct management expenditures borne by Park Authorities and external donors comprise a third of costs associated with the National Park. Only a quarter of the costs of managing the Park are met by income accruing from the Park. The shortfall is covered by budgetary support from external donors. However, of still far greater significance are the costs imposed on nearby livelihoods from damages to crops and livestock (32%), restricted access to resources (20%), and the loss of grazing land (12%). Furthermore, the economic cost to local residents is rising rapidly. Importantly however, Lamerton does not consider the wider non-market values of conservation in her calculations.
- Protected areas can affect more than just primary industries. The designation of protected areas can also sometimes mean extractive industry permits are also revoked, which can have significant effects in terms of employment losses. For instance, the logging of natural forest was banned along the Yangtze River in China to reduce environmental degradation led to 1.1 million people losing their jobs. Many social services provided by state-owned forestry companies (e.g. education and health care) were also lost as a result (IUCN/WCMC, 2008).

A recent analysis of the costs of biodiversity and ecosystem action in the EU (Ecologic *et al.,* 2010)found that the combined cost of different policy actions selected from the EU Biodiversity Action Plan is roughly estimated at €10.7 billion per year. Opportunity costs of this amount to roughly 78%, or €8.4 billion. The estimated opportunity costs largely result from income foregone from reduced agricultural and forestry output from managing land for the benefit of biodiversity. This in turn is likely to be reflected in foregone employment opportunities. Remaining costs of about €2.3 billion are mostly attributed to the financial costs of actions in each of the policy areas.

Alongside the economic costs of protected areas, much attention has also been given to the social costs. Although little quantitative information exists on forced displacement from protected areas, a review of 250 published articles on conservation displacement found estimates ranging from 900,000 to 14.4 million people. However, much of this displacement occurred in the 1970s. It is likely that current forced displacements are much less frequent or severe (UNCEP/WCMC, 2008).

Recent arguments also suggest that employment opportunities arising from conservation most often go to the more affluent people in local communities, which can increase social inequalities. Not only are better-off households more likely to participate in a conservation initiative, but they are often the main recipients of conservation-related livelihood benefits. For instance, analysis of a community forest management programme in Malawi showed that wealthier participants captured most of the benefits due to discrimination and differences in capital endowments (Leisher, 2009). Indeed, a meta-analysis of 400 studies found that most studies showed little or no economic benefit from protected areas for those in lower income groups (Leisher, 2009).

This might be a reflection of an observation commonly made, for instance by Vira et al. (2010), that the poor depend disproportionately on low value goods and services from biodiversity, whilst more affluent groups get interested in resources if they have higher commercial values (often crowding out the poor in the process). Thus, if conservation initiatives increase the returns from certain types of resources, the rich and powerful groups may try and capture these resources, which may further exclude the poor from access.

Protected areas which consider these social impacts, and include social/cultural objectives, are most likely to minimise the trade-offs listed above. There has been a significant increase already in protected areas which seek a better balance between biodiversity objectives and social needs (categories V and VI of the IUCN categories for protected areas). However, whether these types of protected areas deliver the best biodiversity conservation is uncertain. WWF (2008) for instance, noted that a protected area network made up entirely of these types of conservation areas may well be insufficient to adequately conserve a nation's biodiversity.

6.1.2 The Synergies Available with Protected Areas

Although in many cases the costs of protected areas can be significant, there are examples where the benefits are greater (see Box 6.2). The benefits often outweigh the costs , especially on a national and global scale (TEEB, 2009e). On a local scale this is less often the case (see above). However, benefits can also be significant at a local and regional level. For instance, a survey of protected area managers at the 5th World Parks Congress in 2003 found that 78 per cent believed that economic benefits of protected benefits were significant to the broader community (WWF, 2008). Furthermore, Balmford et al. (2002), find that the benefits of conversion of land (and subsequent loss of ecosystem services) were always outweighed by the costs. In each case, private benefits were accrued at the cost of social (community) benefits.

Box 6.2: Examples where protected areas resulted in benefits which outweighed potential costs

- In comparing forest to agricultural values, one study finds that alternative forestry practices in Nepal generate more than 10% higher values per hectare than agriculture (at a net present value of $3,140 for non-irrigated agriculture), illustrating that multiple use forestry management practices are the most efficient use of forests in Nepal (IUCN, 1998).
- In Brazil's Amazon, ecosystem services from protected areas provide national and local benefits worth over 50% more than the return to smallholder farming and draw three times more money into the state economy than would extensive cattle ranching, the most likely alternative use for park lands;
- In Madagascar, investment in managing the national protected area system and providing compensation to local farmers for the opportunity costs of foregone farm expansion would pay for

itself and generate an additional return of 50% from tourism revenues, watershed protection, and international transfers to support biodiversity;

- In Scotland, the ecosystems protected by Natura 2000 sites provide benefits to the Scottish public worth more than seven times the associated costs, including direct management and opportunity costs.
- The Massola National Park in Madagascar was found to provide a net benefit over a ten-year timescale for local communities, mainly through the sustainable community forestry programme, and the use and protection from forestry of NTFPs. The costs were focussed at the national level, due to the loss of large-scale timber extraction, and a net global benefit was calculated, as a result of the carbon value of the forest protected from future logging activity (UNEP/WCMC, 2008).
- A study of Kruger National Park in South Africa suggests that wildlife conservation is 18 times more profitable than using the same land for livestock and crops, largely thanks to ecotourism (WWF, 2008)

A meta-analysis found that of 400 studies, 150 provided some evidence that conservation projects benefit the poor. Although protected areas deliver multiple benefits, the empirical evidence that is available shows that the most significant direct benefit from protected areas is employment generation (Leisher, 2009). The WWF, for instance, notes that the creation of conservation parks can create opportunities for employment and income if local people are involved in their creation and maintenance. Two examples from South Africa illustrate this point. It is hoped that by employing local people in eco-tourism in the Eastern Cape, 5,000 jobs will be created. Already, the Kruger National Park in another part of South Africa employs 60,000 people. Additionally, the use of goods and services in the surrounding area means that the park supports somewhere between 300,000 and 500,000 people.

Besides direct employment from the protected area itself, employment in associated services is also possible. For instance, tourism generates revenue directly, and has therefore been purported to be an ideal alternative income. Several studies document local benefits being derived through the sale of goods and services to tourists, or through the sharing of a portion of direct revenues such as entrance fees with local communities (UNEP/WCMC, 2008). Non-financial benefits can also include the development of skills, access to information, credits and markets, as well as improved infrastructure. However, such benefits depend on the strategies used to manage the protected area, including for instance the extent to which local communities and their livelihood activities are excluded or included, and the extent to which the benefits of protected area revenue is shared with surrounding communities.

Overall, it is possible to categorise the different benefits from protected areas which accrue to poorer populations as follows:

- Collected or harvested directly from the protected area – for example NTFPs
- Derived directly from the protected area – for example jobs in the protected area
- Derived indirectly from the protected area – for example hospitals set up thanks to funds raised by the protected area or subsidies for the protected area and its surroundings
- Empowering and engaging poor people – for example through co-management of the protected area (WWF, 2008).

One report by WWF (2008) sets out a comprehensive list of examples where protected areas have made economic contributions to employment and poverty reduction. A few examples of these, including those where protected areas have created jobs, are shown in Box 6.3. Overall, protected areas contribute to poverty reduction indirectly, through the measures put in place as a result of the protected area's designation (e.g. compensation, or support for alternative livelihood options), or directly, where the natural resources within a protected area contributes to poverty reduction.

Box 6.3: Examples of the economic contributions protected areas can make to poverty reduction (WWF, 2008)

- The Serenget National Park in **Tanzania** (1.5 million hectares) supports 385 jobs. In the ten years between 1993 and 2003 the park contributed US$292,000 to local community projects (particularly in the field of education). In 1999, some US$15,000 was spent in Bunda and Serengeti Districts, contributing up to three quarters of the cost of development projects, i.e. construction, rehabilitation or maintenance of local infrastructure such as schools
- A community campsite set up near the Bwindi Impenetrable Forest National Park (32,092 hectares) in **Uganda** earned US$70,628 (up from US$22,000 in 2001) in 2004 and employed 11 local villagers on a permanent basis. The revenue is used in community infrastructure projects, such as provision of a water pump. A Trust Fund established to protect mountain gorilla habitat distributes 60 per cent of its funds to community projects promoting conservation and sustainable development activities (including schools, feeder roads etc.
- The Okavango Delta System (6.8 million hectares) in **Botswana** is home to an estimated 122,000 people, 90 per cent of whom are dependent on the delta for their livelihoods. In 2001, 923 people were employed in 30 tourist accommodation facilities. It is estimated that 50 (i.e. nearly 80 per cent) of the safari camps and lodges in the delta employ about 1,658 people, which represents 16.6 per cent of formal employment in the tourism sector. In 2001, community organisations in the delta generated an estimated US$800,000 through contracts and joint venture partnerships with safari operators, sale of hunting quotas, crafts and small-scale tourism ventures. Part of this money has been reinvested in community development projects such as recreational facilities, vehicles, lodges, campsites and bars, as well as to pay the salaries of employees in Trusts.
- The Sabie Sabie Game Reserve (13,641 hectares) in **South Africa** has a number of lodges and operates ecotourism tours. It employs 190 locals and thus contributes to the livelihoods of about 1,200 people.
- The Maya Biosphere Reserve in **Guatemala** (2.1 million hectares) provides employment for over 7,000 people in the Petén region of Guatemala and generates an annual income of approximately US$47 million. The reserve is credited with close to doubling local family incomes. Five per cent of net earnings from ecotourism go to local people and are invested in community projects such as handicraft production and local schools.
- The Bunaken National Park in **Indonesia** (70,060 hectares) benefits 40,000 people economically and has created over 1,000 jobs for local people. Thirty per cent of the park entrance revenues are used for development programmes in local villages.
- The Tortugeuro National Park (18,946 hectares) in **Costa Rica** has generated 359 jobs through ecotourism. In addition, a local high school, clinic and improved water and waste treatment were set up thanks to revenue from the park. In 2003, direct income to the Gandoca community (situated 125km from the Park) was estimated at US$92,300; i.e. 6.8 times more than the potential income from selling turtle eggs on the black market. It was also estimated that each local tour guide in Tortuguero earned on average 2 to 4 times the minimum wage during the five-month period.
- In **Germany**, Muritz-Seen-Park Landscape Protection Area (30,000 hectares) generates over US$ 17.7 million per year for the region in tourism, supporting an estimated 628 jobs.

Leisher (2009) shows that there is empirical evidence that at least six conservation mechanisms can be a route out of poverty in some cases (community timber enterprises, nature-based tourism, fish spillover, protected area jobs, agroforestry and agrobiodiversity conservation). A further four conservation mechanisms can at the very least contribute to reducing poverty, or provide a safety net as and when the need arises (non-timber forest products (NTFPs), payments for environmental services, mangrove restoration, and grassland management).

Protected areas clearly have the potential to provide important benefits that help to address issues of poverty. The potential benefits are linked to the ways in which the poor depend on biodiversity, both directly in terms of income or subsistence, and indirectly as insurance from risks and shocks. Consequently, protected areas can result in direct economic benefits, but more commonly they provide a safety net which prevents the poor from falling further into poverty. The literature suggests therefore that protected areas mostly contribute to the wider aspects of poverty rather than to poverty reduction per se, in the traditional sense of increasing the number of dollars people earn a day (WWF, 2008).

6.1.3 Maximising the Synergies and Managing the Trade-offs

Overall, the evidence suggests that although biodiversity conservation can provide opportunities for job creation and can deliver significant benefits, this is not always certain. Whilst there are cases where it is evident that conservation has contributed towards poverty, equally there are cases where protected areas have also served a purpose in its reduction. At any rate, protected areas and poor people are inextricably linked, especially given the significant geographical overlap between the two. The link is diverse and complex, which creates significant challenges in creating ‘win-win’ solutions. These challenges should be acknowledged, and managed accordingly.

This will become increasingly important, given that remaining gaps in national protected area networks are likely to be in valuable areas such as lowland forest, grasslands and in the heavily modified cultural ecosystems of some of the world’s great agricultural areas (WWF, 2008), where trade-offs will play an increasingly prominent role. In these cases, protected areas will have to provide benefits that extend well beyond traditional conservation concerns. Efforts will also have to be made to improve the benefits from existing protected areas in order for them to justify their continued sustainability over the long term.

Research by WWF (2008) and Mellor (2002), suggests that a key consideration should be population density. The size of the population living in and around a protected area significantly influences its potential to contribute to well-being. The smaller the population that relies on the resources in question, the more likely that the benefits from a protected area will be sufficient to contribute to poverty reduction as economic benefits derived from the protected lands accrue to a considerable portion of the population. In more densely populated areas, pressures on a protected area may be too great to adequately provide for the population. Mellor (2002) highlights that recognising that the small niche markets generally associated with protected areas cannot support an income increase for large numbers of people makes it clear that “the bulk of the poverty problem must be solved elsewhere”. In some cases therefore, it might be necessary to accept that protected areas cannot always be a tool to reduce poverty.

Nonetheless, it is equally important to acknowledge that whilst protected areas might not always provide economic benefits to local communities, the global benefits are hugely significant, and in many cases, sufficient to justify their continued presence. In these cases, innovative (global) mechanisms which compensate communities for the costs incurred locally in return for global benefits should play an important role.

For instance, carbon-finance mechanisms such as REDD (reducing emissions from deforestation and forest degradation) have the potential to have considerable impacts upon the costs and benefits for livelihoods associated with protected areas. The potential benefits to local communities are especially significant, if mechanisms are carefully managed. Clear governance, including well-defined property rights, will be critical in these emerging international markets.

On a smaller scale, payments for ecosystem services are also increasingly cited as means to capture elusive ‘win-wins’, where biodiversity is directly valued and local people are compensated for the impacts of protected areas through increased income, diversified livelihoods, formalised land tenure and strengthened social organisations (UNEP/WCMC, 2008).

6.2 Employment Implications of Biodiversity Loss

It does not necessarily follow that greater biodiversity, and improved ecosystem services mean more human well-being, or vice versa. It is, for instance, quite widely observed that general improvements in well-being often occur despite, or because, of decreases in ecosystem services, at least at the local scale (MEA, 2005n).

Indeed, substantial benefits have been gained from many of the actions that have caused the homogenisation or loss of biodiversity (MEA, 2005o). Often this is based on trade-offs between different services, usually in the form of trading regulating or supporting services in favour of increasing provisioning services. For example, food production may be increased at the expense of water quality (MEA, 2005p). Indeed, only 4 of the 24 ecosystem services examined in the Millennium Ecosystem Assessment (MEA) have been enhanced: crops, livestock, aquaculture, and (in recent decades) carbon sequestration, while a further 15 services have been degraded (MEA, 2005o).

Trade-offs between services from inland waters in particular have been considerable, yet poorly considered. Alteration of rivers through infrastructure has improved transportation, provided flood control and hydropower, and boosted agricultural output by making more land and irrigation water available. At the same time, rivers have been disconnected from their floodplains and other inland water habitats, water velocity in riverine systems has decreased, in some places rivers have been converted to a chain of connected reservoirs, and groundwater recharge has been reduced. In other places, infrastructure has increased the likelihood of flooding by diverting water and increasing flows. These types of trade-offs between ecosystem services will continue and may intensify (MEA, 2005l).

Although trade-offs are common, various synergistic interactions can allow for the simultaneous enhancement of more than one ecosystem service. Increasing the supply of some ecosystem services can enhance the supply of others (forest restoration, for instance, may lead to improvements in carbon sequestration, runoff regulation, pollination, and wildlife), although there are also trade-offs (in this case with reduced capacity to provide food, for example) (MEA, 2005o).

Such trade-offs between ecosystem services have implications for employment, although the implications vary as the relationship is rarely straightforward or obvious. For instance, while the establishment of areas to protect biodiversity increases related ecosystem services, it can nonetheless also contribute to poverty where rural people are excluded from the provisioning services that have traditionally supported their livelihoods and well-being (MEA, 2005o).

The relationship between economic output and employment through changes in ecosystem services is not straightforward either. In some cases, changes in production methods may reduce labour inputs while maintaining output of services. In South Africa, for instance, initial deforestation has led to a gradually increasing use of trees-on-farms in some places, but not for environmental protection as much as for labour-sparing, high-yield investment (MEA, 2005n). Indeed, in the global forestry sector, labour requirements per unit of output in all regions will continue to shrink due to technological change. In the United States, from 1997–2003, employment in the paper and paperboard production fell by one third while total production barely declined (MEA, 2005d)

Nonetheless, natural capital is often a relatively labour-intensive form of investment, and can have long term economic benefits (TEEB, 2009c). For instance, it has been estimated that a global marine protected area system, accounting for the closure of 20%of total fishing area and resulting in a lost profit of US$ 270 million per year, would nonetheless help sustain fisheries worth US$ 70-80 billion per year while creating 1 million jobs (TEEB, 2008). Within the West Coast Region of New Zealand's South Island, economic activity in conservation lands led to an extra 1,814 jobs in 2004 (15% of total jobs) (TEEB, 2009c).

Ironically however, the sectors which are most highly dependent on biodiversity and related ecosystem services are often also those which are causing the most damage to the same services and inputs that they rely upon. For instance, whilst agricultural production is highly dependent on the regulation of water quality and flows, agricultural production shows an inverse relationship with water quality and quantity. Equally, agriculture is both extremely vulnerable to climate change, and is simultaneously a major contributor to it (ILO, 2007). Furthermore, modern agricultural methods as a whole have resulted in significant biodiversity declines and losses. Indeed, 35% of the Earth's surface has already been converted for agriculture, limiting scope for the future productivity of natural systems. For marine ecosystems, fishing is the major direct anthropogenic force affecting the structure, function, and biodiversity of the oceans. Since industrial fishing began, the total mass of commercially exploited marine species has been reduced by 90% in much of the world. In bio-prospecting, it is ironic that the recent explosion of new techniques in the biological, chemical, and physical sciences that has generated a vastly improved capacity to understand and use biodiversity has been accompanied by a global decline in this very resource. The loss of biodiversity may not only lead to a loss of commercial opportunity but may also compromise ecosystem function. Overall these trends point towards significant implications for these sectors and the employment they support.

As these trends continue, where sectors which rely on biodiversity simultaneously degrade the services it delivers, thresholds may be crossed beyond which employment might no longer be sustained. Similarly to the way that ecosystems may tolerate gradual changes in biodiversity up until a point, employment may also persist until a tipping point is reached with jobs then being rapidly affected. This threshold may or may not be related to the ecosystem's threshold being reached. The sensitivity of jobs to changes in biodiversity and ecosystem services will depend largely on the extent to which these can be substituted; indeed, technological substitutes can sometimes require more labour inputs than natural alternatives. For example, wetlands naturally provide water purification services without the need for labour inputs, whilst waste water treatment plants require staff to maintenance and operate the facilities. However, the effects will also depend on the extent of the biodiversity loss and ecosystem service degradation. For instance marine tourism may continue despite some biodiversity loss, until either a charismatic species is lost (e.g. manatees, dolphins or albatrosses) or a significant disturbance means too much biodiversity is lost to make it a worthwhile tourist destination (e.g. an occurrence of coral bleaching).

It is worth noting that all the above relationships may take place simultaneously, across a variety of sectors. As illustrated above, increased investment in ecosystem services might result in increased jobs in some sectors (e.g. conservation management), but decrease employment in others (e.g. forestry). Equally, however, degraded ecosystem services might also result in varying effects on employment depending on the sectors in question. This is best illustrated by the example of the Aral Sea; its degradation supported a very successful cotton industry, but also resulted in thousands of jobs being lost in other sectors (Box 6.4).

Box 6.4: Employment and Ecosystem Services: The Aral Sea (MEA, 2005a; TEEB, 2009b)

Fifty years ago, the Aral Sea was the world's fourth largest freshwater lake and supported a large and vibrant economy based on fisheries, agriculture and trade in goods and services. Under Soviet rule, in the 1960s the two main rivers flowing into the Aral Sea were massively diverted for cotton cultivation.

Small-scale independent irrigation systems were transformed into unsustainable large-scale collective irrigation systems for cotton production. With the Soviet Union's attention focused on cotton self-sufficiency, the long-term adverse effects of a rapid, large-scale expansion of inefficient irrigation systems, sole reliance on high-water demanding production systems, poor water distribution and drainage, and non-dose related uses of fertilizers and pesticides around the Aral Sea were not considered high priority.

Consequently, the Sea began to shrink and to split into smaller pieces – the 'Northern Aral' and 'Southern Aral' seas. The new system decreased water inflow into the sea to a mere trickle, shrunk the size of the sea by half, reduced the water level by 16 meters, and tripled its salinity. Although large amounts of cotton were grown and exported in subsequent decades, thousands of jobs were lost in other sectors, the surrounding environment was severely degraded and the health of local people deteriorated. Thirty-five million people have lost access to the lake for its water, fish, reed beds, and transport functions. The fishing industry around the Aral Sea has collapsed, with fishing ceasing in the 1980s.

By 1996, the Aral Sea's surface area was half its original size and its volume had been reduced by 75%. The southern part had further split into eastern and western lobes, reducing much of the former sea to a salt pan.

To further illustrate the scale and complexity of the problem and its possible solutions, the implications for climate regulation also need to be considered. The discharge of major Siberian rivers into the Arctic Ocean appears to be increasing which could affect the global oceanic 'conveyor belt', with potentially severe consequences for the climate in Western and Northern Europe. By diverting part of this river water towards the Aral Sea, a restoration project may have potential beneficial effects on climate, human health, fishery and ecology in general.

The after effects of degraded ecosystems, and their restoration can also increase employment. The biological control of invasive species for instance, can require significant labour inputs. The treatment of 3,387 hectares of land in South Africa to deal with invasive alien species created 91 person years of employment. Meanwhile, the restoration of grasslands and riparian zones in South Africa created 2.5 million person days of work during the restoration phase, whilst the necessary ongoing catchment management will create 310 permanent jobs (TEEB, 2009b).

Overall, the conversion of natural systems may create immediate wealth and short term employment, but often ecosystem services would provide wealth and jobs indefinitely, albeit at lower levels (TEEB, 2009a). Ecological degradation (e.g. soil erosion, desertification, reduced water supply, loss of waste water filtering) impacts on productivity, livelihoods and economic opportunities (TEEB, 2009b).

6.3 Opportunities for Job Creation through Biodiversity Conservation – Where are the Opportunities and How Many Jobs Can be Created?

6.3.1 Overview

Although difficult to concretely estimate, the potential for future job creation within the field of biodiversity conservation and tangential sectors is substantial. In addition to the creation of new kinds of jobs, there will also be the adaptation of traditional professions and occupations, requiring new competencies and increased labor investments (Castañeda, 2010). Following the sectoral approach outlined in Section 3.4, this section discusses opportunities for the development of existing jobs and creation of new opportunities, as well as the additional prospects created by recent 'Green New Deal' proposals in Europe and globally.

6.3.2 *Conservation Sector*

Within the conservation sector, direct actions are being taken to protect biodiversity. Such actions include creating protected areas, both terrestrial and marine, and controlling the threat posed to indigenous species by the introduction and spread of invasive plants and animals. Given the success to date of protected areas in conserving biodiversity and their projected enlargement, EUROPARC[84] projects that the jobs associated with such designated areas will increase by 150% between 2010 and 2013 (Castañeda, 2010). Regarding marine protected areas (MPAs) specifically, achieving a network of MPAs covering 30% of the oceans would generate between 830,000 and 1.1 million full time equivalent jobs in such areas as tourism, park monitoring, etc (WWF, 1996). Evidence suggests that those who gain full-time jobs in conservation can be lifted out of poverty. For instance, in the remote community of Puros, almost all adults were able to get jobs in the conservancy (or associated tourism enterprises). However, this situation is rare (IIED, 2010). As mentioned, the threat posed by invasive species is another area with severe potential effects for biodiversity. As the spread of these species is forecast to increase in magnitude, considerable labour inputs and an enlarged work force will be necessary to address this growing problem.

Overall there is significant potential for job numbers in the conservation sector to increase. For one, the number of protected areas is steadily increasing. These areas will need staff to manage them. However, there is also potential to increase employment in existing conservation areas. A report from the WWF found that staff numbers are a significant factor in determining the condition of biodiversity within a protected area, as well as the effectiveness of its management. However, many protected areas were found to have very low and inadequate staff numbers. Thus there is considerable potential to increase staff numbers of currently designated protection areas, where there is a lack of adequate staffing.

The conservation sector also provides significant employment opportunities through associated tourism. In the EU-15, nearly 9 million people worked in tourism in 1999. It has been estimated that the eco-tourism sector could represent between 0.5 – 15% of this (450,000 – 1.5 million jobs). The EU market-share could significantly increase given that eco-tourism is a relatively new sector, and that the sector is not yet able to deliver the same quality as traditional tourism. Furthermore, there is still significant potential for developing new forms of eco-tourism (e.g. new types of accommodation, new places etc.) (Ernst & Young, 2006). These opportunities are of course not limited to the EU, but also apply to developing countries.

Similarly, payments for ecosystem services (PES) appears to also present significant opportunities for employment creation, especially when administered as public works projects (UNEP, 2008). Studies of PES in developed countries show evidence of tangible employment benefits. For instance, the Tir Cymen scheme in Wales, which promotes sustainable farming in three areas of rural Wales, produced 204 casual jobs and 62 person-years of environmental work. If replicated across Wales, it could generate an estimated 1,230 years in full-time jobs (UNEP, 2008). However, conclusions should be reached cautiously given that PES projects are still few in number, small in scale, and mostly limited to developed countries. Most are driven by the public sector, and it is here where the greatest potential for further growth can be expected. However, the benefits of PES need to be set alongside the shortcomings. There are, for instance, risks associated with dependence on payments that may lack a long-term financing strategy. The poorest members of a community are also easily excluded from the scheme, since they lack capital for initial involvement and often have few land-use rights (often a pre-requisite for claiming payment). Additionally, if the conservation encouraged under PES is less labour intensive, the poor and landless may be further harmed (Leisher et al., 2009).

[84] EUROPARC is a federation representing 441 members, including protected areas, governmental departments, NGOs and businesses in 36 countries (http://www.europarc.org/home/).

6.3.3 Natural Resource Based Sectors

The agricultural sector is the largest employer worldwide, accounting for approximately 45% of the world's labor force and employing an estimated 1.3 billion farmers and agricultural workers (UN, 2007); the magnitude of this sector creates a large potential to either harm or support biodiversity conservation. Organic agriculture, a growing subset of this sector, already employs a third more workers than traditional agriculture (Castañeda, 2010) and, due to abstaining from high-input, petroleum-based techniques, requires 30% more labor than conventional production (Kamenetz, 2009; UNEP, 2009a). Given these factors and the growing international demand for sustainably produced agricultural products, the United Nations Environment Programme (UNEP) predicts that the current global creation rate of 172,000 jobs per year in organic agriculture will continue, if not increase, in the future (UNEP, 2009a).

Increasing biological and genetic diversity via crop rotation and diversification could also have positive employment implications. Due to the knowledge intensive character of this type of farming and the substantial research required to optimise and master current techniques, the creation of a sizeable expert work force will be necessary to develop the ecological and economic literacy of farmers (Renner et al, 2008) and improve their aptitude in applying such methods.

Within the field of forestry, afforestation, reforestation and sustainable forestry management have the potential to increase job prospects. Regarding the first direction, afforestation and reforestation efforts in combination with an improved stewardship of vital ecosystems could support the livelihoods of over one billion people dependant on forests (Renner, 2008). Such work also comprises sizeable amounts of manual labor, including cutting down unwanted trees, removing brush around the trees and pruning the new trees to maximize growth. Additional indirect jobs[85] including growing the seedlings in nurseries and transporting the trees to the respective forests could also increase (Renner et al, 2008). Foresters can additionally aid local populations in switching from unsustainable slash-and-burn practices to silviculture and can teach cultivation techniques involving higher-value, faster-growing species that can be utilised to satisfy fruit, medicinal or timber needs (Kamenetz, 2009).

Sustainable forestry management (SFM) is another promising area for future employment. As such efforts focus on sustainability and the lasting preservation of forest ecosystems, long-term employment opportunities could be created for rural economies (Renner et al, 2008). Studies to date have varied in estimating the effects of certification schemes on numbers of jobs, but most have indicated an increase in levels of employment and project a continuation of this trend into the future[86] (Renner et al, 2008). Jan Heino of the UN Food and Agriculture Organization speculates that increased investments in sustainable forestry could create at least an additional 10 million new jobs worldwide in such areas as forest management, agroforestry and the restoration of degraded forests (FAO, 2009).

Other fields indicating a potential future increase in career opportunities include education, research, climate change related adaptation and additional forms of labour intensive conservation work hereto not addressed. In order to provide increasingly necessary skills for emerging and changing job markets, the expansion of green education alongside training and skill-building programs covering a range of occupations will be necessary (Renner, 2008). The need to preserve ecosystem integrity and the biodiversity contained within also mandates opportunities in teaching, research and fieldwork for employees of governments, NGOs and private companies (Kamenetz, 2009). Further jobs will be

[85] Defined as jobs which are not directly engaged in the activities in question; i.e. they cannot be specifically identified through the relevant activity, but can be attributed to it. E.g. For example a tourist facility expands using structural funding and a local firm needs to take on new staff as a result of the increase in business

created via the need to build flood barriers, terrace land and rehabilitate wetlands as methods of adaptation to climate change and to prevent further resource depletion and degradation harmful to biodiversity (Renner, 2008; Renner et al, 2008).

The new report released by TEEB has further highlighted the multiple new business opportunities offered by biodiversity and its conservation, with regard to two aspects in particular:

- **Untapped opportunities in the form of new 'sustainable' products, goods and services**: These include opportunities such as those already mentioned above (in ecotourism, organic agriculture and sustainable forestry). Estimates suggest that sustainability-related business opportunities in natural resources more generally (e.g. energy, forestry, food and agriculture, water and metals) may be in the range of US$ 2-6 trillion by 2050 (in 2008 prices). These projections suggest that the private sector (with the associated employment opportunities) will play an increasingly important role in natural resource management.
- **New markets for biodiversity and ecosystem services**: In a similar vein to the growth in the global carbon market (from virtually nothing in 2004 to over US$ 140 billion in 2009), the opportunities for growth in markets for biodiversity 'credits' and intangible ecosystem services such as watershed protection are also emerging. They provide new environmental assets with both local and international trading opportunities. Valuable lessons should be drawn from REDD+, the first internationally coordinated, biodiversity related market of significant size.

If these opportunities are realised, the potential for new jobs to be created is significant. The TEEB report estimates the size of these new market opportunities, which illustrate that at least some of the business opportunities are likely to be highly lucrative. Many of these jobs are likely to be decent as well. For instance, given the necessary skills that will be necessary, many jobs should be well-paid. However, to what extent these business opportunities will create decent employment opportunities in developing countries (as opposed to just developed countries), remains to be seen. For instance, fair trade and sustainable handicraft goods provide opportunities for job creation in developing countries. However, these are strongly influenced by fashion trends, consumer purchasing patterns and economic conditions, all of which can very easily change.

[86] One case showed a decline in the number of jobs due to the limits placed on timber production.

Table 6.2: Markets opportunities for biodiversity and ecosystem services

Biodiversity and ecosystem service market opportunities	Market size (US$ per annum)		
	2008 (actual)	2020 (est.)	2050 (est.)
Certified agricultural products (e.g., organic, fair-trade)	$40billion (2.5% of global food and beverage market)	$210 billion	$900 billion
Certified forest products	$5 billion of FSC-certified products	$15 billion	$50 billion
Forest-based carbon offsets in regulated markets (e.g. CDM, REDD+)	Various pilots (e.g. New South Wales GHG Abatement Scheme): $0.5 million	$5 billion	$5 billion
Forest-based carbon offsets in voluntary markets (e.g. VCS)	$21 million in 2006	$5 billion	$5 billion
Payments for ecosystem services mediated by government	$3 billion	$7 billion	$15 billion
Government payments for water-related ecosystem services	$5.2 billion	$6 billion	$20 billion
Voluntary payments for watershed management	Various pilots such as in Costa Rica, Ecuador, etc: $5 million	$2 billion	$10 billion
Biodiversity offsets in regulated markets (e.g. US wetland banking)	$3.4 billion	$10 billion	$20 billion
Voluntary biodiversity offsets	$17 million	$100 million	$400 million
Bio-prospecting agreements	$30 million	$100 million	$500 million
Land trusts, easements and other fiscal incentives for conservation (e.g. TNC programmes in North America and Australia)	$8 billion in U.S. alone	$20 billion	Difficult to predict

Source: *TEEB, 2010 (Chapter 5: Increasing biodiversity business opportunities)*

6.3.4 'Green New Deal' Programmes

In addition to the aforementioned potential jobs, numerous governments have recently proposed 'Green New Deal' programs to decrease their carbon footprints and increase the number of 'green jobs'. These jobs aim to reduce the negative environmental impacts of enterprises and economic sectors and, in doing so, protect ecosystems and biodiversity, reduce the consumption of energy, material and water, de-carbonize the economy and minimize waste and pollution production (Kievani, 2010).

UNEP outlines five critical areas that should be invested in within the context of economic stimulus plans, including: energy efficiency in old and new buildings; renewable energy technologies, such as wind, solar, geothermal and biomass technologies; sustainable transport technologies, such as hybrid vehicles, high speed rail and bus rapid transit systems; the planet's ecological infrastructure, include freshwaters, forests, soils and coral reefs; and sustainable agriculture, including organic production (2009b).

While jobs relating to green infrastructure and sustainable agriculture have already been discussed due to their clear role in biodiversity conservation, the remaining prioritisation areas outlined by UNEP have more indirect and less easily quantifiable effects on biodiversity. Furthermore, the effectiveness of these deals remains contested due to the potential of supporting increased consumption behaviours, the failure to properly account for job destruction and the double counting of employed individuals87 (Michaels, 2009). Despite these possible points of contention, the general aims of such Green New Deal programs to minimise harmful environmental impacts and increase resource use efficiency have the potential to aid in the conservation of biodiversity, given that such considerations are more thoroughly considered and accounted for in their implementation.

Although further research regarding the implications of proposed Green New Deal programs is clearly needed, some estimates of their job creation potential have been compiled and can be found in Table 6.3 below. It is important to note that these projections include all sectors of 'green jobs' mentioned above and do not necessarily have direct links or implications for biodiversity conservation, with the exception of green infrastructure and sustainable agriculture jobs.

Table 6.3: Job creation potential from Green New Deal programs (Schepelmann et al, 2009)

Country	**Job Creation Potential**
Germany	No less than 250,000 jobs can be saved through the German stimulus plan
France	A job creation potential of 80,000-110,000 is estimated, offset by the possible loss of 90,000 jobs
United Kingdom	350,000 jobs can be saved and gained in the low-carbon sector
Canada	An estimated 407,000 jobs can be created
South Korea	A total of 960,000 jobs are envisaged, mainly through green spending
United States	Aims to create and save 3,500,000 jobs in the United States

UNEP's recent invitation to the twenty largest economies in the world to support a Global Green New Deal by investing at least one percent of their total GDP in green economic sectors (UNEP, 2009b) has the potential to change the priorities and investment behaviours of governments around the world. Support for UNEPs priority areas could create a dramatic rise in green jobs, including those both directly and indirectly supporting biodiversity.

Box 6.5: The Korean Green New Deal – Creating Jobs by Enhancing River Ecosystems

[87] As some of the 'new' green jobs will be filled by workers who were previously employed, estimates of job creation are often overstated; additionally, the studies do not necessarily account for increases in worker productivity over time (Michaels, 2009).

The Republic of Korea launched a "Green New Deal" on 6 January 2009 as a means of stimulating job creation and revitalising the economy. The stimulus package, which comprises a mix of financial, fiscal and taxation policies, amounted to a total of US$ 38.1 billion, the equivalent of 4% of GDP, to be implemented over the period 2009-2012. A total of US$ 30.7 billion (about 80% of the total stimulus package) was allocated to environmental themes such as renewable energies (US$ 1.80 billion), energy efficient buildings (US$ 6.19 billion), low carbon vehicles (US$ 1.80 billion), railways (US$ 7.01 billion) and water and waste management (US$ 13.89 billion).

The Plan includes a project on the restoration of the Republic of Korea's four major rivers, involving a total investment of 22.2 trillion won (US$ 17.3 billion). The project will improve water quality by expanding sewage treatment facilities and establishing green algae reduction facilities. It aims to restore freshwater ecosystems and to develop an aquatic ecosystem-monitoring network. More than 84 riparian wetlands will be reconstructed. Riparian areas will be afforested or reforested, and will also be used for biomass production.

The project seeks to support regional economic development through the creation of multipurpose spaces for cultural and touristic activities near rivers which are expected to contribute to job creation and local economic revitalisation. Overall, it is expected that the project will create 340,000 jobs and generate an estimated 40 trillion won (US$ 31.1 billion) of positive economic effects.

Source: UNEP (2010

SECTION II: VALUING BIODIVERSITY BENEFITS FOR RURAL VULNERABLE GROUPS

Leader: FEEM
Contributors: IEEP

Introduction

In rural areas most human livelihoods are directly or indirectly linked with ecosystem health and the respective overall provision of ecosystem goods and services and natural resource. This is mainly due to the fact that a significant proportion of the population is engaged in agricultural and other activities in the primary sector so as to support their very own survival. Compared to secondary and tertiary economic sectors, agriculture and the primary sector involve extensive uses of natural resources as production inputs. In this context, valuing ecosystem services used by rural households enables us to assess their quantitative contribution to rural livelihoods and the extent of dependency of rural people on environmental products and ecosystem services. Moreover, estimating the economic value of environmental resources used in rural livelihood systems will contribute to our knowledge of the role of ecosystem and biodiversity in supporting the livelihoods of vulnerable groups, in particular in rural areas, and thus highlight its social dimension in biodiversity policy.

This section focuses on valuing the economic values of ecosystem and biodiversity and analyzing the strength of the linkage of ecosystem services and biodiversity with human livelihoods through empirical evidence in Europe and beyond. The section consists of four chapters, i.e. Chapter 7, 8, 9 and 10.

Firstly, in *Chapter 7* a conceptual model for analyzing the linkages between biodiversity, ecosystem services and human livelihoods is developed. Furthermore, a hybrid economic valuation model is adopted in the analysis of the biodiversity benefits and their contribution to supporting human livelihoods, in particular the livelihoods of the rural poor communities. Finally, the chapter ends with an introduction to a spatial mapping tool and its application to analyzing the coherence of biodiversity benefits and vulnerable groups. The analytical framework developed and methodologies introduced in this chapter will be further elaborated in Chapter 8, Chapter 9 and Chapter10.

Secondly, *Chapter 8* reports the empirical evidence of biodiversity richness and the underpinning ecosystem values in the European Union (EU). Socio-economic indicators and biodiversity indicators are used to profile the rural vulnerable groups and measure the biodiversity status in Europe. Moreover, a European based empirical application of the hybrid economic valuation model is conducted to estimate the biodiversity benefits derived from a variety of ecosystems, including forest, marine/coastal and freshwater ecosystems. The economic value estimates are reported by ecosystems and service types at country level.

Thirdly, *Chapter 9* explores a spatial perspective in the analysis of biodiversity, ecosystem services and human welfare for vulnerable groups, including the rural poor, using the state-of-the-art geographic information systems (GIS) and spider-diagram. The analysis focuses on the European scale using the data obtained in Chapter 8. The results may provide interesting insights on the coincidence of poverty and biodiversity resources and assist EU policymakers to identify priorities for biodiversity policies.

Finally, *Chapter 10* investigates the evidence of economic significance of ecosystem to the rural poor in developing countries, where it is widely acknowledged that biodiversity and ecosystem services are vital to the rural livelihoods. Due to a lack of data, it is impossible to implement the hybrid economic valuation model at global scale and alternatively, a qualitative analysis of the selected case studies in some developing countries is preferred.

7 SETTING THE SCENE: LINKAGES BETWEEN BIODIVERSITY, ECOSYSTEM SERVICES AND HUMAN LIVELIHOODS

> ***"… More than a billion people now live within the world's 19% forest biodiversity 'hotspots' and population growth in the world's tropical wilderness area is 3.1 percent, over twice the world's average rate of growth. Over 90 percent of those who live on less than a dollar a day depend fully or in part on forest products for their livelihoods."*** **Scherr et al. (2003)**

7.1 Introduction

The implications of biodiversity to the support of human livelihoods, including those of vulnerable groups such as the rural poor, can be examined by the intensity of the linkage between ecosystems, and services provided (also known as biodiversity benefits), and the constituents of human wellbeing – see Figure 7.1. This includes the examination of ecosystem services such as the provision of food and water, disease management, climate regulation, flood control, spiritual fulfillment, and aesthetic enjoyment – see Chapter 3 for details. These have been recognized as having an essential role in achieving the United Nation's Millennium Development Goals (UNEP-WCMC, 2007). In section II, we shall embrace a conceptual model for valuing the linkages of biodiversity benefits and human livelihoods that sheds light on two distinct value transmission mechanisms. The first captures the market value components of the biodiversity benefits on human livelihoods. A second component encapsulates the non-market dimensions. This approach will be presented and discussed in the following sub-sections.

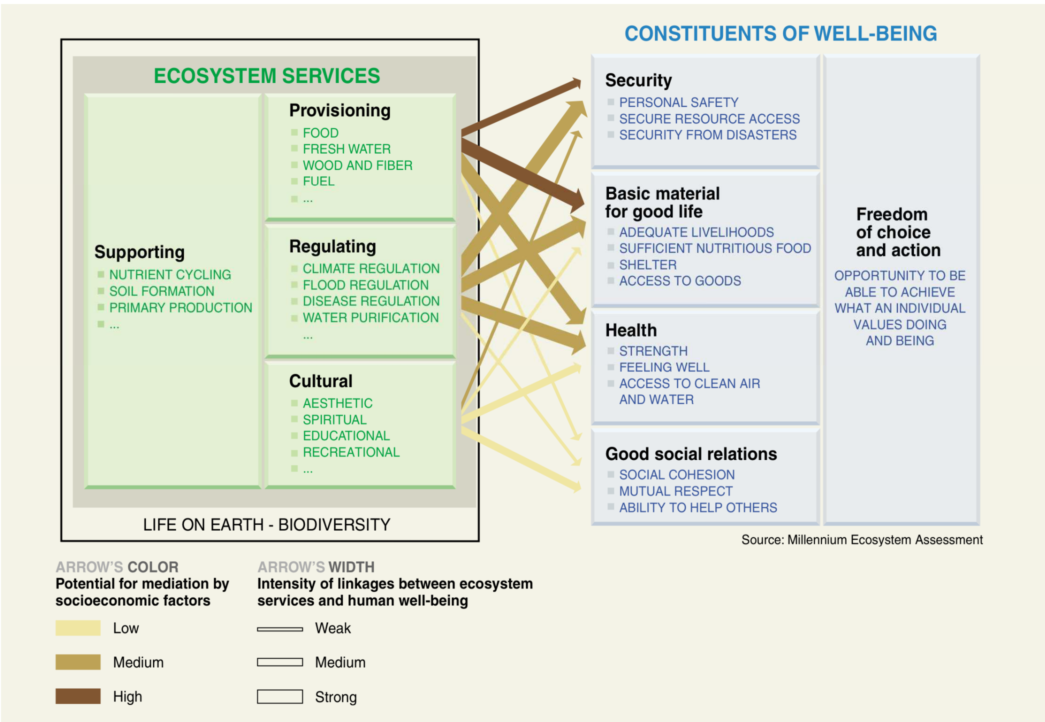


Figure 7.1: Linkages between ecosystem services and human well-being (Source: MEA, 2005, pp. iv)

7.2 Conceptual Model for Mapping the Linkages of Biodiversity Benefits and Human Livelihoods

Human livelihoods are defined as comprising the capabilities, assets (including natural capital, physical capital, human capital, financial capital and social capital) and activities, such as crops, livestock, extractive activities, wage employment and own business, that are required for a means of living (Babulo et al., 2008). This definition indicates that biodiversity benefits and ecosystem services substantially contribute to people's livelihoods in terms of direct increases in people's revenues as well as the enhancement of non-income benefits from the ecosystem services received. In other words, we can argue that biodiversity benefits, and ecosystem services, are linked with human livelihoods in two ways – see Figure 7.2.

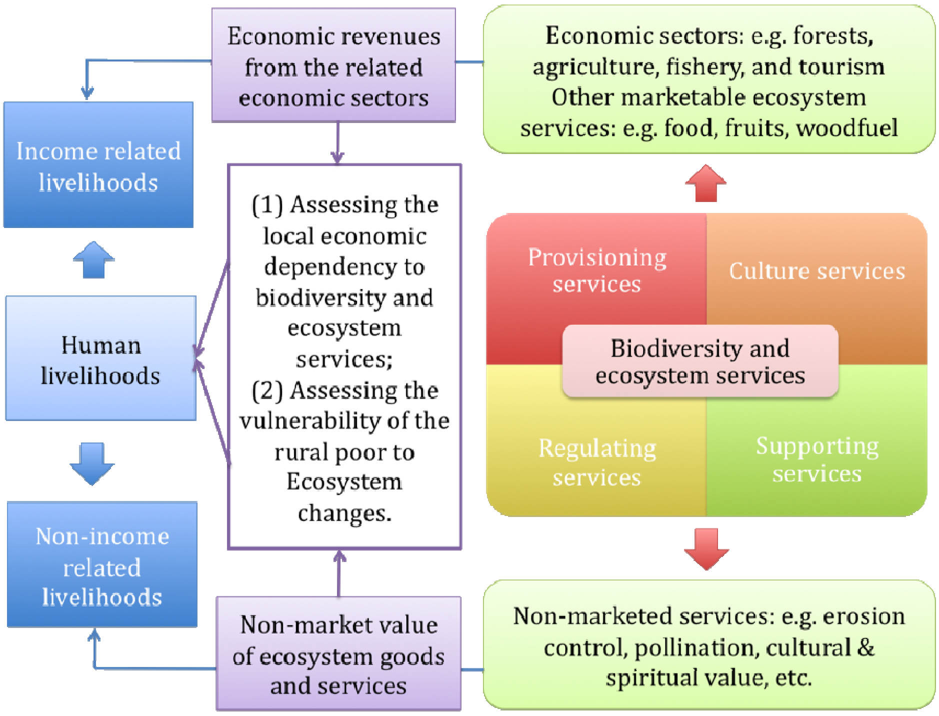


Figure 7.2: Framework of assessing the human livelihoods through biodiversity and ecosystem services

On the one hand, ecosystem services are essential inputs for many primary sectors in the economy, including forestry, agriculture, fishery, and tourism or direct source of income/revenues to the local communities (consumers/firms) who are involved in markets trading ecosystem services, such as food and wood fuel, among others. The strength of this linkage can be estimated through a systematic economic sector analysis, and the results reflect the degree of *dependency* of the local economies with respect to biodiversity and ecosystem services, including their role in the creation of employment/income opportunities to the communities. In this context, valuing the economic revenues that rural dwellers or poor local communities can extract from the use of environmental resources enables us to assess their quantitative contribution to rural livelihoods and the extent of dependency of rural people on natural products and ecosystem services.

On the other hand, ecosystem services also contribute to non-income related livelihoods. The ecosystem regulating and supporting services will safeguard the living environment as well as guarantee the continuous economic activities of humans, in particular the rural dwellers; whereas the ecosystem cultural services are essential to the spiritual and cultural value of the local communities. The strength of these linkages can be estimated through a systematic economic analysis of the non-income related value of biodiversity and ecosystem services on human livelihood systems, which in turn will allow us to complement the understanding of the degree of *dependency* of the local economies with respect to biodiversity and ecosystem services. Moreover, both value transmission mechanisms will allow us to understand the degree of *vulnerability* of the local economies, in particular the rural poor, with respect to changes, or losses, of biodiversity and the respective impacts in the provision of ecosystem services.

It is important to note that the economic valuation exercise stems from microeconomic theory, proving a partial-equilibrium analysis of the economic problem at a local scale. In the case of quantifying the biodiversity benefits to the rural poor, we are particularly interested in the cash or non-cash income that local communities can obtain from the extractive use of natural resources and how much can this contribute to rural livelihoods. This perspective indicates that the current economic analysis focuses on the supply side of products, which are transformed into benefits to the economy by either being used as resource endowments in production of the primary sectors (e.g. timber production) or being provided to outsiders in the form of ecosystem-based services (e.g. recreation/tourism services). Although benefits of ecosystem services exist in different forms, it is clear that both benefits can be traced directly/indirectly in the marketplace and lead to the increase of cash income and the creation of new job opportunities to the local population. Therefore, we interpret the estimated economic values of ecosystem services as the contribution to the total income that supports the livelihoods of rural communities. The magnitude of the ecosystem value can also reflect the poverty level of vulnerable groups in the rural areas.

7.3 A Hybrid Economic Model for Valuing the Magnitudes of Biodiversity Benefits on Human Livelihoods

As previously shown, ecosystems provide an array of services to human wellbeing in terms of provisioning services, cultural services, regulating services and supporting services (MA, 2005), many of which are associated with a variety of economic activities that substantially contribute to the livelihoods of local population, including either direct or indirect employment in the related economic sectors, which lead to direct changes of incomes to the relevant households; some others will contribute to direct welfare enhancement of the local communities derived from their extractive use of nature resources, knowledge of biodiversity and ecosystem as well as other non-marketed values of biodiversity and ecosystem services. Due to the complex nature of biodiversity and ecosystem services, economic valuation of the biodiversity benefits is not always straightforward. Different economic valuation approaches are needed. In fact, economists have been applying different valuation methodologies to estimate the economic values of ecosystems and the services they provide.

In Table 7.1, we summarize the standard ecosystem valuation techniques that are mostly used in the literature – see Appendix I for more detailed explanation on each methodology. It is important to note that in economic theory, socio-economic valuation of biodiversity and ecosystems is anchored in the assessment of changes in the productivity of the economic sectors under concern and/or respective consumer's utility and requires the investigation of appropriate microeconomic valuation techniques, including both market-based economic valuation tools (e.g. market price analysis) and non-market valuation tools (e.g. contingent valuation methods, travel costs methods, meta-analysis, and value transfer methods). Therefore, the estimated economic benefits of biodiversity and ecosystems should reflect the welfare changes of the individuals being directly affected by changes in biodiversity and ecosystems, or the average welfare change of the individuals in a considered population (Nunes et al. 2003).

Table 7.1: Tool box of economic valuation techniques

Category	Technique	Description	Example

Revealed preference approaches			
Market prices	Market prices	How much does it cost to buy an ecosystem good or service?	The price of timber or mineral.
Production function approach	Effect on production	Relates changes in the output of a marketed good or service due to the changes in a measurable amount of production inputs.	The reduction in lifespan of a hydro.
Surrogate market approach	Travel costs	Valuation method based on the willingness to pay for recreational/leisure use of nature resources, derived from the amount of time and money people spend on visiting a relevant ecosystem.	The transport and accommodation costs, entry fees and time spent to visit a natural park.
	Hedonic pricing	The difference in property prices or wage rates that can be ascribed to the different ecosystem quality or values.	The difference in house prices between those overlooking an area of natural beauty and those without a view of the landscape.
Cost-based approach			
Damage costs avoided		The costs incurred to property, infrastructure, and production when ecosystem services that protect economically valuable assets are lost	The damage to roads, bridges, farms and property resulting from increased flooding after the loss of catchment protection forest.
Stated preference approaches			
Contingent valuation method		Infer ecosystem value by asking people directly what is their willingness to pay (WTP) for resource conservation or willingness to accept for (WTA) compensation for the loss of biodiversity/ ecosystems	How much would you be willing to contribute towards a fund to clean up and conserve a river?
Conjoint analysis		Elicit information on preferences between scenarios involving ecosystems between which the respondents would have to make a choice, at different price or cost saved.	The relative value of wildlife, landscape and water quality attributes of a river under different conservation scenarios, relative to the status quo.
Choice experiments		Presents a series of alternative resource or ecosystem use options, each defined by various attributes including price and asks respondents to evaluate these “sets”, which each contain different bundles of ecosystem services.	Respondents’ preferences for conservation, recreational facilities, and educational attributes of natural woodlands.
Value transfer approaches			
Meta-analysis		This technique takes the result from a number of studies and analyses in such a way that the variation in value of ecosystem services obtained in those primary studies can be explained.	Analysis of many primary contingent valuation studies for woodlands to derive the trends in the key variables affecting visitor WTP values for woodlands, to establish a suitable variable for adjustments for the site to be assessed.

Source: adapted from WBCSD (2009)

The monetary valuation exercise of the present report is based on the application of an integrated, hybrid valuation model. It is *integrated*, because the model is characterized by an integrated use of both of biophysical and economic valuation models and *hybrid* because the model consists of alternative economic valuation techniques to estimate various ecosystem goods and services (see Figure 2.3), including market price analysis methods, cost assessments methods and meta-analysis-based value transfer methods. These techniques are most appropriately applied in the context of regional or national scale ecosystem changes, disaggregated by sector or market. The use of the techniques in isolation (sometimes referred to as ‘bottom-up studies) is predicated on an assumption that any incremental damage in ecosystems will not have large, indirect (non-marginal) impacts, affecting the prices of a range of goods and services that flow through the macro-economy.

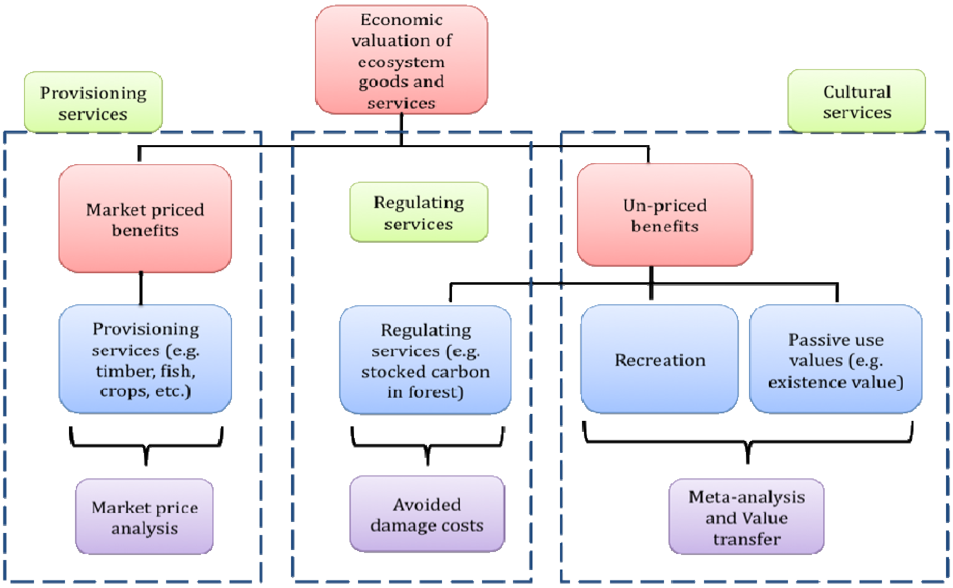


Figure 7.3: A hybrid economic valuation methodology *(adapted from Ding et al. 2010)*

Moreover, Figure 7.3 also shows that benefits derived from ecosystem provisioning services are estimated in terms of direct financial returns from the related economic sectors using ecosystem goods and services as production inputs. Since market information is readily available for these services, a direct market pricing method is used in the valuation exercise. The estimated financial revenues are used as a proxy of annual income of the local population/households, whose livelihoods are directly/indirectly influenced by the ecosystem. As regards the regulating services, such as carbon cycle regulation, there is no market available for trading the service, therefore the damage costs avoided method is applied to value the expenditure saved (thus the benefits gained) from not losing economically valuable assets due to the loss of ecosystem services under social and environmental drivers. Finally, the value of cultural services, which consist of the recreational value and passive–use value of ecosystems, is captured by using revealed preference (e.g. Travel Cost Methods and Hedonic Pricing) or stated preference methods (e.g. Contingent Valuation Method and Choice Experiment) in a surrogate market. However, given the limited resources available for the present study, no original valuation studies using revealed and stated preference methods were conducted. Instead, a meta-analysis based value transfer method is used to estimate the WTP for receiving or increasing cultural services provided by ecosystems.

We shall present the empirical application of the hybrid valuation model for three ecosystems, including forest, wetlands/freshwater and marine/coastal systems in 32 European countries, including (1) Mediterranean Europe - Greece, Italy, Portugal, Spain, Albania, Bosnia and Herzegovina, Bulgaria, Serbia and Montenegro, Turkey; (2) Central and Northern Europe - Austria, Belgium, Denmark, Estonia, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Switzerland, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, United Kingdom; (3) Scandinavian Europe - Finland, Norway, Sweden. This will allow us to evaluate the potential of these in terms of respective (market and non-market) support to human livelihoods.

7.4 Spatial Mapping of Biodiversity Benefits and Rural Vulnerable Groups

Evidence has shown spatial coincidence between ecosystem services and strong dependence of poor rural livelihoods on those services. In other words, strong dependence on natural resources makes the rural poor very vulnerable to any changes in ecosystem and biodiversity. Natural resource degradation and biodiversity loss can affect the poor by affecting the quantity of household consumption derived from natural products and the proportion of wealth generated in ecosystem-related production and employment. Thus, quantification of the contribution of varying biodiversity and ecosystem benefits to the livelihoods of specific vulnerable groups in rural areas is important for better understanding of the social dimension of biodiversity policy, which in turn can help policy makers to identify conservation priorities and to evaluate the effectiveness of biodiversity policy implementation in terms of its ecological and socio-economic effects. In this context, GIS maps can be a powerful tool for investigating the spatial coherence of biodiversity and rural vulnerable groups and identifying cost-effective policies that halt biodiversity loss and reduce poverty. Spatial mapping requires both data quality and quantity. In the present study, we explore the best country data available for all European countries under consideration for describing (1) the socio-economic characteristics, (2) the value of ecosystem goods and services, and (3) biodiversity conditions. More specifically, we will explore the use of a set of indicators to evaluate and map all three abovementioned aspects in a spatial gradient, so that we are able to identify and analyze the strength of the linkage between biodiversity and human livelihoods at different geographic locations. Furthermore, a qualitative analysis of case studies selected from the rest of the world will be conducted to provide evidence that goes beyond the EU geographical scale. The results of this study will provide important insights for the EU to design potential policy instruments that can on the one hand promote biodiversity conservation and prevent natural resources from degradation, and on the other hand contribute to social stability and human livelihoods (e.g. increased number of jobs in the protected area and/or ecosystem-related economic activities).

8 THE ECONOMICS OF BIODIVERSITY AND THE RURAL POOR IN EUROPE

8.1 The Evidence of the Rural Poor and the Richness of Ecosystem and Biodiversity Resources

The World Bank estimates that 70 percent of the world's poor live in rural areas (UNDP, 2004), which by OECD definition are usually characterized as large and isolated areas of an open country, often with low population density around 150 inhabitants or below per square kilometre. The livelihoods of the rural poor are often strongly dependent on biodiversity and natural resources in both monetary and non-monetary terms, but the level of the dependency varies across regions. In particular, the strength of the link between biodiversity and local livelihoods depends on (1) the local economic, social and cultural profiles of the economic agents, notably among households; (2) the degree of access to economic endowments such as land, labour and capital; as well as (3) the local people's motivations and working skills related to income generation activities (Kamagna, et al., 2009). Empirical evidence has shown a spatial coincidence of poverty and ecosystems in many regions, in particular in the developing world (Chomitz and Nelson, 2003; Müller et al., 2006 and Dasgupta et al. 2005). In other words, ecosystem rich areas tend to be associated with a high degree of poverty. This is mainly because poor households depend more directly on natural resource based activities, e.g. timber production and fishery, which contains relatively low value, compared to those higher added value industries developed by wealthy households and communities (Byron and Arnold, 1999; Ruiz Perez and Arnold, 1996; Cavendish, 2000; Vedeld et al., 2007). Therefore, the precarious economies of many rural livelihoods are often prone to various environmental risks, such as drought, floods and climate change. Moreover, the rural poor also benefit directly from ecosystem services (including regulating and supporting services) that cannot be monetized but are essential to safeguard the living environment from environmental risks and to the continued provision of resources for basic human needs and economic production.

In most rural areas, incomes from environmental sources contribute substantially to the local livelihoods, in particular in developing countries, where as much as 20-25% of rural people's income may be derived from environmental resources (Freudenburg, 1992; Sunderlin et al., 2007; Vedeld et al., 2007; WRI, 2005). More specifically, it is estimated that 35% of the total income of rural households in communal areas of Zimbabwe originates from environmental products (Cavendish, 1999); 30% of household income in rural Malawi is accounted for by forest income (Fisher, 2004); 39% of average household income in the Dendi distribute of south-western Ethiopia comes from forest income (Getachew mamo et al., 2007); and an average of 17-45% of household earnings across four Amerindian villages in the Bolivian lowlands and eastern Honduras is generated from forest activities (Godoy et al., 2002). In the EU, however, the percentage of employment strongly depending on biodiversity is much lower than those of the developing countries. For instance, about 6.2% of total employment in the EU is recorded in agricultural and forestry sectors. But in the developing economies, the agricultural and forestry sectors combined account for 34.4% of total employment (see Table 4.1 in *Chapter 2*).

As far as biodiversity is concerned, the selection of appropriate biodiversity indicators is essential for analyzing the patterns of spatial association between the location of the rural poor and distribution of biodiversity and ecosystems. Studies on the spatial coincidence of poverty and ecosystems show that in remote areas low poverty density in terms of absolute number of poor in the area is associated with high ecosystem coverage and abundant biodiversity resources (Sunderlin et al. 2007). In particular, there is strong evidence for supposing that many of the poorest of the poor in developing countries live in or near forested areas. For instance, in India, the greatest poverty is experienced among the people in forest-based economies. In the case of Europe, the South and East of the EU are also richer in biodiversity and natural resources, as many least developed areas are located in remote regions, where forests still remain pristine and unreachable from human economic activities. The next chapter will test the spatial coincidence between biodiversity richness, value of ecosystem services and rural vulnerable groups in an EU context, by exploring empirical data and GIS mapping techniques.

8.2 Identification of the Rural Poor in Europe

Poverty is multidimensional and encompasses inability to satisfy basic needs, lack of control over resources, lack of education and skills, poor health, malnutrition, lack of shelter, poor access to water and sanitation, vulnerability to shocks, violence and crime, lack of freedom and powerlessness. In most world areas, the poorest people of a country are often the indigenous people or ethnic minorities who live in a remote location or on the marginal lands of rural areas, relatively far from essential elements of the modern economies, such as big cities, large paved roads and ports. Whereas in Europe, rural poverty is practically nonexistent in the EU and in Northern Europe, where 25-40% of total population is rural. However, poverty in Europe is on the rise due to the extension of new member states in Central and Eastern Europe. For instance, in Romania and Bulgaria, almost 40 per cent of the poor people are the Roma community, who are among the poorest people in Europe. More than eight out of ten in the Republic of Moldova live below the two-dollar-a-day poverty line, many of them in rural areas[88].

In many rural areas of the number member states, poverty has increased as a result of privatization of former collective and state farms after the collapse of the former communist system, leaving rural workers unemployed and with few opportunities for alternative employment. In particular, lack of local employment, distances from the markets of Western Europe, and scarcity of land and plot fragmentation are key factors that determine the rural poverty in the region and result in a flow of rural migration to urban areas in search of jobs and services (IFAD, 2002). In response, the EU has earmarked a significant part of its common budget for development of the least advantaged rural areas within new member states in Eastern Europe.

One way of measuring rural poverty is to use income indicators and employment occurred in the natural resource based sectors, such as agriculture, forestry and other primary sectors, which plays a more significant role in the livelihoods of poorer economies in Europe. In fact, if comparing the rural economies across different countries in Europe, one can find a downward trend of the employment rate in these sectors along with the growth of rural economy. For instance, the South and East of the EU have higher proportion in employment in the primary sector, accounting for over 25%, more than an average of 10% among all member states (COM, 2006). In addition, it is important to note that non-market benefits of biodiversity and ecosystems, such as food, fuel, erosion control, pollination and so on play a more significant role in the livelihoods of poorer European economies, such as the Roma community, who live directly on the natural resources but lack of assets to cope with changing environment and losing biodiversity. Therefore, to better understand the strength of link between poverty, biodiversity and ecosystems, it is an essential step to estimate the total benefits that biodiversity and ecossytem can provide to human wellbeing. In this regard, a detailed illustration of the economic valuation exercise has been conducted for three selected ecossytems in Europe. The magnitudes of ecosystem benefits are reported in section 8.4 by the type of ecosystems and services for each European country under consideration.

As for the socio-economic characteristics of all European countries under consideration, we selected four main indicators to measure the countries' income level and importance of their rural economy: including GDP per capita (2007US$, PPP), agriculture added value over GDP, unemployment rate (% of population aged 15 and over, 2007) and rural population (% of total, 2007). Table 8.2 summarises the key socio-economic indicators adopted in this study. As one can see, the countries in the EU are not homogeneous with respect to the average income levels. For instance, the GDP per capita in the European countries considered in this study ranged in 2007 between $82,480–$103,042 in, respectively, Norway and Luxembourg, and $5,163–$7,703 in Bulgaria and Romania. Such disparities are captured in the OECD classification of economies, which identifies three distinct groups: high-income, middle-income and low-income[89]. Non-OECD countries are classified based on the relative value of GDP per capita in 2007 as middle-income economies (Slovenia) or low-income economies (i.e., Bulgaria, Croatia, Estonia, Latvia, Lithuania, and Romania). The unemployment rate provides some insights on a country's social stability and the size of rural population is an important demographic indicator for calculating population density and income disparities between the rural and urban areas. Moreover, the table also shows that an average of nearly 40% of the population in the selected Eastern and Southern European countries are rural, with agriculture added value over GDP doubled compared to those of the industrialized northern and western zones of Europe.

Finally, agriculture added value over GDP is an important socio-economic indicator for measuring the extent to which a nation's economy can depend on its primary products - raw materials extracted from land and ocean. It refers to the net outputs of primary sectors - including forestry, hunting, and fishing, as well as cultivation of crops and livestock production - after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. Apparently, this indicator embraces all kinds of agricultural products that are traded in the marketplace. The economic dependence of less developed economies on natural capital is considered more significant than those in the developed countries because the economic structure of the former is based on the production and export of primary products, which are characterised by high labor intensity production, but low technical inputs. Thus in Table 8.2, a high value of this indicator is found to correspond to poorer economies in the low-income category, while low value of the same indicator falls between high- and middle- income categories. In other words, high agriculture added value over GDP indicates that the country's economy depends largely on the quantitative extraction of natural resources, which in turn suggest that these economies appear more vulnerable to the changes in biodiversity and ecosystem services provided.

Vulnerability is a measurement of the societal resistance or resilience of rural communities to the loss of biodiversity and ecosystem services, reflecting their inability of adapting to any shocks and damages (e.g. climate change, floods and drought) to the natural resources on which their livelihoods depend. High vulnerability arises in the rural communities whose livelihoods are directly extracted from the sale of primary resources (farmers, fishermen and foresters) or reliant on the selling of their labour. Moreover, vulnerability may also increase with respect to the increasing remoteness of communities whose potential is limited in terms of their accessibility to markets in big towns/cities, and additional source of income from off-farm employment opportunities in the nearby urban areas. Thus

[88] http://www.ruralpovertyportal.org/web/guest/region/home/tags/europe

[89] The OECD classification distinguishes three income categories as follows: i.e. high-income countries (with a GDP per capita about $29,254 USD), middle-income countries (with a GDP per capita between $19,244 USD and $29,254 USD) and low-income countries (with a GDP per capita lower than $19,244 USD) (OECD, 2010).

the vulnerability of rural poor can be explained by (1) the share of ecosystem benefits in the local GDP and (2) the remoteness of communities from the nearby cities. It is a complementary element to the understanding of rural poverty and will be further discussed in *Chapter 9*, where a spatial mapping of the rural poor and their dependence on varying ecosystem goods and services is of particular importance for directing the EU policy in the least developed economies in the EU. If empirical evidence supports the assumption that a biodiversity rich area is associated with high poverty, then the enforcement of well-defined biodiversity policies are expected to have multiple positive effects in these regions, in terms of reducing natural degradation, improving the living environment of the rural poor, and increasing income and employment opportunities to the local communities.

Table 8.2: Socio-economic status of Europe

		Socio-economic Indicators			
OECD Income groups	Country	GDP per capita (2007US$, PPP)	Agriculture added value over GDP	Unemployment rate, 2007 (% of population aged 15 and over)	Rural population, 2007 (% of total)
High income	Austria	44,879	2%	4.4	33
	Belgium	42,609	1%	7.5	3
	Denmark	57,051	1%	3.8	14
	Finland	46,261	3%	6.9	37
	France	41,970	2%	8.3	23
	Germany	40,324	1%	8.6	26
	Ireland	59,324	2%	4.6	39
	Luxembourg	103,042	0%	4.1	17
	Netherlands	46,750	2%	3.2	19
	Norway	82,480	2%	2.5	23
	Sweden	49,662	1%	6.2	16
	Switzerland	56,207	1%	3.7	27
	United Kingdom	45,442	1%	5.3	10
Middle income	Czech Republic	16,934	3%	5.3	26
	Greece	27,995	4%	8.3	39
	Italy	35,396	2%	6.1	32
	Portugal	20,998	3%	8	41
	Spain	32,017	3%	8.3	23
	Slovenia	23,379	3%	4.8	51
Low income	Hungary	13,766	4%	7.4	33
	Poland	11,072	5%	9.6	39
	Slovakia	13,891	4%	11.1	44
	Bulgaria	5,163	9%	6.9	29
	Croatia	11,559	7%	9.6	43
	Estonia	15,578	5%	4.7	31
	Latvia	11,930	4%	6	32
	Lithuania	11,356	5%	4.3	33
	Romania	7,703	10%	6.4	46

Source: World Bank - World development indicator; UNDP - Human Development Indicator

8.3 Biodiversity Spatial Profile in Europe

In order to characterize the spatial distribution of biodiversity in Europe, we rely on the index of biodiversity described in Wendland et al. (2009). Such index builds upon the information on species ranges of mammals, birds and amphibians from global vector data (Baillie et al., 2004; BirdLife International, 2006; IUCN, 2006) and combines it in a single index by weighing species ranges by their threat status as defined by IUCN's Red List (IUCN website, 2007). The technical details on the weighing procedure and construction of the aggregated index are given in Wendland et al. (2009). The final index is presented in a 30 arc second grid (approximately 1 km at the equator) and is mapped globally. In Figure 8.1, we present the distribution of the biodiversity index within Europe.

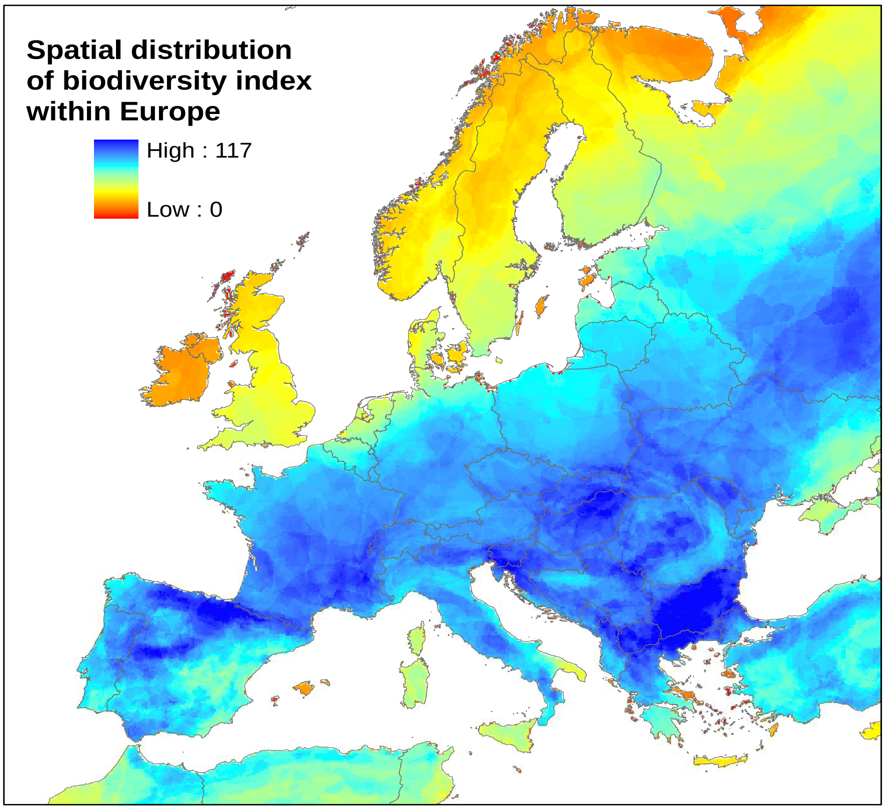


Figure 8.1: Distribution of terrestrial biodiversity within Europe *(based on Wendland et al., 2009)*

Figure 8.1 shows that terrestrial biodiversity is distributed unevenly in Europe. North European countries including Scandinavia, United Kingdom, and Ireland are characterized by relatively low biodiversity. The highest values of terrestrial biodiversity within Europe are found in East European countries, notably Bulgaria and Slovakia, and in the Northern regions of Spain. Within some countries there is an important range of variability in the index. For instance, in Italy high values of the biodiversity index are to be found in mountainous regions in the Alps and Apennines, while low-lying regions and, particularly, islands present lower values of the index. It is important to notice that, at a global scale, European countries score rather poorly in the biodiversity index compared to biodiversity hotspots in South America, Africa and South East Asia where the highest values of the index are found (up to 407).

Table 8.3 below summarizes the information on various biodiversity indicators assessed at country level. The data on the number of known bird, mammal, reptile, and vascular plant species were gathered from UNEP-WCMC (UNEP, 2004) and are compared to the average score of the biodiversity index by Wendland et al. (2009) for each European country. Overall, the highest biodiversity in terms of number of species of birds, mammals, amphibians, and vascular plants is found in France, Italy, and Spain. All three countries are characterized by a relatively high value in the biodiversity index. It is reminded that the index is not constructed only based on the number of species but also on their threat status as defined by IUCN's Red List. Despite the smaller range of species, several Central and East European countries (e.g., Bulgaria, Macedonia, Slovenia) are characterized by a higher score in the biodiversity index. On the lower side of the range, countries such as Estonia, Ireland, Lithuania, Luxembourg and Latvia present the smallest range of animal and plant species. Ireland also has the lowest values among the considered countries for what concerns the biodiversity index. Notably, the United Kingdom is characterized by the largest number of known bird species but shows a relatively low diversity in reptiles and vascular plants and is characterized by a low value of the biodiversity index.

Table 8.3: Biodiversity indicators for Europe

Country	Bird species (number)[1]	Mammal species (number)[1]	Reptile species (number)[1]	Vascular plant species (number)[1]	Biodiversity index[2]
Albania	303	73	37	3031	76.29
Austria	412	101	16	3100	76.52
Belgium	427	92	12	1550	62.13
Bulgaria	379	106	33	3572	91.31
Bosnia-Herzegovina	312	78	27	-	77.69
Switzerland	382	93	17	3030	77.35
Czech Republic	386	88	11	1900	76.60
Germany	487	126	15	2682	68.99
Denmark	427	81	8	1450	36.50
Spain	515	132	67	5050	70.81
Estonia	267	67	6	1630	54.85
Finland	421	80	5	1102	39.70
France	517	148	46	4630	76.46
United Kingdom	557	103	16	1623	34.73
Greece	412	118	63	4992	62.74
Croatia	365	96	34	4288	76.90
Hungary	367	88	18	2214	84.62
Ireland	408	63	6	950	22.93
Italy	478	132	55	5599	67.14
Lithuania	227	71	6	1796	67.32
Luxembourg	284	66	9	1246	71.94
Latvia	325	68	7	1153	60.33
Macedonia	291	89	29	3500	89.93
Netherlands	444	95	13	1221	49.16
Norway	442	83	7	1715	29.65
Poland	424	110	11	2450	70.82
Portugal	501	105	38	5050	68.75
Romania	365	101	22	3400	78.36
Serbia and Montenegro	381	96	35	4082	81.01
Slovakia	332	87	14	3124	83.67
Slovenia	350	87	29	3200	85.71
Sweden	457	85	7	1750	34.14

[1] Source: UNEP-WCMC (2004)
[2] Estimated by the authors based on the index in Wendland et al. (2009)

8.4 The Value of Ecosystems in Europe

This section reports economic values provided by a number of key ecosystems in Europe, including forest ecosystems, marine/costal ecosystems and freshwater/wetland ecosystems. The numeric valuation results will allow us to explicitly infer their magnitude in terms of their contribution to human wellbeing and therefore to the support of human livelihoods. In this context, this valuation exercise becomes of particular interest since it will shed light on the identification of the impacts of losing biodiversity and ecosystem services on vulnerable groups, including the rural poor. In addition, economic valuation also builds the basis for designing policy instruments that enhance the current allocation of market driven resources, improve the environmental sustainability of economic activities as well as contribute to a reallocation of resources from the high- and middle-income countries, where environmental costs arise overwhelmingly to the low-income countries, which bear the most consequences of resource degradation. In other words, the effort of making the values of biodiversity and ecosystem services explicit will contribute to reaching the United Nations' Millennium Development Goals (MDGs), including alleviating poverty, enhancing social structure and creating jobs.

Therefore, valuing ecosystem services, understanding their contributions to human livelihoods and identifying the beneficiaries and relevant stakeholders is important for any policy design targeted at (1) halting biodiversity degradation, (2) correcting the externalities, (3) compensating the losers of biodiversity loss, (4) creating incentives to more effective conservation of biodiversity, and (5) ultimately sustaining the long-term local economic development and human well-being, In conclusion, notwithstanding the direction of causalities, it is the poorer segments of society that are both assumed to be most vulnerable to, and affected by, biodiversity degradation.

The three ecosystems are valued in terms of three types of ecosystem service defined in the MEA report (2005), including provisioning services, regulating services and cultural services. The valuation exercise is conducted using a hybrid economic valuation methodology, which combines the use of alternative valuation techniques, depending on the type of ecosystem under consideration. In this study, data are taken from various sources. Bio-physical data regarding the land-use changes and quantity of various forest products and carbon stocks are taken from FAO (2005). Economic valuation databases (such as EVRI) are surveyed to select original non-market valuation studies for meta-analysis and value transfer. The numeric value of three ecosystems is estimated by type of ecosystem services and expressed in 2005 US$. Economic value of ecosystem is reported in Table 8.5, 8.6 and 8.7 below (For details about valuation techniques, see Annex F).

The Economic Value Provided by European Forest Ecosystem

In Europe, more than 185 million ha are covered by forestland, which accounts for 32.7% of the territories combined. Forests are important ecosystems in Europe, in terms of their essential role in supporting ecosystem functioning and the diversity of biological species, stabilizing carbon sequestration and preventing soil erosion, etc. In addition, forest ecosystems provide various goods and services for direct human consumption and as inputs to other economic activities, such as timber production and tourism industries, which contribute substantially to household income. The present study covers the value of forests in total 34 European countries.

Table 8.5 shows the weight of ecosystem service values in a country's total forestry benefits may vary depending on the type and extent of the forests in the country as well as the ecosystem services under consideration. Finally, the last column of the table calculates the aggregated economic value that each European country can get from their forest ecosystems. Not surprisingly, highest aggregated economic values are mostly found in forests located in Central - Northern European countries which host (a) the largest forest areas, (2) the higher number of households, and (3) high rates of forest recreation. In addition, high values are found also in two eastern European countries, Poland and Romania, due to the rich forest resources and large forest areas found in these countries. For an aggregated perspective, we can see that the biodiversity benefits from European forests are mainly concentrated in the regulating services, which count for about half of the total value. Cultural values amount to 5% and the provisioning services 45%. In addition, if we take a closer look into the cultural value component, we can see that Germany, Italy, Spain, France, UK and Poland are the countries that show the highest economic values on this component. However the relative value composition is not the same among those countries.

Table 8.5: Economic values derived from three forest ecosystem services in Europe

Country	Regulating Service (2005 Million US$/yr)	Cultural Services (2005 Million US$/yr)	Provisioning services (2005 Million US$/yr)	Total (2005 Million US$/yr)
Albania	305	0.3	6	1,300
Austria	4,451	91	5,990	24,949
Belgium	344	75	4,807	6,339
Bosnia&Herzegovina	839	0.2	202	3,761
Bulgaria	1,393	40	256	6,200
Croatia	2,721	8.2	343	11,884
Czech Republic	3,375	73	1,568	15,946
Denmark	296	57	465	1,776
Estonia	1,465	2.3	510	6,723
Finland	4,913	3.3	12,067	32,897
France	8,137	831	7,204	42,529
Germany	5,933	2,440	16,636	44,228
Greece	1,442	89	141	6,341
Hungary	2,518	107	693	11,474
Ireland	370	0.03	506	2,072
Italy	6,557	1,734	3,225	32,753
Latvia	1,887	1.1	977	8,976
Lithuania	1,347	7.8	354	6,069
Luxembourg	111	5.2	216	691
Netherlands	249	166	3,693	4,915
Norway	3,744	1.2	1,863	17,737
Poland	11,714	224	2,127	52,007
Portugal	802	42	1,859	5,302
Romania	8,118	143	848	35,403
Serbia&Montenegro	1,035	0.3	137	4,525
Slovakia	2,458	35	1,025	11,481
Slovenia	1,611	17	684	7,529
Spain	5,078	1,034	3,337	25,897
Sweden	8,371	149	13,200	48,834
Switzerland	1,416	46	2,003	8,050
Turkey	3,909	0.02	256	16,827
United Kingdom	1,967	734	2,665	11,739

As we can see, in Germany, forests are predominantly producing provisioning services. In fact, in this setting Germany is the country that has the strongest profile of provisioning services. On the other hand, Poland has the weakest profile in forest provisioning services. However, Poland has the strongest profile with respect to regulating services. Italy, France and Spain do not have any predominant profile with respect to any of the forest ecosystem services but show the strongest balance in terms of distribution of the economic value for each of the three dimensions under consideration. Finally, the UK show a profile closer to the France/Spain/Italy rather than Germany or

Poland. In any case, the intensity of the forest values produced in the UK when compared to France/Spain/Italy are weaker: the UK profile lies inside all the individual maps of France/Spain/Italy.

In addition, we can also explore the use of GIS tools so as to map the economic values of forest ecosystem services – see Figure 8.2.

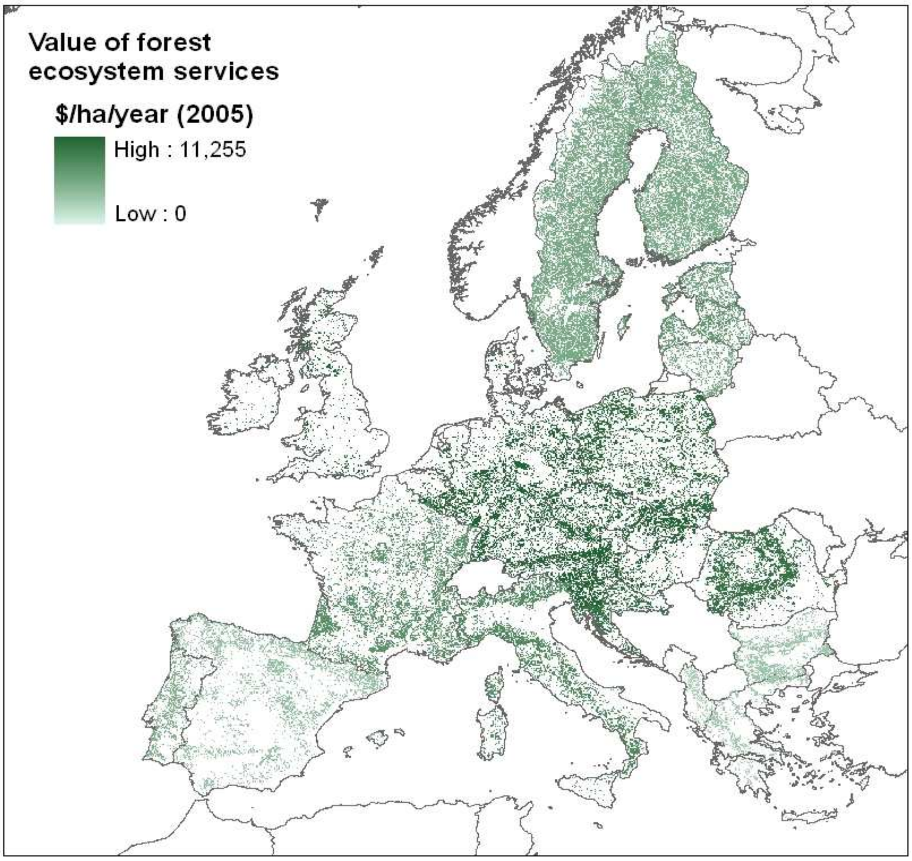


Figure 8.2: The productivity value of per hectare forests in Europe

The GIS map is created based on the geographical distribution of forests in Europe as identified in the Corine land use map. Within each country, the average per hectare values estimated in the economic valuation analysis described in this section are distributed over the forest grid cells in Corine, with a 100x100 meter resolution. These maps provide detailed information with respect to the spatial distribution of the economic values. Whereas Spain and France show again similar profiles, which are characterized by a balanced distribution of the values at stake, respectively provisioning, regulating and cultural, UK is the country with the highest forest productivity in terms of cultural values. Germany and Italy are the second and third most productive European forests, again when measured in terms of cultural values.[90] For regulating services, all the countries show similar profiles where the differences account the differences of the forest type and geographical locations.

The Economic Value Provided by European Freshwater Ecosystem

Freshwater ecosystems have long been recognized as sources of important services and goods for humans. The range of benefits encompasses provisioning of goods such as water, fuel wood, materials, and fish for commercial exploitation, regulating flood events and water quality processes,

90 The Netherlands is the most productive country in terms of cultural values provided by forests, well ahead the UK.

providing the setting for recreational activities and amenity values, and supporting a rich biological diversity. Both the level of provisioning of ecosystem services and their impact on human welfare are threatened by a series of environmental stressors, such as habitat conversion and climate change, which have a potential to affect the ecological equilibriums services rely upon and the patterns of human exploitation.

The review of literature shows that ecosystems located at temperate Northern latitudes between 35°N and 45°N provide statistically higher values than e cosystems at higher latitudes, in proximity of the Equator or at temperate climates in the Southern hemisphere. The average size of freshwater ecosystems in European countries was derived from Brander et al. (2008), who created a dataset of 50,533 individual European coastal and freshwater wetlands with GIS analysis from the Corine land cover.

Table 8.6: Estimated value of freshwater ecosystem services in Europe

Country	Mean value [$/ha year]	Total area [ha]	Aggregated value [Million US$2003/year]
Austria	17,969	95,685	1,719
Belgium	113,286	24,762	2,805
Bulgaria	69,497	111,972	7,782
Croatia	166,508	71,551	11,914
Czech Republic	14,589	60,688	885
Denmark	11,266	90,495	1,020
Estonia	1,205	396,919	478
Finland	1,779	5,396,898	9,599
France	10,851	400,351	4,344
Germany	14,935	518,158	7,739
Greece	81,645	132,851	10,847
Hungary	5,867	279,976	1,642
Ireland	9,155	1,271,368	11,640
Italy	200,278	233,984	46,862
Latvia	2,396	272,944	654
Lithuania	1,789	182,333	326
Luxemburg	121,994	733	89
Netherlands	20,734	226,065	4,687
Norway	3,672	1,005,407	3,692
Poland	6,150	556,487	3,423
Portugal	275,265	55,567	15,296
Romania	4,495	683,155	3,071
Slovakia	12,728	30,435	387
Slovenia	30,095	10,307	310
Spain	117,314	342,307	40,157
Sweden	5,926	6,523,231	38,658
Switzerland	19,624	52,326	1,027
UK	8,819	747,987	6,596

To aggregate the values at country level we multiplied the per hectare values estimated for each country with the benefit transfer exercise by the total area of freshwater ecosystems in the investigated countries. Since the Corine dataset provides a more refined land use classification for European countries, the total area for the aggregation of the values was estimated based on the categories of inland marshes, peatbogs, water courses and inland water bodies in the Corine classification. Table 8.6 presents the mean value per hectare, the total area per country and the estimated aggregated value of ecosystem services provided by freshwater ecosystems for each of the 28 European countries.

On average, Mediterranean countries (Italy and Portugal in particular) show high mean values per hectare. This is partly due to the relative scarcity of freshwater ecosystems compared to Northern European countries. Countries with high population density such as Belgium or high values of GDP per capita such as Luxembourg also show high values. The lowest mean values per hectare are found in Scandinavian countries and Ireland, i.e., where the largest total area of freshwater ecosystems is concentrated and population density is low. We estimate thus that the highest aggregated values are in countries with high mean values per hectare, such as Italy and Spain, or with very large total ecosystem areas, such as Sweden. Despite the large area in Finland and Norway, the aggregated values for these two countries are relatively low.

To investigate the spatial distribution of values within each country, we combined the results of the meta-analysis and value transfer exercise with the information on land use from the Corine land use map. The spatial location of inland wetlands and freshwater ecosystems is identified and the average per hectare value estimated with the meta-regression is attributed to each pixel according to the country where the pixel is located. Since the resolution of the Corine map is 100 m x 100 m (i.e., every grid cell has an extension of one hectare), the value thus attributed coincides with the yearly flow of value from each grid cell. The distribution of values thus obtained is presented in Figure 8.2.

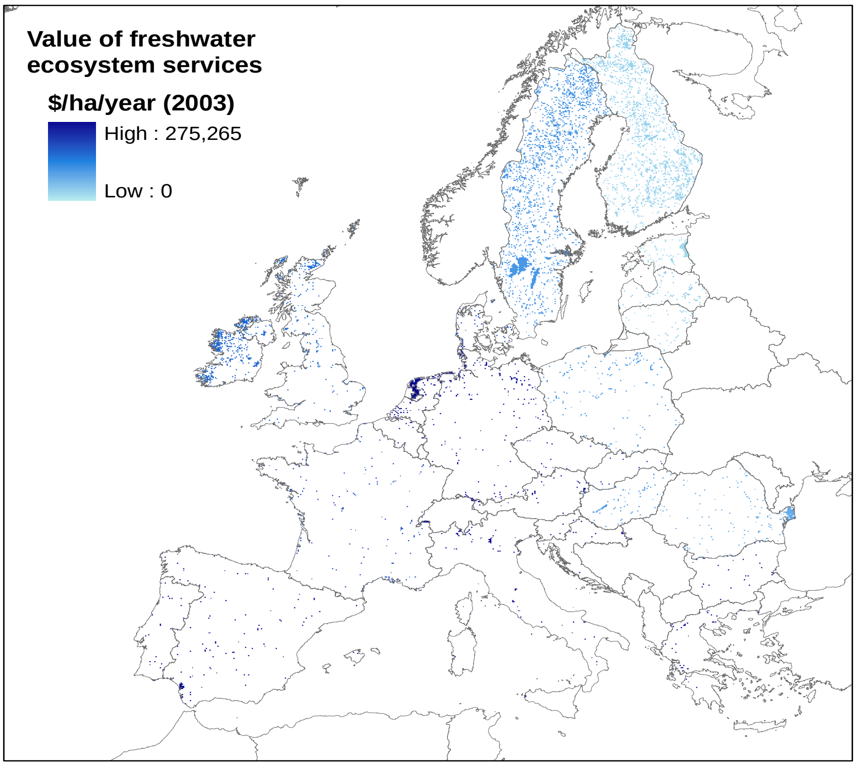


Figure 8.3: The distribution of values of freshwater ecosystem services in Europe

Figure 8.3 illustrates how the spatial distribution of economic values does not necessarily follow the geographic distribution of freshwater ecosystems. While most freshwater ecosystems are concentrated in North Europe (i.e., in Scandinavian and Baltic countries, United Kingdom, and Ireland), such sites are characterized by low per hectare values (bright blue in the map). Ecosystems with substantially higher per hectare values are scattered in Southern European and Mediterranean countries (dark blue in the map).

The Economic Value Provided by European Coastal and Marine Ecosystems

Marine and coastal areas host biodiversity-rich ecosystems that are among the world's most valuable. Apart from their ecological value, coastal ecosystems deliver a series of goods and services that are of benefit to humanity. These include cultural values that support tourism and recreational activities such as beach leisure (Bin et al. 2005; Freeman III 1995), wildlife watching (Loomis et al. 2000), diving (Depondt & Green 2006), bathing (Georgiou et al. 1998) recreational fishing and boating (Freeman III 1995). Market failures induced by the public good character of many of the aforementioned goods and services or from ill-defined property rights result in many of the benefits delivered by coastal and marine ecosystems being overlooked in the policy-making process. While the number of published primary valuation studies focusing on the cultural values of marine and coastal ecosystems is rapidly growing, there is still a limited understanding of what the principal drivers of coastal recreation values are and how human welfare may be affected by disappearance of habitats and species due to anthropogenic pressure and shifting environmental conditions (Brander et al. 2007; Liu & Stern 2008).

Table 8.7: Values of context variables in baseline year regression (2003)

Country	Population density, inhab./km^2	GDP per capita, US$	Number of birds species	Number of threatened bird species	Min monthly temperature, °C	Max monthly temperature, °C
Belgium	340.81	32,808	427	10	2.12	16.94
Bulgaria	69.78	9,354	379	11	-3.14	21.82
Croatia	80.49	13,342	365	9	-2.45	19.90
Denmark	125.70	34,669	427	10	-1.32	15.13
Estonia	29.71	16,127	267	3	-15.36	15.20
Finland	15.59	32,678	421	10	-15.47	12.09
France	111.49	29,276	517	15	3.17	17.56
Germany	231.50	29,550	487	14	-1.53	17.29
Greece	84.13	24,399	412	14	12.90	24.11
Ireland	58.95	41,492	408	8	2.05	13.97
Italy	194.69	29,502	478	15	10.06	20.89
Latvia	35.64	13,540	325	8	-15.36	15.20
Lithuania	52.45	14,569	227	4	-9.11	15.91
Netherlands	393.20	33,198	444	11	5.99	14.58
Norway	14.31	41,630	442	6	-10.19	11.14
Poland	122.15	13,741	424	12	-5.22	17.58
Portugal	114.97	21,791	501	15	5.52	20.38
Romania	90.73	9,056	365	13	3.68	15.05
Slovenia	98.62	22,261	350	7	-2.45	19.90
Spain	85.96	26,296	515	20	3.69	20.87
Sweden	20.09	32,325	457	9	-0.40	4.37
UK	246.08	33,314	557	10	2.07	14.75

The value of WTP per person per year for coastal recreational activities for 22 European countries during the baseline year 2003 was estimated using meta-regression based value transfer method. The calculated values reflect the total WTP for the provision of recreational services. Values are calculated for a generic coastal ecosystem. The value of the context variables during the baseline year is illustrated in Table 8.7.

Table 8.8 presents the mean baseline values of WTP per person per year and the aggregated values of coastal recreational activities in the 22 European countries investigated. The total number of visitors per year represents the total number of domestic and international tourist arrivals in coastal NUTS2 regions in each of the considered countries, as estimated by Eurostat (2010) for year 2003.

The highest WTP per person per year is found in the Mediterranean countries, Greece and Italy in particular. This is partly due to the fact that both minimum and maximum yearly temperatures are observed to be positively correlated with the values of WTP per person per year. WTP for tourism in Ireland and Norway is also high in spite of the low temperatures compared to Mediterranean countries. This suggests that a different type of tourism may take place there, where climatic conditions are less crucial and tourists may be willing to pay more in order to enjoy the values of the natural landscape in a more pristine and less densely populated environment. Finland and Sweden have the lowest values of WTP per person per year, which suggests that in these countries the cold climate plays a crucial role in determining tourist demand.

Table 8.8: Aggregated WTP for coastal and marine recreation in Europe

Country	Average individual WTP [US$ /person year]	Arrivals in coastal NUTS2 (thousands) [a]	Aggregated value [Million US$/year]
Belgium	159.24	1,691	269
Bulgaria	103.58	1,330	138
Croatia	127.07	3,466	440
Denmark	144.73	2,951	427
Estonia	120.48	1,315	158
Finland	74.48	6,256	466
France	172.19	37,298	6422
Germany	110.12	9,385	1033
Greece	447.54	12,019	5379
Ireland [b]	250.55	8264	2071
Italy	282.54	48,662	13749
Latvia	49.70	659	33
Lithuania	104.54	560	59
Netherlands	153.51	9,199	1412
Norway	183.37	9,437	1730
Poland	71.40	975	70
Portugal	204.88	9,619	1971
Romania	70.56	907	64
Slovenia	195.08	1,015	198
Spain	176.64	47,383	8370
Sweden	110.62	12,911	1428
UK	178.24	39,334	7011

[a] Source: Total arrivals of residents and tourists according to Eurostat (2010) and referring to year 2003; [b] Number of arrivals refers to year 2000.

Table 8.8 also provides estimates of the aggregated WTP values for all yearly visitors in the coastal regions of each considered country. High aggregated values are found in Mediterranean countries due to the fact that the estimated individual WTP in those countries is high and the tourism industry particularly developed there. High values are found in particular in Italy, France, and Spain. One of the highest total recreational values is found in the United Kingdom due to the high number of domestic and international arrivals reported for the reference year.

To spatially disaggregate the total values at country level, Figure 8.4 presents the values estimated for coastal NUTS2 regions in Europe. The values are obtained multiplying the individual WTP estimated at country level by the total number of arrivals in each region during year 2003, as reported by Eurostat.

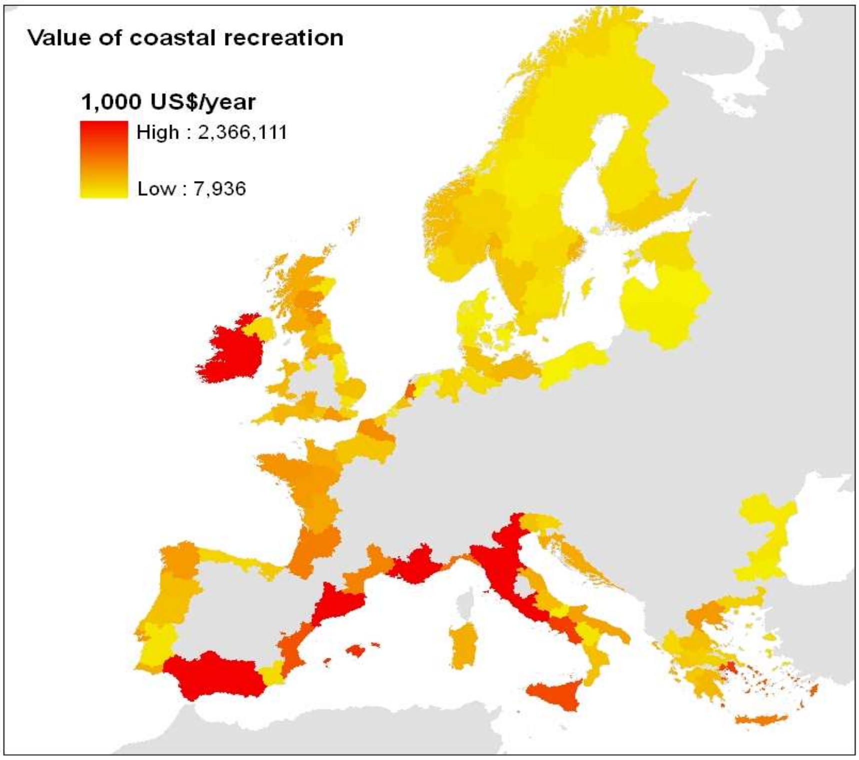


Figure 8.4: Aggregated values of recreation in coastal NUTS2 regions of Europe

The NUTS2 regions with the highest recreation values are those located in the Mediterranean coast of Italy, Spain, and France. Relatively high values are found also in the western coast of France and in the United Kingdom. A high aggregated value is found also for Ireland, although one should notice that due to lack of data relative to the number of visitors in NUTS2 regions of Ireland, it was not possible to disentangle the total country value into smaller units. Low aggregated recreation values are found in the Baltic and Scandinavia countries, and along the Black Sea coastline.

9 DEPENDENCY OF HUMAN LIVELIHOODS ON BENEFITS OF BIODIVERSITY AND ECOSYSTEM SERVICES IN EUROPE

9.1 Introduction

The analysis in the previous sections of this report suggests that environmental income can play a crucial role in the livelihoods of communities in rural and remote locations, especially the poorest. Moreover and despite the fact that biodiversity and environmental conservation policies are mostly advocated in developed economies, larger proportions of the more pristine and less exploited natural resources are found in less developed economies where the resources are and were in the past less extensively exploited to support economic activities.

The purpose of this section is to investigate the links between a country's or region's economy, its biodiversity richness and the provision of ecosystem services. The information on socio-economic indicators and the spatial profile of biodiversity in European countries is combined here with the results of the economic valuation of the ecosystem services provided by European ecosystems discussed in Section 8. The goal is to identify possible patterns in the level of dependency of national and local economies on the benefits of biodiversity and ecosystem services across a range of indicators which are chosen to represent different degrees of economic development and vulnerability. Otherwise stated, the objective of the investigation is to test whether poor and vulnerable rural and remote communities are more strongly dependent on the provision of ecosystem services. In the analysis we strongly rely on Geographic Information Systems (GIS) to integrate different spatial layers of information which are targeted at capturing various levels of socio-economic characteristics of the population, biodiversity richness or economic value of ecosystem services. In the context of GIS mapping, we focus in particular on those vulnerability-related indicators that allow us to look for in detail to the spatial disaggregation of the data. In the following sections, the role of biodiversity and ecosystem services in supporting human well-being is discussed at different geographical scales and for different types of vulnerability in poor economies, rural communities and remote communities.

9.2 Analyzing the Dependency of Human Livelihoods on Benefits of Biodiversity and Ecosystem Services

The analysis of the dependency of human livelihoods on the benefits of biodiversity and ecosystem services is based on the spatial integration of a set of selected indicators and aggregation at an appropriate spatial level. For the visualization of the data spider charts are used, in which each of the axes represents one of the indicators related to either the socio-economic characteristics of the population, biodiversity richness or the value of ecosystem services in the country or region under investigation. In the following, we consider three different types of vulnerability:

(1) Income-related vulnerability, based on OECD classification of European economies;
(2) Vulnerability of rural communities, with a focus on six agricultural NUTS2 regions of Europe that were selected as case-study areas;
(3) Vulnerability of remote communities, with a focus on case-study mountainous areas.

9.2.1 Income-related Vulnerability and the Link to Biodiversity

Household income level is a direct indicator of the current levels of poverty and, bearing in mind that low income communities are generally less resilient to shocks at the community level or at the national and international level, may as well be interpreted as a measure of the risk to fall into poverty or deeper poverty in the future. It can thus provide an indication of the vulnerability of communities to socio-economic or environmental changes at the local or larger scale.

The countries in the European Union are not homogeneous with respect to the average income levels. In Figure 9.1 the average values of the selected socio-economic, biodiversity and ecosystem service value indicators across the three OECD income categories are presented[91]. The socio-economic indicators chosen are the rural population as percentage of the total population, the unemployment rate in 2007 and the added value of agriculture to the country's GDP in 2007. The ecosystem services indicator reflects the total economic value of forests, wetlands, freshwater ecosystems and recreation in coastal areas as elicited in Section 8 over the total GDP of the country. The biodiversity indicator is the country average of the terrestrial biodiversity indicator discussed in Section 8.

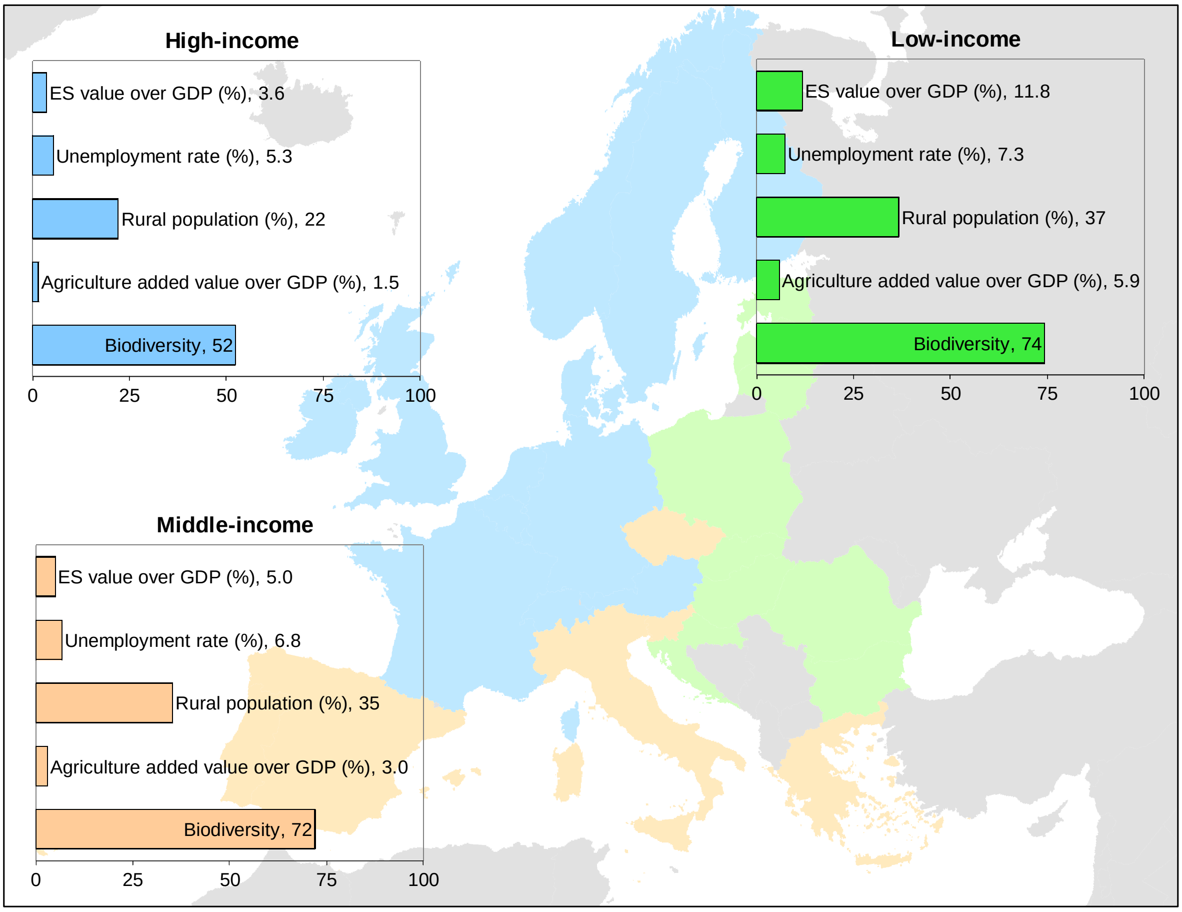


Figure 9.1: Average value of socio-economic, biodiversity and ecosystem service indicators in European countries according to income categories

[91] High income countries in Figure 9.1 are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom; middle-income countries are the Czech Republic, Greece, Italy, Portugal, Spain and Slovenia; low-income countries are Hungary, Poland, Slovakia and Bulgaria.

The results in Figure 9.1 highlight the presence of a correlation between ecosystem services, biodiversity and income-related vulnerability in the selected European countries. Moving from high-income to low-income countries one can note that the values of all socio-economic indicators increase towards higher vulnerability. The unemployment rate increases from 5.3% to 7.3%, the percentage of rural population from 22% to 37% and the dependence of GDP from the agricultural sector increases from 1.5% in high-income countries to 5.9% in low-income countries. High income countries show, however, a lower value of the biodiversity index than low-income countries. The dependence of the latter economies from ecosystem services is, on the other hand, higher. Ecosystem service values account for 11.8% of the GDP of low-income countries while only for 3.6% of high-income economies.

The dependencies between the three dimensions in the individual countries emerge more clearly in Figures 9.2-4 where European countries are grouped according to their income level based on the OECD classification and each of the axes in the spider charts represents one of the indicators. To enhance the readability of the results, the values of the indicators were standardized between 0 and 100, so that for each indicator the highest value on the axis is attributed to the country with the highest value of the indicator and the values for the remaining countries are rescaled accordingly.

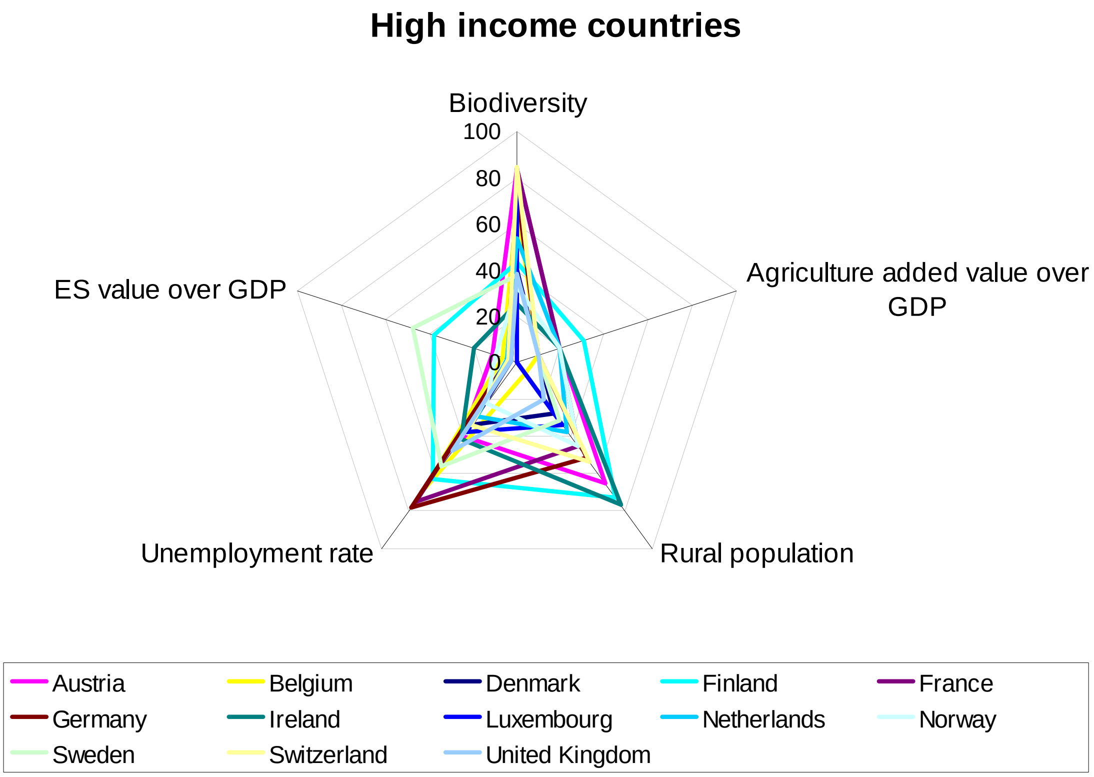


Figure 9.2: Linkage between ecosystem services value, biodiversity and socio-economic indicators in high-income European countries

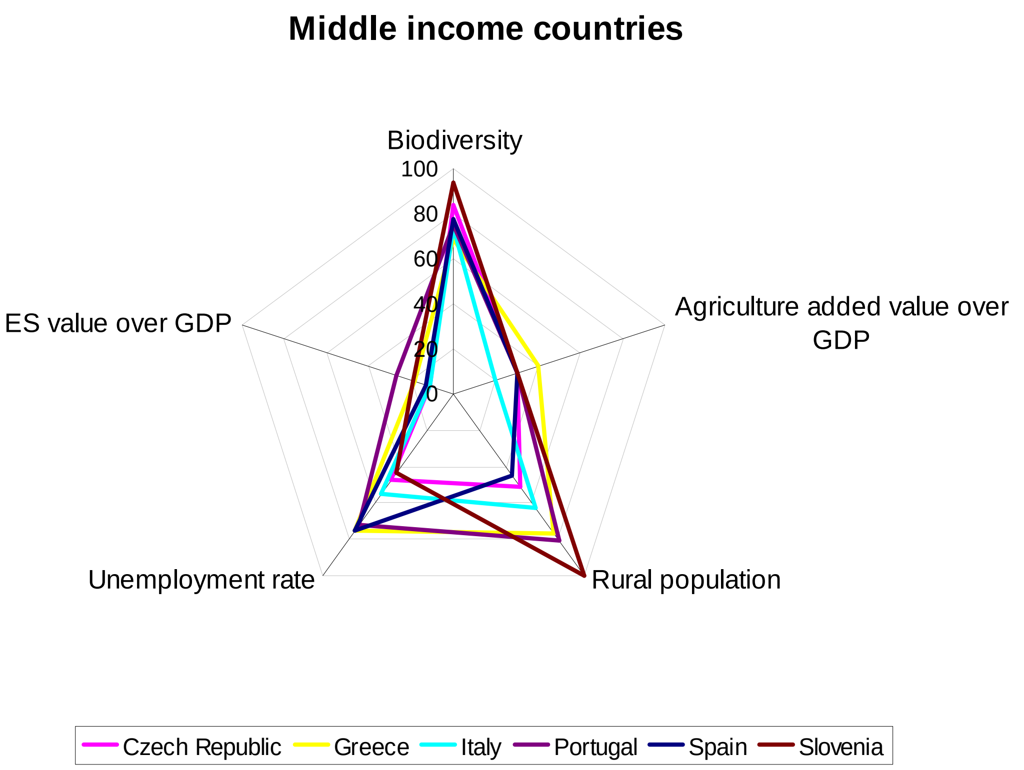


Figure 9.3: Linkage between ecosystem services value, biodiversity and socio-economic indicators in middle-income European countries

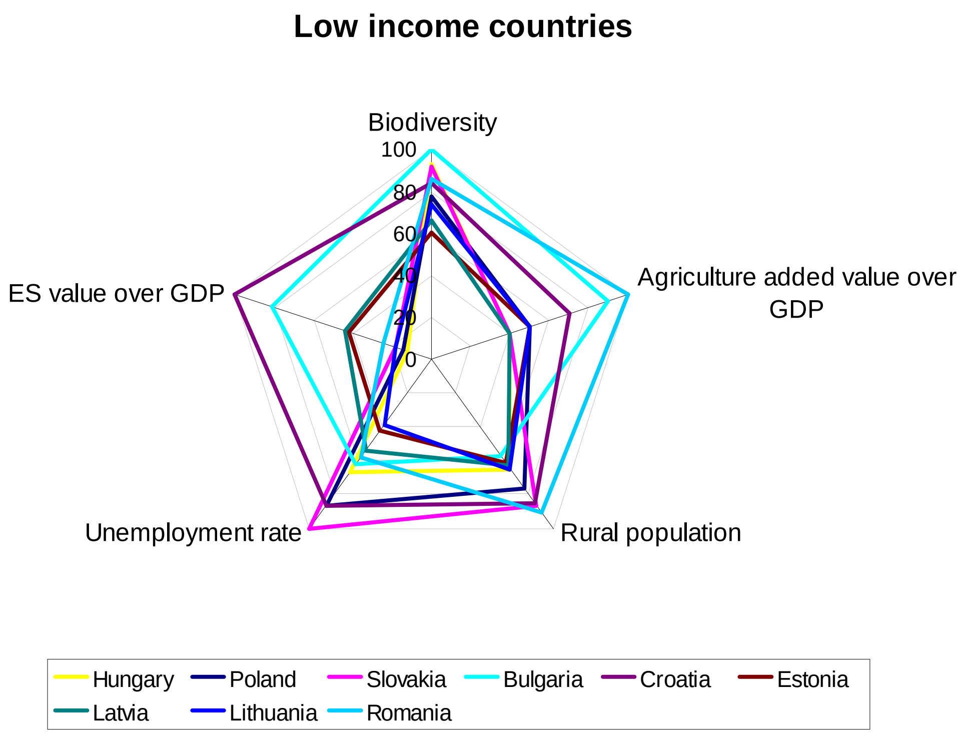


Figure 9.4: Linkage between ecosystem services value, biodiversity and socio-economic indicators in low-income European countries

Figures 9.2-4 identify the possibility contours of human livelihood, biodiversity and ecosystem services in European countries. Among the three income categories, the narrowest boundaries are found in high-income countries. With the exception of Austria, France and Switzerland, the biodiversity levels are lower than the average values in middle- and low-income countries. Moreover, the contribution of agricultural activities to the countries' economy is generally low, with the exception of Finland, where agriculture added value accounts for 3% of the GDP and 37% of the population lives in rural areas. Ecosystem service values generally provide a small contribution to the economy of high-income countries, with the notable exception of Sweden and Finland where they account for 14% and 11% of the country's GDP. In middle-income countries one can notice an enlargement of the boundaries, with the added value of agriculture, rural population and biodiversity levels increasing compared to high-income countries.

The largest possibility contours are found however in low-income countries where the highest levels of agricultural added value (10% in Romania), unemployment rate (11.1% in Slovakia) are found, suggesting a higher vulnerability of these economies to socio-economic and environmental shocks. Significantly, the highest values of biodiversity (91.3 in Bulgaria) and ecosystem service value over GDP (30% in Croatia) are also found in low-income economies. This suggests a large potential for biodiversity, mediated through the provision of ecosystem goods and services, to act as a positive stimulus for the countries' economy, create employment, and contribute to the livelihood and welfare of the populations.

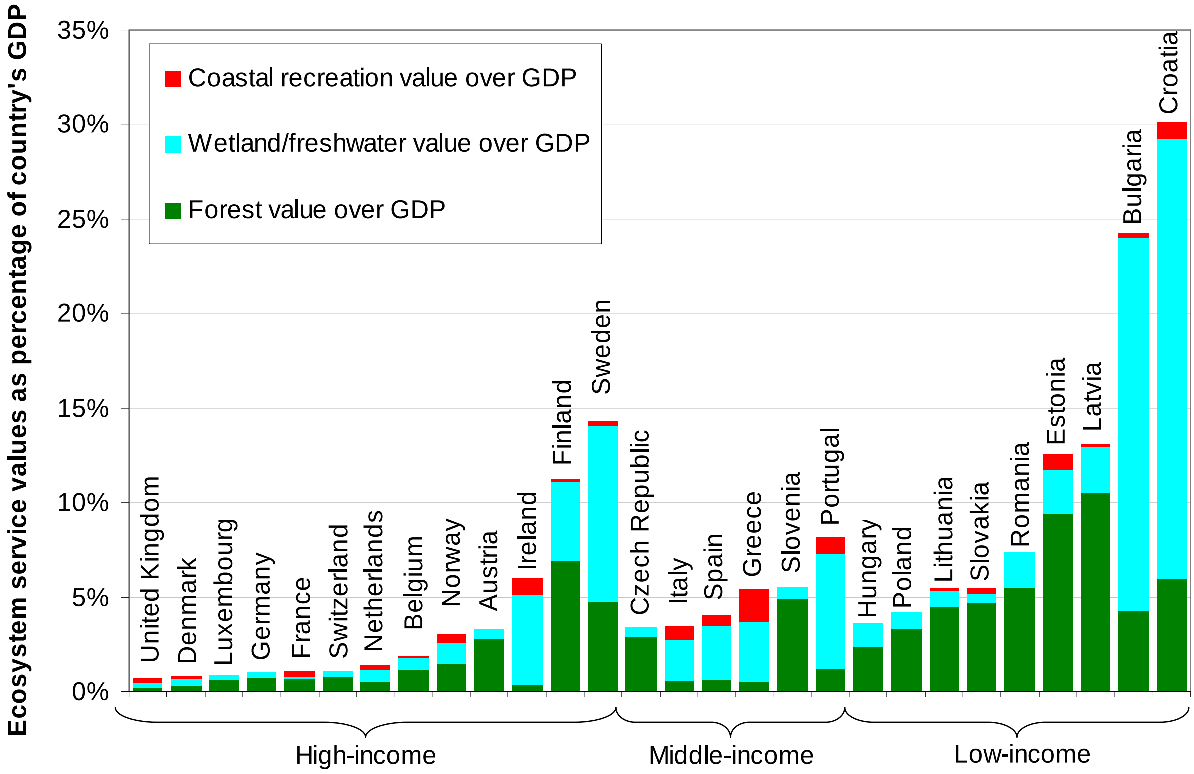


Figure 9.5: Contribution of forests, wetlands, freshwater and coastal ecosystem service values as percentage of country's GDP

Figure 9.5 shows the composition of the ecosystem service value for each European country with the purpose of illustrating how the total values—calculated as percentage of GDP—and their composition in terms of the considered ecosystem types vary across different countries and income categories. The results presented in Figure 9.5 are the results of a partial analysis which considers only a subset of all ecosystem types and services, namely forests, wetlands and freshwater ecosystems, and coastal recreation. Among high-income countries, Finland, Sweden and Ireland show the highest value of ecosystem services with respect to the national GDP. This is partly due to the large total area of wetland and freshwater ecosystems in these countries, which, despite the low per-hectare values (see Table 2.11) results in high aggregated values. Secondly, the value of forest provisioning services in Sweden and Finland are particularly high, reflecting the fact that forestry is a widely practiced activity in these countries (see Table 2.10). In middle-income countries, relatively high values of forest ecosystems are found in countries that are landlocked or with a short coastline, such as the Czech Republic and Slovenia, while in the remaining countries high values are provided by wetlands and freshwater ecosystems and coastal recreation. In low-income countries, ecosystem service values tend to be high particularly for forests and, in Bulgaria and Croatia, wetlands and freshwater ecosystems. The high values of wetlands and freshwater ecosystems in Bulgaria and Croatia reflects the relatively high per-hectare values and the low GDP in those countries.

9.2.2 Vulnerable Rural Communities and their Dependency on Biodiversity

Because they are more highly dependent on the natural environment for the provision of food, shelter, and income, rural poor communities are more vulnerable to environmental and socio-economic changes. Biodiversity loss and degradation in the provision of ecosystem services may further aggravate the risk of social exclusion for such communities. Rural agricultural households are particularly vulnerable, since their income may be expected to be more subject to variability than, for instance, low-income wage workers in urban areas. For this reason we focus in this section on rural agricultural areas to investigate the link between the livelihood of the rural poor, biodiversity and the provision of ecosystem services.

Among all NUTS2 regions in Europe, those with the highest density of agricultural land-use were selected, based on the land-use patterns identified by the Corine land use map. For the calculation, all the grid cells identified as “agricultural areas” in Corine were considered. These include arable land (i.e., non-irrigated, permanently irrigated and rice fields), permanent crops (i.e., vineyards, olive groves, fruit trees and berry plantations), pastures, and heterogeneous agricultural areas (i.e., annual crops associated with permanent crops, complex cultivation patterns, land principally occupied by agriculture with significant areas of natural vegetation, and agro-forestry areas). Among regions with agricultural land-use density of 70% or higher, the three NUTS2 regions with the lowest and highest GDP per capita in 2007 – based on GDP per capita data referring to year 2007 from Eurostat – were selected in order to verify the existence of different patterns in their dependence from biodiversity and ecosystem services. The three rural poor regions identified with this procedure are: Del-Alfold and Eszak-Alfold in Hungary, and Lubelskie in Poland. In addition, and for the sake of a running a comparative analysis, the three rural regions with highest GDP per capita values among the regions with a strong agricultural land-use density are also selected. We refer to Southern and Eastern Ireland, Berkshire, Buckinghamshire and Oxfordshire in the United Kingdom, and Groningen in the Netherlands. Table 9.2 summarizes the characteristics of the selected NUTS2 regions, including the values of the socio-economic, ecosystem service value and biodiversity indicators.

The total value of ecosystem services in the selected NUTS2 regions was calculated multiplying the average per-hectare value in the country where the regions are located (as calculated in Section 8) by the total area of respectively forests, wetlands and freshwater ecosystems. Coastal recreation was not considered in this analysis since some of the regions are landlocked (Del-Alfold, Eszak-Alfold, Lubelskie, and Berkshire, Buckinghamshire and Oxfordshire) while the remaining are not. The total area of forests and wetlands/freshwater ecosystems in each NUTS2 region was estimated based on the land-use categories of Corine and with the procedure previously described in Section 8. The value of the terrestrial biodiversity index in table 9.2 is the average value in each of the considered NUTS2 regions.

Table 9.2: Indicators of socio-economic condition, biodiversity richness and ecosystem services value in selected rural agricultural NUTS2 regions of Europe

NUTS2 region	GDP per capita, 2005 (US$/person/ year)	Employment in primary sector, 2006 (% of total employment)	Unemployment rate, 2007 (% of population aged 15 and over)	Biodiversity index	Forest ecosystem service value (% of GDP)	Wetlands/ freshwater ecosystem service value (% of GDP)
Southern and Eastern (IE)	45,321	4.70	4.5	23.0	0.2	2.7
Berkshire, Buckinghamshire and Oxfordshire (UK)	43,269	1.19	4.0	40.4	0.1	0.0
Groningen (NL)	43,998	3.17	4.9	45.3	0.2	0.8
Lubelskie (PL)	9,773	35.86	9.5	77.1	4.2	0.8
Eszak-Alfold (HU)	10,708	4.42	10.3	87.6	1.5	1.8
Del-Alfold (HU)	11,388	9.38	10.8	82.8	1.7	1.9

The dependencies between the socio-economic, biodiversity and ecosystem value indicators in the selected rural regions are graphically visualized in Figure 9.6. Each of the axes in the spider charts represents one of the indicators, with the values of the indicators standardized between 0 and 100.

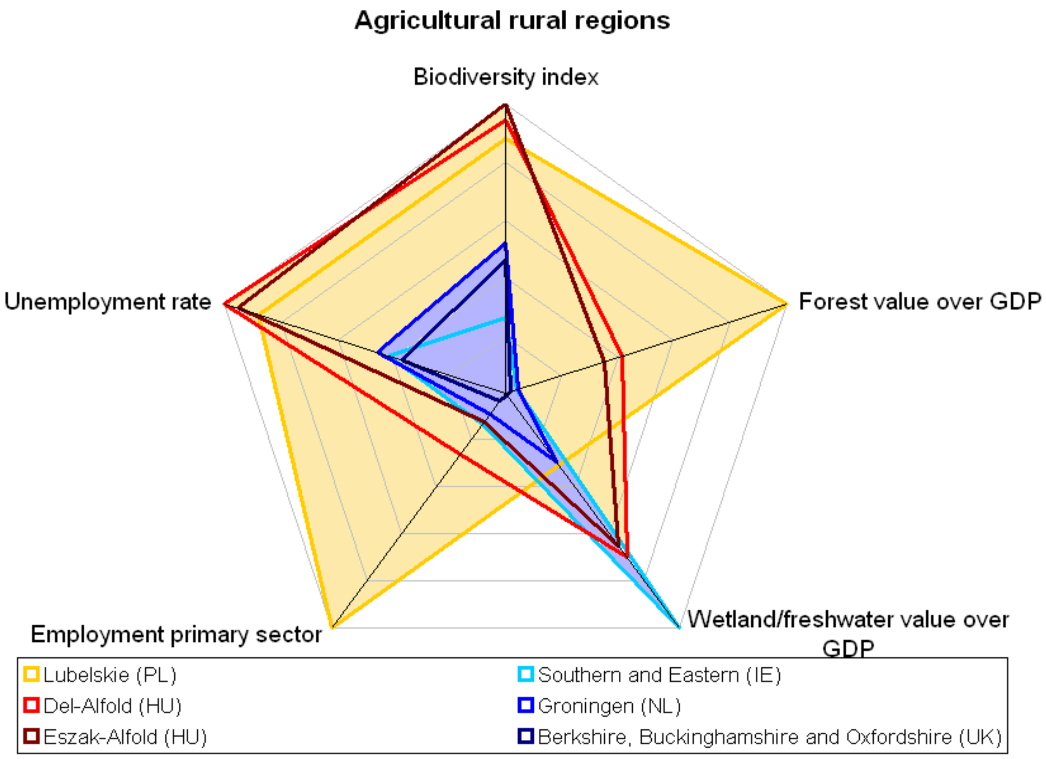


Figure 9.6: Linkage between ecosystem services value, biodiversity and socio-economic indicators in selected rural agricultural regions of Europe

Figure 9.6 shows that the contours of human livelihood, biodiversity and ecosystem service values differ substantially between the two groups of regions, despite the fact that both groups represent rural agricultural areas. In low-income regions, both the employment in the primary sector as a share of total employment and the overall unemployment rate are higher, suggesting that these areas are particularly vulnerable to socio-economic changes and environmental degradation. The low employment rate in high-income agricultural regions may be explained by the high level of mechanization of agricultural practices in these areas. On the other hand, biodiversity levels are substantially higher in low-income regions and the value of forest ecosystem services is particularly high when compared to the total GDP of these regions. This supports the hypothesis that the economic structure of vulnerable rural regions of Europe – such as the selected low-income, agricultural regions – is more strongly dependent on biodiversity and the provision of ecosystem services than that of richer areas, even if remote and predominantly agricultural.

9.2.3 Vulnerable Remote Communities and their Dependency on Biodiversity

Communities living in remote regions are more vulnerable than populations in more accessible regions since access to substitute products and services may not be available or expensive. In mountainous areas, for instance, income alternatives are often scarce and communities are in general strongly dependent on the natural environment for their wellbeing. Here, we focus on two types of remoteness: first we consider mountainous regions of Europe as case-study for geographical remoteness, and second we look at distance from major cities as an indicator of the social dimension of accessibility.

The procedure followed for the selection of the mountainous case-study regions reflects the method used for the discussion of rural agricultural regions. Among all NUTS2 regions in Europe, we selected the regions with average elevation equal or higher than 700 m a.s.l. The average elevation in each region was obtained in a GIS software, based on the information contained in the NOAA Digital Elevation Model, with 5 minutes resolution (http://www.ngdc.noaa.gov/mgg/global/seltopo.html). Among such regions, the three with the lowest GDP per capita and the four with the highest GDP per capita were selected for further investigation. The three remote poor regions are Yugozapaden in Bulgaria, Centru in Romania, and Ipeiros in Greece. The regions with highest GDP per capita are the Austrian regions of Salzburg, Vorarlberg, and Tirol and the Provincia Autonoma Bolzano/Bozen in Italy. The latter was included in the analysis as a fourth region in order to provide a differentiation of the considered regions across at least two different countries (i.e., Austria and Italy). Table 9.2 summarizes the characteristics of the selected NUTS2 regions, including the values of the socio-economic, ecosystem service value and biodiversity indicators. The total value of ecosystem services and biodiversity were calculated following the procedure previously outlined for rural regions. As before, the value of coastal recreation was not included in the analysis since all the selected regions are landlocked with the only exception of Ipeiros.

In addition to the indicators in Table 9.3, we evaluated the accessibility to large cities and exchange markets of the selected mountainous regions. For this purpose, we used a global map of accessibility that was developed by the Joint Research Center of the European Commission (http://bioval.jrc.ec.europa.eu/products/gam/index.htm) and that contains information on the travel time to the nearest city with population of 50,000 inhabitants or more in a 30 arc seconds resolution. As expected due to their geographical isolation, all the selected mountainous regions are in remote locations that are characterized by a low accessibility. The average travel time in the selected regions is 168 minutes, the least accessible of them being Provincia Autonoma Bolzano/Bozen with an average travel time equal to 215 minutes. The median and mean travel time in the 367 NUTS2 regions of Europe that were considered in this analysis are respectively 107 and 140 minutes.

Table 9.3: Indicators of socio-economic condition, biodiversity richness and ecosystem services value in selected remote mountainous NUTS2 regions of Europe

NUTS2 region	GDP per capita, 2005 (US$/person/year)	Employment in primary sector, 2006 (% of total employment)	Unemployment rate, 2007 (% of population aged 15 and over)	Biodiversity index	Forest ecosystem service value (% of GDP)	Wetlands/freshwater ecosystem service value (% of GDP)
Yugozapaden (BG)	11,557	2.77	3.9	94.1	1.7	2.4
Centru (RO)	10,255	16.90	8.5	83.9	7.4	0.5
Ipeiros (GR)	19,185	19.21	10.0	75.2	1.5	15.3
Provincia Autonoma Bolzano/Bozen (IT)	36,805	0.00	2.6	77.5	2.0	2.0
Tirol (AT)	36,631	5.09	2.8	75.1	5.3	0.3
Vorarlberg (AT)	36,631	2.81	3.6	75.0	2.0	1.2
Salzburg (AT)	39,863	5.54	3.0	74.9	4.2	0.6

Figure 9.7 illustrates the dependencies between the socio-economic, biodiversity and ecosystem value indicators in the selected remote regions. Each of the axes in the spider charts represents one of the indicators, with the values of the indicators standardized between 0 and 100.

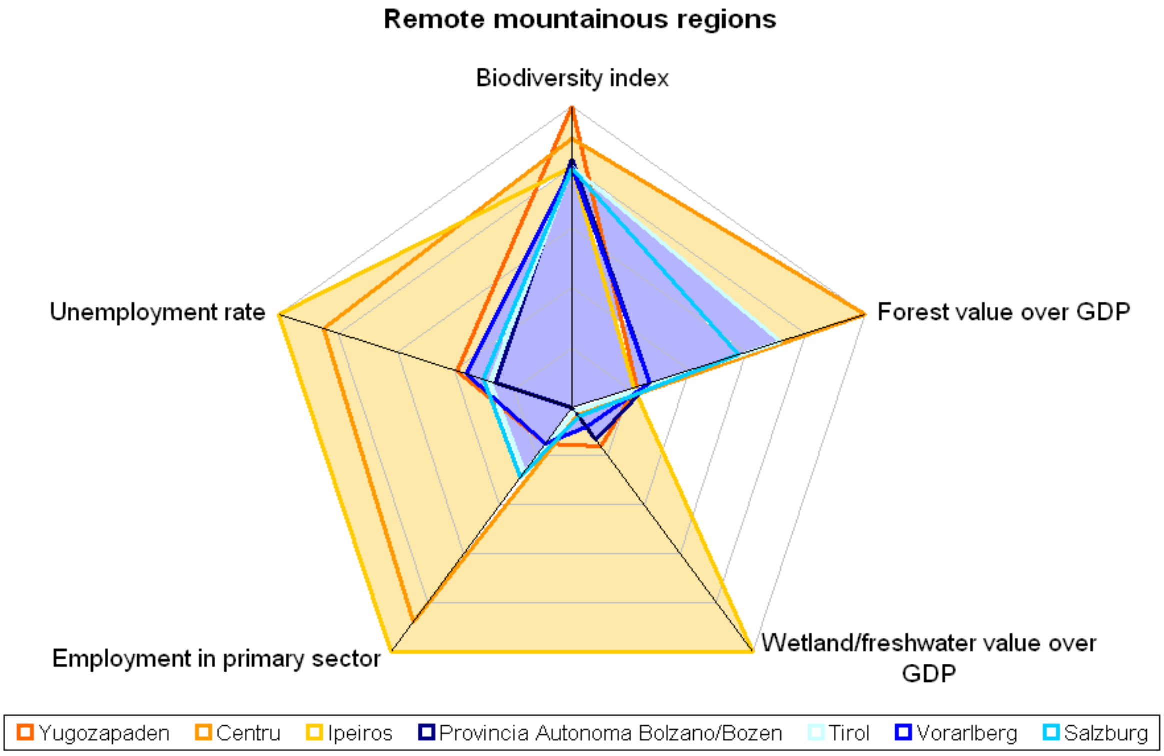


Figure 9.7: Linkage between ecosystem services value, biodiversity and socio-economic indicators in selected mountainous regions of Europe

The trends in the indicators in Figure 9.7 are qualitatively similar to what was found for rural regions, although the differences in some of the indicators are less marked. Unemployment rates and employment in the primary sector are higher in the considered poor remote regions and so are the values of the biodiversity indicator, although high biodiversity levels are found also in the high-income regions. Population density is relatively low in all considered regions and, on average, lower in low-income regions (72 inhabitants per square km versus 84 in high-income regions). On the other hand, the value of ecosystem services as percentage of the GDP is, on average, higher in low-income regions and is highest in Ipeiros for wetlands and freshwater ecosystems (15.26%) and in Centru for forest ecosystems (7.42%).

In general, the results for remote mountainous regions support the previous findings for rural areas in the sense that they confirm that poor communities are more reliant on ecosystem services and biodiversity than less vulnerable ones. The comparison with rural regions, however, highlights how remote mountainous regions are more homogeneous in terms of biodiversity levels, population density and ecosystem service values.

10 GLOBAL EVIDENCE ON THE ECONOMIC SIGNIFICANCE OF THE LINKAGES BETWEEN BIODIVERSITY, ECOSYSTEM SERVICES AND HUMAN LIVELIHOODS

10.1 Introduction to Global Case Studies on People's Vulnerability to Ecosystem Loss

The case for protecting biodiversity and ecosystem services has already been made in the context of protecting jobs (see section 4.1 above) and creating wealth within the EU (see sections 9.1 - 9.4). Potentially of greater importance, however, are the services that ecosystems provide in developing nations, particularly to those least likely to benefit from economic activity. Several studies have demonstrated how the rural poor depend most directly on the services provided by biodiversity (e.g. Gundimeda and Sukhdev, 2008) and therefore remain the most vulnerable to the impacts of degradation and ecosystem loss.

The European Union impacts directly and indirectly on the state of global ecosystems through the use of natural resources (such as the demand for timber and meat), its role in negotiating global treaties (such as the Doha Trade Agreement and the successor to the Kyoto Protocol) and the investments made by its MS and multinational firms in developing nations. The EU can also take a lead role in establishing payments for ecosystem services that could directly pay vulnerable people to protect ecosystems. Understanding the dependencies of different people on ecosystems can assist the EU in ensuring that its activities at the very least do not adversely affect the poorest people, and at best, contribute to improving their prospects.

A key step towards this goal will be the integration of development and environmental goals. There has long been a perception that the needs of development and conservation are necessarily in opposition, although this appears to be changing (e.g. Sayer, 2009). The perception was fuelled by models of economic development which often saw the development of natural areas at the expense of biodiversity. On the other hand, conventional conservation methods often involved the barring of local people's access to areas important for nature conservation. Both of these approaches frequently resulted in the deterioration of conditions for the poor who rely directly on ecosystems for their subsistence. There is little debate now, however, that the protection of ecosystem services and allowing the rural poor to make decisions about the use of biodiversity contributes to well-being and can make a significant contribution to the United Nations' Millennium Development Goals (MDGs), including alleviating poverty, enhancing social structure and creating jobs.

This section provides an introduction to the international perspective of the groups of people particularly dependent on biodiversity and ecosystem services for their survival and well-being, especially the rural poor. It lists a number of case studies in the table below and examines a few specific case studies in more detail that demonstrate the extent to which certain groups are at risk from the degradation of ecosystems.

Policy linkages

Although the case studies reflect different areas and circumstances, they provide interesting insights on the types of measures that may be universally applicable to protect the rural poor from ecosystem degradation. For example, the case studies suggest it can often be beneficial to return the ownership and management of the land to local groups to establish patterns of sustainable use, so as to exclude behaviour that damages the resource. However, these local or 'customary' laws must be supported by national legislation and gain the support of the authorities. The granting of land tenure to the rural poor has been partially successful in Mexico but it was found that the poor lack the skills to properly benefit from the resource. In other cases, the reintroduction of traditional farming techniques has allowed the continuation of techniques that had been used for generations. Therefore, close co-operation with the rural poor to discover their needs, returning to modes of resource use that have been successful in the past, establishing land tenure rights and supporting local laws and plans nationally appear to be relatively successful and provide ideas for moving forward.

Table 9.9: Overview of vulnerable people

Vulnerable groups	Biodiversity benefits & ES dependency	Environmental risks	Scale &/or impact	Examples	Policy linkages
Subsistence farmers (i.e. little access to external markets for trade)	*Provisioning*: food *Regulating:* soil protection, pollination, water retention, flood control, genetic resources.	**1. Soil Erosion** due to deforestation, poor agricultural practice, or extreme weather events. **2. Salinisation** of soils in coastal areas related to sea level rise, tsunamis & irrigation practice. **3. Falling water tables** due to urban abstraction & (in some areas) climate change induced drought.	**All.** Loss of outputs & livelihoods; Reduced output. **2.** 60,000km2 inundated by the 2004 tsunami[92].	**All.** Green Accounting for Indian States Project; **2.** Salinisation in India	**1.** Implementing modern techniques, reduced tillage, restoring traditional practices, financing aforestation projects; **2.** Improvement of irrigation technique **3.** Property use rights, stronger regulation, protection of forests. **All.** Relocation, change of sector
Highland peoples	Forested slopes mitigating the impact of natural hazards	**1 .Deforestation**	Loss of infrastructure and food shortages.	40,000 farmers in Palas valley, Pakistan[93]	Protect remaining forests and support afforestation projects.
Drylands people	*Provisioning:* food	**1. Degradation of grasslands** **2. Desertification**	Drylands occupy 41% of the earth's land surface and are home to 35% of its population; threatened by climate change.	Many countries: see map in Mortimore et al. (2009)[vii].	Mitigate against climate change.
Inland fishing communities (both subsistence and small traders)	*Provisioning*: food	**1. Water quality deterioration** due to industrial, urban or agricultural effluent **2. Dam Construction** leading to loss of fisheries	**All.** Loss of livelihoods/jobs; around 90% of the world's 38 million fishers are classified as small scale [iv].	Fisheries along the Mekong River: See Case Study;	Consider the impact of dams on artisanal fishing communities; manage fisheries sustainably; enforce dynamite fishing bans.
Coastal Peoples	Natural hazard management	**1. Overexploitation of fisheries** – both local and external exploitation **2. Coral reef degradation** through acidification of seas, overexploitation, tourism & damaging fishing practices **3. Loss of mangroves** through coastal development, shrimp farming. **4. Pollution** both through increased nutrients, and oil spills	**All.** Loss of livelihoods. **3.** Reduced resilience to natural disasters	**1.** EU fishing off West coast of Africa; **2.** Turk and Caicos islands marginally threatened by tourism[94] **3.** Shrimp farming in Thailand (see below), Boxing Day tsunami.	**1.** Strengthen bilateral fishing agreements to favour vulnerable, address socio-economic issues at regional & national scale; **2.** Ban damaging fishing gear, restrictions on tourists, 'tourist tax' used for protection of reefs. **3.** Remove shrimp farming subsidies; account for ES during the planning of coastal developments **4.** Strengthen water treatment standards for discharge into fresh and coastal water.
Indigenous and forest peoples	*Provisioning*: food, fuel wood, medicines; *Regulating:* soil protection, *Supporting:* pollination,	**1. Deforestation** for timber, cattle ranching, agriculture, economic development **2. Fragmentation** due to infrastructure, development	**All.** Loss of livelihoods; loss of nutrient cycling, collapse of culture.	*Ejidos* in Chamela district of Mexico (see below), 2.8m subsistence agro-pastoralists in Tanzania using traditional *ngitili*[95].	**All.** Establish local ownership rights, recognise local arrangements in federal law, train locals to develop sustainable businesses, reduce incentives for agricultural expansion, support forestry commission regulations.

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10.2 Forestry along Mexico's Pacific Coast

Introduction

Mexico's forests cover approximately 65 million hectares, providing homes to 13 million people, 55% of whom live in extreme poverty (World Bank, 2008; 2009). The forests are divided between the pine and oak woodlands of the north and the tropical forests in the southern states. Along the western Pacific coast, dry tropical forest is the dominant habitat type.

Mexico's dry tropical forests are considered to be the most ecologically diverse in the Neotropics (WWF, 2005). Of the 724 vertebrate species that are found in this ecoregion, 233 (29%) are believed to be endemic. The state of Jalisco alone supports 1,200 vascular plant species, of which 16% are endemic (Lott et al., 1987). Therefore the area supports not only a high level of biodiversity, but also many unique species with restricted ranges.

This area experiences highly seasonal precipitation, with 80% of its rainfall occurring between June and October, followed by severe droughts from February to April (Maass et al., 2005). Furthermore, the frequent occurrence of storms and cyclones means that rainfall events are highly episodic in nature, contributing to high erosion rates in the states of Jalisco and Oaxaca. These characteristics, coupled with shallow soils in upland areas, make the region particularly vulnerable to reduced productivity following deforestation.

Due to uncertain land tenure and expansionist agricultural policies, 73% of Mexico's dry tropical forests were lost by 1990 (Trejo & Dirzo, 2000). Indeed prior to the 1992 Forestry Law, Mexico's forests were managed through concessions which the government awarded to private companies. This prevented rural communities, or '*ejidos*', from managing their forests and resulted in high levels of both legal and illegal logging. Now ownership has largely been transferred to some 10,000 *ejidos* who manage 65% of Mexico's forests. However these indigenous people are some of Mexico's poorest, with 81% living below the poverty line, and they still lack the organisational and technical capacity to manage their forests sustainably. Therefore deforestation rates remain moderately high, with approximately 330,000ha lost in 2008, representing an annual rate of 0.5% (World Bank, 2009).

Benefits of Biodiversity and Ecosystem Services to local livelihoods

The biodiversity of Mexico's dry tropical forests plays an important role in supporting the livelihood of the area's landed and landless populations. The provision of timber and a variety of food sources enables the local poor to earn or at least supplement their household income. Furthermore, all sectors of society benefit through the role ecosystem services play in regulating the biophysical environment.

While forestry activities only account for 1.8% of the country's GDP, World Bank statistics suggest that 300,000 people work in the sector, although the actual number is likely to be higher owing to informal employment (World Bank, 2009). This figure not only accounts for the loggers themselves, but also those operating in other parts of the industry such as administration and transport. In the tropical dry forests, logging activities focus on commercially harvesting precious timber species including *Cordia spp.*, *Enterolobium cyclocarpum*, *Tabebuia spp*., and *Pirhanea mexicana*.

The value of Mexico's forests, particularly along the Pacific coast where average canopy height is only 8-12m (Trejo & Dirzo, 2000), is not confined to timber alone. Indeed up to 12 million people are believed to be dependent on non-timber forest products (NTFP) for subsistence or as a source of income (FAO, 2005; ITTO, 2003). In the District of Chamela, a 16,000km^2 area within the coastal state of Jalisco, up to 162 plant species are known to be harvested by the local poor (Maass et al., 2005). These products are used for a wide range of applications such as medicine, beverages, food, and spices. The forest also supports a variety of mammals, birds, and reptiles which are hunted for food including white-tailed deer (*Odocoileus virginianus*), collared peccary (*Tayassu tajacu*), white-nosed coati (*Nasua narica*), plain chachalaca (*Ortalis vetula*), and green iguana (*Iguana iguana*).

Aside from the provision of food goods which can be directly quantified and traded, the dry tropical forests also provide a variety of other ecosystem services. The forests are of great importance for bioregulation, maintaining the structure and fertility of the soils while reducing the risk of landslides during the wet season storms. During the dry season, when up to 90% of precipitation is lost through evapotranspiration, the upland forests are critical in maintaining the region's water table (Burgos & Maass, 2004).

Another significant ecosystem service is pollination, which supports the agricultural industry along the Pacific coast, estimated to be worth US$12 million in 2000 (INEGI, 2000). Indeed the agricultural sector accounted for 15% of total employment in 2009, largely consisting of small scale bean and corn farming (US Department of State, 2010). In the district of Chamela squash farming is an import economic activity, which is dependent on the native solitary bee species' *Peponapis spp.* and *Xenoglossa spp.* for pollination (Hurd et al., 1971). However pollinator species react negatively to the fragmentation of the dry tropical forest, with lower population levels and therefore reduced pollination activity.

Threats to the vulnerable group due to the Loss of ecosystem services

The destruction of Mexico's tropical dry forests, so that only 30% of original forest cover remains in districts such as Chamela, has a variety of consequences for the provision of ecosystem services (Maass et al., 2005). Forest loss immediately results in the reduced supply of timber and NTFPs, directly lowering the welfare of the rural poor who are dependent upon such sources of food provision.

Broader consequences include those which reduce the fertility of the soil. The extreme seasonality in precipitation along the Pacific coast means that the area is particularly prone to soil nutrient leaching and landslides. The tropical dry forests not only uphold the structure of the soil, but also recycle nutrients very efficiently. A dense leaf litter of up to 8.2Mg/ha (Martinez-Yrizar & Sarukhan, 1990), microbial immobilisation of nutrients during the dry season (Campo et al., 2001), and high aggregate soil stability combine to significantly reduce leaching. However, following conversion to pasture, carbon and nitrogen content in surface biomass drops by 77% and 82% respectively (Jaramillo et al., 2003). Soil nutrient loss associated with erosion accelerates by an order of magnitude, with 24kg of potassium lost per hectare per year as soil aggregates degenerate, thus losing their stability (Garcia-Oliva et al., 1995). Therefore the removal of tropical dry forests not only results in the loss of food provision, but also in the reduced productivity of the agricultural land which replaces it.

Deforestation along Mexico's Pacific coast has led to the reduced provision of ecosystem services, leading to a variety of secondary socio-economic effects. The loss of the forests and hence soil fertility has a disproportionately large impact on the poorest farmers. This is because they inhabit and farm upland areas with steeper slopes, and so their land is more prone to erosion and leaching, which results in lower farm productivity. This may also produce class tension and conflict over the remaining forest resources, while the reduced income creates pressure to grow illicit drugs or migrate from the area (Maass et al., 2005; World Bank, 2009).

Policy Implications

However, by recognising the severity of the problem, the response of government, NGOs, and other stakeholders offers an opportunity to temper the deforestation issue through wider social policies. In the past deforestation was driven by a combination of agricultural expansion, population growth, poorly regulated tourism, and arbitrary resettlement projects. The commercial timber industry operated through government concession or '*parastatals*', which had no incentives to promote sustainability. They were also disinterested in the needs of the rural *ejidos* communities, until agriculture and land tenure reforms in the

1990s returned land ownership to them. Although the Forestry Law of 1992 created a framework for *ejidos* to sustainably manage their forests, they did not have the technical capacity or access to NTFP markets needed to support their new initiatives (World Bank, 2008). Work to resolve these issues should focus on building capacity and promoting sustainable community schemes. This should also be coupled with the systematic recognition of new *ejidos* land use and forest management customs, so that they are integrated into national legal structures to ensure permanence.

10.3 Fisheries along the Mekong River, South-east Asia

Introduction

The Mekong River, which runs from the Tibetan Plateau through South-east Asia to the South China Sea, is estimated to be the world's most productive inland fishery. Its 4,180km length produces a catch of 2.6 million tons of fish per year, estimated to be worth US$2.5 billion, and supports the livelihoods of some 60 million people (WWF, 2010). This resource is also critical to the nutrition of the wider South-east Asian population, as the fisheries provide 80% of all animal protein consumed within the Mekong Basin. The biodiversity of the river is the key factor underpinning its rich fisheries, with 1,300 species known to occur. These include some of the world's largest and most endangered freshwater fish species. Examples include endemic species such as the 600kg Giant Freshwater Stingray (*Himantura chaophraya*), the critically endangered Mekong Giant Catfish (*Pangasianodon gigas*), and the largest carp in the world, the Siamese Giant Carp (*Catlocarpio siamensis*).

The Mekong's fisheries supply one quarter of the world's freshwater fish catch, but this important ecosystem service is threatened by unsustainable fishing practices and transboundary hydroelectric schemes. Far from being a homogenous resource, the river's waterways support a range of aquatic habitats. Critical amongst these are 'deep pools' where the river reaches depths of up to 76m (MCR Technical Paper 11, 2006). Such areas are important fish spawning grounds, key habitats for the river's larger species, and act as critical refuges during the dry season when many sections of the river become inhospitable. Local fishermen have long recognised the importance of these sites for healthy fisheries, which is reflected in the designation of 'Fish Conservation Zones' in the 1990s. Such measures are accredited with increasing 24 fish populations, including both sedentary and migratory species (Vannaren & Kin, 2003). Indeed these migratory species, of which there are 600, require a variety of different habitats along the Mekong through their life cycles (WWF, 2010). Approximately 75% of the commercial catch at Tonle Sap in Cambodia originates from migratory species that have sheltered in deep pools in northern Cambodia or Laos (MRC, 2010). Therefore the connectivity of the river is critical to enabling these important species to migrate according to season or age, both for the artisanal fishing communities and the commercial operations.

Benefits of Biodiversity and Ecosystem Services to the Local Livelihoods

The Mekong fisheries play a significant role in the livelihood of the Basin's inhabitants, as well as the GDP of Cambodia, Laos, Thailand, and Vietnam. In Laos the Mekong fishery is estimated to contribute 6-8% of national GDP, but its true value is likely to be much higher (WWF, 2010). This is because while the growing rural fishing communities are resource rich, they are financially very poor. With little access to electricity or other industries, the population is largely dependent on fish for employment and nutrition. Approximately 40kg of fish are consumed per capita per year in Laos, while in southern Laos about 80% of households participate in fisheries, accounting for around 20% of household income (WWF, 2010).

The dependency of rural fishing communities on the Mekong's ecosystem services are further highlighted by the study of a small village in northern Cambodia. Veun Sean is a village of 150 people, located within the Stoeng Treng Ramsar Site along the Mekong (de Groot et al., 2006). The village has no electricity, no latrines, no running water, and an illiteracy rate of almost 75%. The value of the Mekong to each household in the community was estimated to be US$3,200 in 2005, incorporating major ecosystem services in the form of fisheries, water provision, transportation, construction materials, fuelwood, traditional medicine, and a range of game animals (IUCN, 2005). Indeed the importance of these ecosystem services is particularly significant for the Basin's poorer people. Furthermore, whilst a rich biodiversity has a range of benefits for rural communities, the Veun Sean study found that fisheries still constitute the largest share, earning each household US$650 per year (de Groot et al., 2006).

Threats to the Vulnerable Group due to the Loss of Ecosystem Services

The Mekong River fisheries face two major threats: the unsustainable exploitation of deep pools during the dry season, and blocking fish migration routes due to the construction of dams. The use of explosives and large mesh size monofilament gill nets by local fishermen, especially in deep pools during the dry season, has had a negative impact on fish catches up and down the Mekong Basin. Between 1993 and 1997, approximately 8,000 explosives per year were used to catch fish in Cambodian deep pools (Vanneran & Kin, 2003). These activities severely depleted the populations of fish taking refuge there, damaged fish spawning efforts, and caught a disproportionate number of the river's endangered species, which are particularly dependent on deep pool habitats.

Hydroelectric dam construction also damages the health of fisheries by reducing river sediment loads and cutting off important fish migration routes. *Dams on Mekong tributaries and the mainstream in China are already producing 1,600 megawatts of electricity, most of which is used to power industries and cities outside the basin (MRC, 2010). In this way local fishermen's livelihoods are damaged whilst they also fail to receive the benefits of increased electricity generation. Indeed, a study published by the inter-governmental Mekong River Commission analysing the impact of mainstream dams concluded that: 'Rural populations, river dependant populations and the poor stand to lose most. In fact impacts are concentrated on some of the most vulnerable populations. Whereas the main the benefits will accrue to developers and their investors, to a lesser extent power consumers and host governments. These beneficiaries notably exclude the rural poor who are often not connected electricity grids' (MRC SEA, 2010:72). However 11 more dam construction plans have been proposed in an attempt to capture more of the river's estimated 30,000 megawatt capacity, despite the risk of losing 1.4 million tonnes from the fish catch in the Lower Mekong Basin (MRC SEA, 2010).*

Policy Implications

Schemes to conserve the fish stock of the Mekong River have been implemented by local fishermen since the mid 1990s. In Cambodia, riverside villages have established 'Fisheries Community Commissions' along with 'Village Fisheries Community Regulations'. These local bodies established 'Protected Zones' around their deep pools, preventing the use of large mesh nets, dynamite, and the capture of endangered fish species. These measures, coupled with limits to catch sizes in the dry season, have been attributed with partly restoring fish stocks in many areas of Cambodia (Vannaren & Kin, 2003). A similar initiative has been introduced in Laos, where WWF's 'Community Fisheries' project has run since 2005. This scheme helps fishermen create 'Fish Conservation Zones' and 'Village Aquatic Management Plans' to improve the sustainability of their fisheries (WWF, 2010). These new local customary laws need to be recognised in national legislation to secure permanence and aid enforcement, whilst the initiative should also be expanded to more tributaries around the Lower Mekong Basin.

The proposed dam schemes need to continue to be reviewed with regard to their wider social, economic, and environmental impacts. Although creating dams to aid development and export electricity appears attractive, they are likely to have a perverse impact on the poorest communities (Middleton, 2007; Rivers, 2009). Furthermore, reduced sediment flow and an altered flood regime are likely to negatively affect not only aquatic but also internationally important terrestrial ecosystems all over the Lower Mekong Basin. Therefore great care should be taken to consider the full range of transboundary consequences of the proposed dam developments.

10.4 Aquaculture in Thailand

Introduction

The latest figures, published by the FAO in 2009, indicate that around 43.5 million people around the world are directly involved in the fishing industry (FAO, 2009). 86% of these people live in Asia, with China, Thailand, Indonesia, and Vietnam having significant sections of their populations employed in the sector. Indeed fishing has been an important cultural and economic activity in coastal Thai communities for centuries. As of April 2010, 442,790 people were employed in the Thai fishing industry out of a total workforce of 37,257,280 (Bank of Thailand Statistics, 2010). However, the United Nations estimates that for each person directly employed in the fishing industry, as many as four further people may be employed in secondary capacities such as fish processing, transport, and marketing (FAO, 2009).

Aside from employment in fishing, the industry also provides a way of life for the extended families and communities of millions of people in coastal Thailand. Fish and therefore fishing are very important to the diet of the national population, with 35kg consumed per person per year. However fish stocks, and in particular the near-shore fisheries, have been 'decimated' in recent years (Royal Danish Embassy Bangkok, 2007:1). The collapse in populations of commercially important species, such as Indian Mackerel and Anchovy, has reduced the income of local fishermen who depend on coastal fisheries. For example, between 1988 and 2002 the total catch dropped from 2.7 million tonnes to 1.1 million tonnes (Paulay & Chuenpadgee, 2003).

One of the main reasons cited for this decrease is the destruction of Thailand's coastal mangrove forests. Rates of lost in Thailand were estimated to be as high as 60 km^2 per year (Sathirathai & Barbier, 2001), which reflects global losses of 35,600km^2 between 1980 and 2005 (FAO, 2005, in UNEP, 2010). Their destruction is important as mangroves are responsible for facilitating a range of ecosystem services. Perhaps the most important of these is their role as fish nurseries. They provide the habitat for young fish and crustaceans to develop, thus supporting a healthy maritime ecosystem. They also act as purifiers of terrestrial run-off, along with trapping sediment and silt, thereby keeping coastal waters clean (Dierberg & Kiattisimkul, 1996). Aside from their benefits to aquatic biodiversity, mangroves also benefit people in other ways. They are important sources of fuel wood and charcoal, whilst also being effective barriers to storm surges and tsunamis, protecting coastlines and therefore settlements.

Benefits of Biodiversity and Ecosystem Services to the Local Livelihoods

The Chief Executive of The Nature Conservancy, Mark Terceck, believes that mangroves provide 'security for rich biodiversity and a lifeline to many of the world's most vulnerable people' (Terceck, quoted in UNEP, 2010). Local populations benefit from the presence of mangroves through the provision of food and building material. When mangroves are lost, artisanal fishing communities not only become highly vulnerable to storm impacts, but they also lose their income. Indeed the economic cost to the fishing sector of Thailand's mangrove deforestation is estimated to amount to US$1.31 million per year, or about US$253 per hectare (Barbier, 2003).

For poor coastal villages in particular, mangroves represent an important type of 'ecosystem infrastructure'. These communities are where most Thai fishermen live, and are typical of small-scale, coastal, artisanal fishing groups. *Their lack of access to infrastructure and education means that they are dependent upon natural fish populations, both as a source of nutrition and income.* Apart from the provision of food and resources, mangroves are also important biophysical regulators. They maintain the natural environment and mitigate the impact of storms. These roles are especially important to poor coastal communities as they do not have the financial means to invest in modern, artificial alternatives such as sea walls. Indeed the UNEP estimates that mangroves generate between US$2,000-9,000 per hectare annually, which is far more than possible alternative land uses (UNEP, 2010).

Barbier and Sathirathai's (2001) study of a small fishing village in Thailand analysed the full range of social costs and benefits of mangroves to the community. They found that the direct value of wood resources amounted to US$88 per hectare annually, while the benefits provided to the off-shore fishery were worth up to US$69 per hectare annually. When the value of mangroves as an effective form of coastal protection was also incorporated, the value of a Thai mangrove ecosystem was estimated to be worth up to US$35,921 to the local community over 20 years.

Threats to the Vulnerable Group due to the Loss of Ecosystem Services

The prospect of large and fast profits in shrimp farming has driven the conversion of mangroves to aquacultural land uses over the last two decades, and has had a considerable impact on Thai fishing communities. However, there is controversy over the extent of the role of aquaculture, with estimates of shrimp farming related mangrove loss varying from 5-60% of total mangrove deforestation (Barbier & Cox, 2002; GAA, 2007). Either way, it does appear that shrimp farming has been a significant factor in the removal of Thai mangroves, especially following the rapid rise in shrimp prices during the 1980s. This was driven by the expansion of the Japanese market, and indeed shrimp farming in Thailand is a major export industry. Today the world export market for shrimp is worth US$14 billion per year, making shrimp the most important internationally traded fisheries commodity (FAO, 2009). Of the 6 million tonnes of shrimp consumed globally each year, 70% are farmed, directly employing at least 9 million people (FAO, 2009).
In Thailand the main farmed species is the native Black Tiger Shrimp (*Panaeus monodon*) which requires open brackish ponds to develop. This encouraged mangrove clearance by fishermen who had land rights, or who at least claimed to have them. However mangrove fish species account for roughly one third of all wild fish landed by artisanal fishermen in Thailand, and it is estimated that the loss of mangroves reduces local fish catches by 434g per kilo of shrimp farmed in mangrove areas (EJF, 2003).

Most shrimp farms were and still are small scale entrepreneurial ventures undertaken by former fishermen and their families. Such land use change has two types of impact, those problems created by the loss of ecosystem services, and those created by poor farming practices on the shrimp farms themselves (Nissapa & Boromthanarat, 2002). Therefore the problems associated with the loss of fish nurseries and other ecosystem services are compounded by increases in water pollution from shrimp pond effluent. *From an annual shrimp harvest of 150,000 tonnes, roughly 17,400 tonnes of nitrogen and 5,600 tonnes of phosphorous waste are produced (Nissapa & Boromthanarat, 2002). Whilst these negative impacts are shared around the entire local community, the benefits in terms of private income only gather with the shrimp farm owners, not the poorest fishermen who had no land to convert to aquaculture. Therefore the loss of mangroves and the growth of the shrimp industry have further increased impoverishment among the poorest members of Thailand's coastal communities.*

Policy Implications

The experience of shrimp farming in Thailand has demonstrated how fast profits for some can leave a legacy of exacerbated poverty for others (FAO, 2009). The loss of mangroves has been described as a 'drastic loss to the global economy and livelihoods', regardless of geographical location or cause FAO, 2009:1). However shrimp farming ponds appear to be a particularly destructive replacement, as they add to water pollution levels, further reducing the already threatened fish stock.

In order to conserve Thai fisheries, remaining areas of mangrove forest in Thailand need to be preserved. Land use regulations should be enforced, while aquaculture zoning studies such as the Coastal Habitats and Resource Management initiative need to be diligently implemented (Szuster, 2006). In areas where mangroves have already been destroyed, sustainability standards as proposed in the form of WWF's 'Shrimp Standards', which should be finalised by the end of 2010, or the FAO's 'International Principles for Shrimp Farming', as adopted in 2006, should be upheld. Furthermore, coastal villages should be clearly informed about the long term risks and ecological costs of shrimp farming to their community, so that they can manage their environment more sustainably.

SECTION III:

OUTLOOK AND POLICY IMPLICATIONS

Leader: Ecologic
Contributors: GHK, FEEM, IEEP

11 SUMMARY AND CONCLUSIONS FROM PREVIOUS SECTIONS

11.1 Section 1: Links between Biodiversity and Employment

There appear to be several and diverse relationships between ecosystem services, jobs and biodiversity. The strongest link between ecosystem services and sectoral output and employment can be found in primary sectors (agriculture, forestry and fisheries). Employment in the EU is less dependent on ecosystem services than in developing economies. In fact, 7% of the jobs in the EU are in the primary sector, compared to an average of 35% in developing countries. Overall it is estimated that a total of 55% of jobs in the EU and 84% of jobs in developing economies may have a direct link to ecosystem services to varying degrees. The remaining 45% of jobs in the EU and 16% in developing economies are indirectly dependent on ecosystem services for sustaining human life and health and a liveable, workable environment. The EU has a larger proportion of employment in service sectors than developing countries, and these jobs are more dependent on the cultural services provided by ecosystems.

As biodiversity is an important component of ecosystems and determines the services they provide, a broadly similar proportion of employment in the EU and in developing countries is related to biodiversity as is related to ecosystem services. However, again, the link between biodiversity and employment is stronger in some sectors (especially the primary sectors) than in others (such as food and drink, manufacturing and construction). The strength of these linkages depends on the extent to which sectors depend on biodiversity (both directly and through the provision of ecosystem services) and the degree to which the role of biodiversity can be substituted by man-made goods and services.

As the primary industries are highly dependent on biodiversity and related ecosystems services, changes in biodiversity and the consequent effects on ecosystem services (and hence employment) will therefore be felt less in the EU than in the developing countries.[96] Biodiversity loss does not, however, necessarily lead to a loss of employment – it can result in increases in direct employment in economic activities such as agriculture, although there may be offsetting effects on other economic activities through loss of ecosystem services, especially over time. In this context, fisheries have proven to be one of the most sensitive sectors (in terms of their dependency on ecosystem quality and services and sensitivity to biodiversity loss) and are facing a serious decline in employment due to the deterioration of habitats, as has been shown in several case studies (e.g. Lake Victoria's fishing industry, cod fishing in eastern Canada and Doñana National Park in Spain).

However, the design of sectoral policies (agriculture, tourism, fisheries, etc.) is best when it builds on knowledge about the linkages between ecosystem services and employment[97]. In particular, a lack of knowledge about the point (thresholds) at which changes in biodiversity will impact ecosystem services to such a degree that economic activity and jobs will no longer be sustained can prevent adequate resource management. Given this, further research and capacity building are needed to increase the level of knowledge in this context and put in place necessary skills.

[96] About 236 million jobs in developing economies are highly dependent on biodiversity, much more than in the EU alone (12.7 million)

[97] Costs for substitutions for ecosystem services can be an assessment tool for evaluating policy impacts and resource management.

Moreover, obvious synergies between the conservation of biodiversity and social benefits should be considered in policy development and natural resource management. For example, when people can rely on a larger variety of resources from diverse ecosystems, biodiversity acts as a safety net that prevents the rural poor from facing further poverty; this is especially relevant during drought periods or when crop harvests are low. It should also be kept in mind that increasing the supply of some ecosystem services can enhance the supply of others (e.g. forest restoration may lead to improvements in carbon sequestration, runoff regulation, pollination and wildlife conservation).

Although there is clear evidence of the dependencies and synergies between ecosystem services, jobs and biodiversity, there are also trade-offs and missing links between these subjects. Given this, general improvements in well-being often occur despite, or even due to, decreases in ecosystem services, at least at the local scale. Indeed, substantial benefits have been gained from many of the actions that have caused the homogenization or loss of biodiversity; for example, land conversion for food production.

In addition, increased investment in supporting the provision of ecosystem services might result in an increase in the number of jobs in some sectors (e.g. conservation management), but may cause a decrease in employment in others (e.g. forestry). A concrete example is the establishment of areas to protect biodiversity; these areas increase related ecosystem services and can create jobs in nature protection, but in developing countries can also contribute to poverty as a result of excluding the access of rural populations to the provisioning services that have traditionally supported their livelihoods, well-being and economic incomes. This most clearly concerns fisherman, subsistence farmers, rural societies and communities representing vulnerable groups.

In such cases, it is important to involve affected local stakeholders in the decision and establishment processes and to find alternative sources of local income to compensate for use restrictions (e.g. conservation easements, payments for ecosystem services and tourism activities).

There is also evidence that the sectors most dependent on biodiversity and related ecosystem services are also those that are causing the most damage to the very services and inputs that they are reliant upon (e.g. agriculture puts pressure to water quality and quantity, fishing in marine ecosystems exploits fish stocks and changes habitat structures). In most cases, such damages are caused by unsustainable resource management and the conversion of natural systems, which may create immediate wealth and short-term employment, but often result in degraded ecosystems, declining provision of ecosystem services and decreases in employment on the long run, depending on the sector. In order to avoid such damages and larger restoration costs[98] and to maintain ecosystem services and jobs, a long-term approach to the sustainable use of natural resources as well as integrated resource management are required. Analysis and planning are also enhanced when they assess the broader picture, rather than focusing purely at the local level.

At the EU-level, different activities have been undertaken to promote such approaches. In the Amvrakikos National Park[99] in Greece, for example, investments have been made in sustainable development actions[100] based on an ecosystem services approach as part of the LIFE programme. This underlines the need to stimulate sustainable development through EU programmes and the implementation of successful approaches at a national level. A further important area of activity concerns tourism and infrastructure,

[98] The Miombo Woodlands/Africa – case study is an example where a loss of biodiversity, through deforestation, poses real risks to rural household incomes (mainly poorest groups depending on woodlands). As a result, governments are pressed with increasing economic and financial burdens to provide alternative safety nets to those affected.

[99] The ecosystems in the Amvrakikos area provide a wide variety of ecosystem services to the region, including agriculture, cattle farming, fisheries, clean water, flood prevention, sedimentary balance, refuge for wildlife species, tourism, research, environmental education and nutrient cycling.

[100] These investments include combined actions targeting more than one function or service of the ecosystems, including food provisioning, nature conservation, tourism and research.

which are often promoted by cohesion and structural funds at national and regional levels. Experiences reveal that the inclusion of environmental protection issues and the implementation and enforcement of legislation for species and habitat protection is crucial for sustainable regional development and maintaining biodiversity (e.g. the Danube Delta/Romania case study).

Case study findings highlight the need for action, particularly for ecosystems that have been over-exploited or where economic output is mainly dependent on tourism. Even if these findings are derived from global case studies (Africa, Asia and Canada), some of them are also relevant within the EU context, especially in terms of governance, the implementation of market-based instruments and knowledge and risk assessment. The following specific needs aim to conserve biodiversity while, at the same time, ensure economic development and create jobs:

- Integrate **conservation goals into development policies**, strategies and plans at all levels and create incentives that reward biodiversity conservation and penalise activities leading to biodiversity loss;
- Promote **knowledge and risk assessments** in regional policies in terms of ecosystems to react to changes in a timely and appropriate manner;
- **Combine different economic and political instruments** with environmental goals and develop/ apply policy instruments (e.g. environmental protection acts, environmental controls, environmental action plans) and financial instruments (e.g. support for investments in environmental technologies and incentives and payment systems that directly reward the provision of environmental goods and services through conservation at the local level) that are targeted at local users and managers of biological systems, such as financing local initiatives that preserve biodiversity;
- Integrate the **economic evaluation of biodiversity** into planning and decision-making processes;
- Improve the **relevance of policy and legal reforms** (establish simple regulatory frameworks) and **enforce existing regulations on resource use and access rights** (e.g. by devolving responsibilities to the communities);
- Establish a **long-term commitment** regarding the use of resources between government, industries and societal groups and improve cooperation between relevant stakeholders*;*
- Enhance **markets for non-timber products** due to the history of local markets and products showing low returns as well as the difficulty of developing successful new products;
- Invest in **capacity building** in local organizations;
- Explore further **funding opportunities for conservation**.

11.2 Section 2: Valuing Biodiversity Benefits for Rural Vulnerable Groups

The correlation between biodiversity, ecosystem services and the security of human livelihoods is complex and extremely varied. Large disparities exist in the degree of dependency on ecosystem services and, subsequently, in the levels of vulnerability to changes in or losses of biodiversity and the respective impacts in the provision of ecosystem services. There is also an imbalance for those most affected by, yet least able to respond to, the loss of ecosystem goods and services as well as the inequality in the global distribution of derived benefits. Several international case studies complement the quantitative assessments.

Vulnerability assessments were conducted based on a partial quantification of the economic dependency of local economies on ecosystem services. The provisioning, cultural, regulating and supporting functions provided by ecosystems services were evaluated based on their direct or indirect contributions to employment (leading to income variations), non-market values and the welfare enhancement of local communities provided by extracting natural resources. The report found rural poor in most of developing countries and the poor communities in the remote rural areas in Europe to be the most directly dependent on ecosystem services as well as the most vulnerable to natural hazards, rapid resource depletion and biodiversity degradation. Concretely, approximately 70% of the world's poor live in rural areas and rely on benefits derived from environmental resources for at least 25% of their incomes.

As already mentioned (3.1.1), the main economic activities of the rural poor occur within the primary sector as well as coming from direct income sources provided by retailers of products from ecosystems such as food, fruits and wood fuel etc. Thus, ecosystem services form the backbone of rural populations' livelihoods; they provide material welfare and enhance non-income benefits, e.g. health and cultural benefits. Interestingly, although wealthy communities and households receive a higher total income from natural resources, poor households remain more dependent upon ecosystem health due to their often direct reliance on selling primary resources or labor (e.g. fishermen and foresters). This was illustrated by a comparison of the vulnerabilities of low versus high-income rural regions within Europe, showing that the economic structure of poor, agricultural regions is more strongly dependent on biodiversity and the provision of ecosystem services than that of richer areas (even when these wealthy areas are also remote and predominantly reliant upon agriculture).

Our results show that the composition of the ecosystem service value for selected European countries, calculated as percentage of GDP, vary across different countries and, more importantly, vary among country-income categories. Among high-income countries, Finland and Sweden show the highest value of ecosystem services with respect to the national GDP. This is partly due to the large total area of wetland and freshwater ecosystems in these countries. Secondly, the value of forest provisioning services in Sweden and Finland are particularly high, reflecting the fact that forestry is a widely practiced activity in these countries. In middle-income countries, relatively high values of forest ecosystems are found in countries that are landlocked or with a short coastline, such as the Czech Republic and Slovenia, while in the remaining countries high values are provided by wetlands and freshwater ecosystems and coastal recreation. In low-income countries, ecosystem service values tend to be high particularly for forests and, in Bulgaria and Croatia, wetlands and freshwater ecosystems. The high value of wetlands and freshwater ecosystems in Bulgaria and Croatia reflects the relatively high per-hectare values and the low GDP in those countries.

The report also explored the relationship between ecosystem services, biodiversity and income-related vulnerability in more detail within Europe. First, we focus our analysis in rural agricultural areas and investigate the link between the livelihood of the rural poor, biodiversity and the provision of ecosystem services. In this context, we proposed to identify the possibility contours, which we define as social vulnerability contours maps linking human livelihoods to biodiversity richness and the level of ecosystem services. Among the three income categories, the narrowest boundaries are found in high-income countries. With the exception of Austria, France and Switzerland, the biodiversity levels are lower than the average values in middle and low-income countries. Moreover, the contribution of agricultural activities to the countries' economy is generally low, with the exception of Finland, where agriculture added value accounts for 3% of the GDP and 37% of the population lives in rural areas. In addition, ecosystem service values generally provide a small contribution to the economy of high-income countries, with the notable exception of Sweden and Finland where they account for 14% and 11% of the country's GDP. In middle-income countries one can notice an enlargement of the boundaries, with the added value of agriculture, rural population and biodiversity levels increasing compared to high-income countries. On the contrary, the largest possibility contours are found in low-income countries, where the highest levels of agricultural added value (10% in Romania), unemployment rate (11.1% in Slovakia) are found, suggesting a higher vulnerability of these economies to socio-economic and environmental shocks. The highest values of biodiversity (91.3 in Bulgaria) and ecosystem service value over GDP (30% in Croatia) are also found in low-income economies. This suggests a large potential for biodiversity, mediated through the provision of ecosystem goods and services, to act as a positive stimulus for the countries' economy, create employment, and contribute to the livelihood and welfare of the populations.

Second, we focused our attention on a more explicit spatial scale and investigate all NUTS2 regions in Europe with the highest density of agricultural land-use. For the calculation, all the grid cells identified as "agricultural areas" in Corine were considered, including arable land (i.e., non-irrigated, permanently irrigated and rice fields), permanent crops (i.e., vineyards, olive groves, fruit trees and berry plantations), pastures, and heterogeneous agricultural areas (i.e., annual crops associated with permanent crops, complex cultivation patterns, land principally occupied by agriculture with significant areas of natural vegetation, and agro-forestry areas). Among regions with agricultural land-use density of 70% or higher, the three NUTS2 regions with the lowest and highest GDP per capita in 2007 were selected. The three rural poor regions identified are Del-Alfold and Eszak-Alfold in Hungary, and Lubelskie in Poland. In addition, and for the sake of a running a comparative analysis, the three rural regions with highest GDP per capita values among the regions with a strong agricultural land-use density are also selected. We refer to Southern and Eastern Ireland, Berkshire, Buckinghamshire and Oxfordshire in the United Kingdom, and Groningen in the Netherlands.

The dependencies between the socio-economic, biodiversity and ecosystem value indicators in the selected rural regions differ substantially between the two groups of regions, despite the fact that both groups represent rural agricultural areas. In low-income regions, both the employment in the primary sector as a share of total employment and the overall unemployment rate are higher, suggesting that these areas are particularly vulnerable to socio-economic changes and environmental degradation. The low employment rate in high-income agricultural regions may be explained by the high level of mechanization of agricultural practices in these areas. On the other hand, biodiversity levels are substantially higher in low-income regions and the value of forest ecosystem services is particularly high when compared to the total GDP of these regions. This supports the hypothesis that the economic structure of vulnerable rural regions of Europe – such as the selected low-income, agricultural regions – is more strongly dependent on biodiversity and the provision of ecosystem services than that of richer areas, even if remote and predominantly agricultural.

Finally, we also investigate the role of biodiversity in the definition of social vulnerability contours maps by focusing our analysis in rural communities living in remote regions. Here, we focus on two types of remoteness: first we consider mountainous regions of Europe, as case-study for geographical remoteness, and second we look at distance from major cities as an indicator of the social dimension of accessibility. The results for remote mountainous regions support the previous findings, and respective social vulnerability contours maps, for rural areas in the sense that they confirm that poor communities are more reliant on ecosystem services and biodiversity than less vulnerable ones. The comparison with rural regions, however, highlights how remote mountainous regions are more homogeneous in terms of biodiversity levels, population density and ecosystem service values. However, unemployment rates and employment in the primary sector are higher in the considered poor remote regions and so are the values of the biodiversity indicator, although high biodiversity levels are found also in the high-income regions. Finally, population density is also lower in all considered regions and lower, on average, among the low-income regions. Communities living in regions with higher distances from major cities were also found to be more vulnerable than populations in more accessible regions. This is largely due to their lack of access to or the prices and affordability of substitute products and services. Isolation additionally limits coping strategies to deal with a deterioration of environmental services. Further, the location of rural households affects their potential to access markets or other sources of income from off-farm employment opportunities in neighboring urban areas.

An introduction to the international perspective of the groups of people particularly particularly at risk from the degradation of ecosystems is presented in three global case studies. Although they reflect different circumstances, they provide interesting insights on the types of measures that may be universally applicable to protect the rural poor from ecosystem degradation, and are summarised below.

- Unclear land tenure rights and expansionist agricultural policies in Mexico resulted in an immense reduction (73%) of the country's dry forests. Although law revisions transferred ownership and management responsibilities to the rural communities, the lack of technical and organizational capacities in place has prevented the sustainable management of their forests. The poorest individuals in these communities remain the most heavily impacted by the loss of forest and soil fertility.
- The case of the Mekong River in China, demonstrates how unsustainable fishing practices and hydroelectric schemes threatened what is considered to be the most productive inland fishery. The dependence on fish of the locals prompted them to create protection schemes and rules limiting fish catches.
- Mangrove destruction due to expanding aquaculture in Thailand has caused a collapse in the populations of commercially important fish species. Surrounding communities have a high dependency on the fish for nutrition and income due to their lack of education and infrastructure, highlighting the importance of preserving the remaining mangrove areas and fish populations.

While these three cases represent very different environmental challenges and require locally adapted solutions, several recommendations and paths of action can be outlined which are also relevant for other environmental degradation cases threatening the livelihoods of vulnerable poor rural populations:

- **Capacity building** both in terms of technical and organizational capacities is required to create more sustainable management schemes
- **Long-term perspectives and knowledge about delayed benefits and costs** should be addressed
- While local communities often develop **sustainable management plans** and locally accepted regulations, these customs **need to be legally integrated into national legislation**, expanded to encompass additional threatened regions and enforced in order to be effective.
- Development plans also need to be reviewed more thoroughly, including considering **transboundary effects**, in order to consider the potential impacts on ecosystem services and thus local populations. Perverse incentives created by poorly developed management plans or governance regimes have to be eliminated and avoided in future policy design.
- **Local knowledge and past sustainable traditions** can also serve as a valuable resource for addressing environmental problems in a more effective, decentralized manner, while also receiving support from local communities and national governments.

Although the above recommendations are by no means intended to serve as a blanket solution to the threats facing vulnerable populations as a result of environmental degradation, they are a useful starting ground. As poor rural populations often bear the largest effects from damaged ecosystem services, they need to be involved and considered throughout policy formulation and revision processes.

12 POLICY RECOMMENDATIONS

The complex linkages and trade-offs between biodiversity, ecosystem services, employment and the impacts on vulnerable groups do not allow for one single simple policy approach to improve conditions both for nature and people. Moreover, the social aspects of biodiversity are not addressed by a specific policy, but rather constitute cross-cutting issues that affect a wide range of policies on different scales. Many other studies have shown that the protection of biodiversity and ecosystems cannot be restricted to nature protection policies only, but instead have to be mainstreamed across different policies and sectors. By expanding the scope to include the even more complex interactions between biodiversity and the enhancement of jobs and of livelihoods in vulnerable areas, the range of relevant policies becomes even larger.

The TEEB report on the economics of ecosystems and biodiversity for policy makers concludes with some specific recommendations. Some of them are also relevant in the context of the social dimension of biodiversity.

1. *Promote investment in ecological infrastructure*. Restoration of wetlands, river basins, forests, wetlands and rivers each offer the potential to increase the provision of a range of ecosystem services. In a number of areas this will lead to an increased availability of products and services either at no cost, low cost (e.g. water supply, non timber forest products) or higher quality (water, soil) than would be the case without restoration. Similarly, it can help in the reduction of natural hazard risks (e.g. flooding and landslides). Investment here has a potential to support the rural poor. The level of the benefits will depend on the level of the service and the reliance and vulnerability of the social groups in question. Investments in the restoration of ecosystems create jobs and may provide new opportunities for income and skills development in rural areas.

2. *Promote payments and markets as a means to reward benefits*. Payments for ecosystem services (PES) have the potential to reward providers of services, including local communities, farmers, and foresters working to maintain or restore ecosystems. This can provide an income stream for different activities and for different sectors and social groups and can support the viability of rural communities. Targeted PES schemes that address ecosystem service provision, biodiversity and social policy (and regional development) objectives can be a constructive tool for sustainable development. The PSAH (National Programme for Hydrological Environmental Services) scheme in Mexico is one example of a tool that addresses multiple objectives – biodiversity, water availability, aquifer recharge, deforestation and poverty.

3. *Enforce regulation and promote pricing as a means to halt losses in biodiversity*. The impacts of biodiversity loss, or of pollution damage, can lead to significant losses for a range of different social groups. For example oil pollution on beaches and coastlines and eutrophication of waters can reduce the productivity of certain economic activities (e.g. aquaculture, oyster beds, mussels and also local tourism). The implementation and improvement of the liability directive and similar compensation mechanisms can help reduce the risk of loss of livelihoods in the future.

4. *Reform environmentally harmful subsidies*. Certain environmentally harmful subsidies have the potential to be both a waste of public monies (e.g. where focused on outdated priorities) and also lead to environmental damage (e.g. water subsidies leading to over abstraction of aquifers). In some cases this can have deleterious effects on social groups – e.g. access to water or increased cost of access to water. Targeted reform of subsidies can help to reduce these problems.

5. *Align policies across sectors with key Millennium Development Goals.* Integration of environmental issues across sectors and into trade and development policies have the potential of taking the EU's external dimension into account and addressing the synergies between biodiversity and social policy, in the EU and internationally. The exact nature of support will naturally depend on the type of policy or activities (e.g. investment in ecosystem based climate adaptation in Bangladesh could offer major social benefits).

6. *Increase the number of protected areas.* Protected areas (PAs) provide a range of often unpriced goods and services to the wider community, including both poorer and richer communities. Where there are poorer communities that benefit from the services (e.g. from terrestrial PAs: clean water provision, non timber forest products, fuel, culture, recreation; from marine PAs: fish and seafood and associated livelihoods, jobs) a policy of PAs can be a critical means of supporting the social dimension. There will be wide variation of importance across country and region. Again, the protection and maintenance of protected areas can offer employment and income opportunities and contribute to rural development.

In order to capture this challenging complexity and to get to policy recommendations as specific as possible, this chapter is divided into two parts, dealing with international policies and EU policies separately. Both sections will firstly summarise policy needs identified in the study, then highlight specific policies where reforms or adjustments will be needed to adequately address these needs. At the end of this section, main findings will be summarised and conclusions will be drawn from the previous parts, mainly to set priorities for policy action from the EU perspective

12.1 International Policies

The analysis of the links between biodiversity, ecosystems, jobs and vulnerable groups has shown that the benefits from biodiversity and ecosystems (and the costs incurred when they are depleted) are often not equally distributed. In general, rural populations in developing countries are the most dependent on ecosystem services for their livelihoods and, more specifically, for nutrition, construction materials, and culture. They are also the most vulnerable to the depletion of or even slight changes to ecosystems.

As a result, international policies must focus especially on these vulnerable groups, thereby opening the discussion to a plethora of different policy fields, including environmental and resource policies, agriculture and land use as well as trade policies and development aid.

In general, international policies have to involve:

POLICY SHIFTS

- **Perverse susbsidies/incentives** that encourage ecosystem degradation **will be removed or phased out** (e.g. promoting large scale and intensive agricultural practices, enhancing pressure on land through biofuel production and further meat consumption and decreasing the number of, or even abandoning, fishing quotas);
- **Short-term policy appraisals** benefitting only limited (but often more economically powerful) groups **will be shifted to long-term policies** that generate more net benefits and take the wider population into account, involving respective stakeholder-groups from the start of the policy formulation/design;
- Access to crucial ecosystem services will be guaranteed for vulnerable groups by **safeguarding tenure and property rights** (e.g. by ABS, national law enforcement, promoting land reforms where needed, ensuring local participation).

MANAGEMENT AT LOCAL LEVEL

- **Local knowledge and experiences** in maintaining ecosystems and biodiversity **will be more seriously taken into account** instead of creating overly broad solutions that cannot be adapted to local and regional conditions;
- Poor people will be **compensated and trained for alternative employment opportunities** if they are affected by regulatory measures to preserve biodiversity.

DEVELOPMENT AND SHARING OF KNOWLEDGE

- **Best practice examples** where the long-term maintenance of ecosystems and biodiversity currently ensures stable livelihoods will be investigated, demonstrated and encouraged; and
- Future **evaluation and assessment methods for biodiversity and ecosystem services** will **consider employment and poverty alleviation** to a higher degree.

RELEVANT INTERNATIONAL POLICIES FOR THE SOCIAL DIMENSION OF BIODIVERSTY

Several policy fields can be considered as relevant when addressing the social aspects of biodiversity conservation. On an international level, the *Convention on Biological Diversity (CBD)* is perhaps the most obvious policy directly regarding biodiversity conservation. Yet, even this conservation-oriented policy raises pertinent social considerations, such as the concept of benefit sharing and sustainable use and development (having long-term benefits, especially for dependent rural and vulnerable populations). Considerations such as local knowledge, practices and innovations of indigenous and rural communities are key aspects of this policy (CBD, Article 8(j)).

In an attempt to address the inequalities existing between those most affected by, yet least able to respond to biodiversity loss, the CBD attempts to balance the right of resource-providing countries to enjoy the benefits of their natural resources, while allowing technology-rich countries selective access under agreed upon conditions through an Access and Benefit Sharing (ABS) program.[101] The use of genetic resources by foreign bodies must be consentual and supported by local populations in an effort to ensure that resource extortion and an exaggeration of pre-existing vulnerabilities are minimized.

Additionally, the CBD includes a Biodiversity for Development Initiative which aims to address the link highlighted throughout this paper between sustainability and poverty reduction and incorporate the three objectives of the Convention[102] into international development processes. This initiative recognizes that development strategies failing to protect biodiversity work counter to poverty alleviation. The International Day of Biodiversity 2010, as part of the International Year of Biodiversity, had the theme ‘Biodiversity, Development and Poverty Alleviation’, attempting to raise awareness of this issue and increase practical action (http://www.cbd.int/idb/2010/).

The 10th Meeting of the Conference of the Parties to the CBD, held in Nagoya, Japan in October 2010, adopted a new strategic plan which includes 20 headline targets organized under five strategic goals. Under Strategic goal D “Enhance the benefits to all from biodiversity and ecosystem services”, Target 14 specifically addresses the role of vulnerable groups within the protection of natural resources and biodiversity: “By 2020, ecosystems that provide essential services, including services related to water, and

[101] On the COP 10, which was held in Japan from from 18 to 29 October 2010, Parties released the Nagoya Protocol setting terms on how countries will permit access to genetic resources, share the benefits arising from their use, and cooperate with one another in allegations of misuse.

[102] The three objectives of the CBD are: the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (http://www.cbd.int/convention/about.shtml)

contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable."

On a related note, the *International Millennium Development Goals (MDG)* strive to support the CBD's 2010 Biodiversity Target in significantly reducing the rate of biodiversity loss (MDG; Goal 7). While this goal focuses predominantly on biodiversity, it inherently appreciates the importance of conserving biodiversity to achieving all eight MDG.

The Millennium Development Goals (MDGs), targeted at cutting world poverty by half in 2015, are the most broadly supported, comprehensive and specific development goals the world has ever agreed upon. Among others, MDG-7 highlighted explicitly the target of reducing biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss. In particular, it acknowledges the existing strong link between biodiversity conservation and poverty alleviation and indicates that biodiversity is vital to the support of human well-being by underpinning a wide range of ecosystem services on which life depends. Evidence has shown that billions of people, in particular the poorest, rely directly on diverse species of plants and animals for their livelihoods and often for their very survival. Therefore, the irreparable loss of biodiversity will gradually affect the capacity of ecosystems to provide goods and services that are essential to the achievement of poverty, hunger and disease reduction as set out by the MDGs. CBD goals and the MDGs implementation should be coordinated so that initiatives targeted to promote the conservation of biodiversity do not limit the benefits that could accrue to local communities, and so that the attainment of MDGs through short-term economic development does not harm biodiversity. This means likely trade-offs and synergies between those development processes should be seriously taken into account in the decision-making procedure.

Moreover, since biodiversity and the environment are public goods, of which the ownership is often poorly defined, the fast growth of economies in the developing countries may lead to the "tragedy of the commons" (Hardin, 1968). Therefore, good local governance is important to guarantee the sustainable use of natural resources for their development, and clearly identified property rights are the basis of equally distributing economic benefits of biodiversity and ecosystem among stakeholders (e.g. Payment for Ecosystem Services schemes) and of creating economic incentives for more effective and efficient conservation of biodviersty. This in turn will stablise the ecological cycling procedure and sustain the continual provision of ecosystem goods and services to support human livelihoods. Finally, international efforts should be placed on helping the developing countries on capacity building, in terms of biodiversity impact assessment, the creation of protected areas for biodiversity conservation and natural resources management. Technological transfer from the North to the South will improve the efficiency of using natural resources in many resource rich developing countries and contribute positively to halting the loss of biodiversity.

REDD is one of the new developed international financing mechanisms, through which developed countries would provide funds by implementing a range of policies and projects to "Reduce Emissions for Deforestation and Degradation" in developing countries. Moreover, the REDD mechanism is believed to have the potential to alleviate poverty and reduce conflict over resources, as it aims to avoid increased threats to the poor ('no-harm' REDD) on the one hand, and seeks to deliver benefits to the poor on the other hand ('pro-poor' REDD) (Peskett et al, 2008). Evidence suggests that early action on REDD has mutual beneficial links to the achievement of other international processes, such as delivery of the Millennium Development Goals that involves both monetary and non-monetary benefits to the local communities and indigenous people. For instance, monetary benefits, such as direct financial flows of REDD voluntary funds to the recipient countries could contribute significant income and growth potential to communities and individuals within these countries. REDD could potentially make communally owned forest areas more 'profitable', and their establishment more attractive to poorer communities, by adding carbon payments on top of the income generated from Non-Timber Forest Products (Peskett et al, 2008).

Moreover, REDD can also lead to an enlarged protection area which contributes to new job opportunities in conservation and tourism activities and increases labour income to local communities (Harvey et al, 2010). As for non-monetary beneifts, the REDD mechanism can provide subsistence forest products, including biodiversity and ecosystem services (food, fuel, water, etc.) to support the livelihoods of local communities and the rural poor. By encouraging the protection of environmental assets, REDD mechanisms could make an important contribution to the resilience of the poor under changing environmental conditions, including climate change (which is projected to increase the frequency of droughts, floods and storms in many areas). However, previous international and national policies have, for various reasons, failed to prevent deforestation in developing countries (Angelsen, 2009). Thus, a new architecture of governance REDD+ is being developed in the international policy arena to go beyond the REDD mechanism by undertaking a suite of actions that reduce or enhance the removal of greenhouse gas emissions through conservation, sustainable management of forests and enhancement of carbon stocks. Therefore, the successful implementation of REDD+ will be able to stabilise forest cover, store carbon in forests more effectively and efficiently and provide co-benefits more equally (incl. poverty reduction and biodiversity conservation) to local communities and indigenous people.

In the last years international trade neotiations under the World Trade Organisations (WTO) have almost seen a standstill also because of increasing scepticism from developing countries in further trade liberalisation and a higher recognition of unjust power conditions. Since 2006, European trade policy has been guided by the Global Europe strategy, which reoriented European bilateral trade agreements through a new generation of Free Trade Agreements with Asian markets and stepped up European focus in key areas such as intellectual property and access to raw materials.[103] The strategy has often been criticised by development and environmental NGOs as being too narrowly focused on the EU competetiveness in the world while widely ingoring sustainable development and human rights in poorer countries. Part of the strategy is to gain an unrestricted access to natural and energy resources in partner countries in response to the high EU dependence from imports and to meet its energy needs (imported energy is estimated to make up 70% of the EU's consumption by 2030).

However, unrestricted and cheap access to natural resources bears the risk that ecosystems are exploited and human rights are violated, especially in countries where land rights are not well established and governements are weak. Currently, this can be observed in the large scale land acquisitions taking place in African countries but also in Latin America and Asia with big companies and governments of industrialised countries buying off vast areas of land to grow energy crops for biofuels or food (World Bank 2010). Although impacts of further liberalisation of trade on natural resources and the rural poor has been widely documented in recent years, it does not seem to be sufficiently reflected in the Global Europe strategy. For better policy coherence and to contribute to the achievement of the Millenium Development Goals, EU trade policies have to be critically assessed for their impacts on developing countries.

12.2 European Polices

Similar to the needs for international policies, the EU also has to ensure that there are no perverse subsidies or incentives for further ecosystem degradation within its own territory due to European policies. More specifically, pressure on ecosystems within and especially outside of protected areas has to be alleviated through land use policies that consider natural thresholds instead of solely focusing on the suggested demand for natural resources. It can be presumed that such a general shift in policies would be beneficial for job creation in agriculture, fisheries, forestry and other sectors since sustainable practices are often more labour intensive than highly industrialised ones.

[103] see website of DG Trade: http://ec.europa.eu/trade/creating-opportunities/trade-topics/european-competitiveness/

Synergies can only be gained if policies ensure that actors investing in and maintaining ecosystems are rewarded for their efforts. If not via the use of markets, additional measures have to be found that make it attractive for farmers or foresters to apply sustainable practices. The discussion on these measures is not new; however, the implementation of alternative measures such as payments for ecosystem services (PES), fiscal transfers or the stronger involvement of the private sector to enhance ecosystems services remains limited.

RELEVANT EUROPEAN POLICIES FOR THE SOCIAL DIMENSION OF BIODIVERSTY

At a European level, the *Common Agricultural Policy (CAP)*, which accounts for 37% of the EU's total budget, involving expenditure of €51.5bn in 2009, is particularly relevant for the protection of biodiversity and the livelihoods of rural communities. The objectives of the CAP, originally focused on securing food supply and securing the incomes of farmers, have over time expanded to incorporate rural development and environmental goals. Member States have been required to provide voluntary schemes to provide payments to farmers to encourage environmentally beneficial management practices since 1992 under the agri-environment measure. In 2000, Pillar 2 of the CAP was established to bring together a range of measures that supported improvements in the environment and countryside, promote the competitiveness of the agricultural and forestry sector and enhance the quality of life in rural areas, thus benefiting both biodiversity and more vulnerable rural communities.

A Commission Communication on a post 2013 CAP[104] published in November 2010 represents a 'potentially bold move' to reorient the CAP towards meeting the needs of EU society over the next decade.[105] It proposes the greening of Pillar 1, which has the potential to deliver a basic standard of environmental management across all European farmland, and it acknowledges the need for rural development policy to provide targeted support for ecosystem services, High Nature Value farming systems and appropriate land management within Natura 2000 areas.

Similarly, the *Common Fisheries Policy (CFP)*'s key objective is to ensure exploitation of living aquatic resources that provides sustainable economic, environmental and social conditions (Council Regulation 2371/2002) but to date this has not been achieved. Although 76% of EU fish stocks are deemed within safe biological limits (Sissenwine, 2010) there is a need to reduce fishing capacity further to bring the remaining 24% in line with the sustainability target. In 2005, the total employment in the fisheries sector of the EU-25 in 2005, amounted to 407,000 persons, representing 0.2% of total EU employment (Salz and Macfadyen, 2007) and the fishing communities involved are likely to suffer the impact of capacity reduction. The CFP is currently undergoing a major reform, which will be concluded in 2012.

Recent debate in the European Commission placed increased emphasis on the importance of green infrastructure for multi benefits to the economy.[106] *Green infrastructure* can be defined as the distribution of natural capital that benefits society through the provision of ecosystem services (TEEB, 2010), which may take the form of climate regulation, water purification, and space for recreation. Green infrastructure is likely to become a key component of the delivery of the new biodiversity target for 2020, and could play a decisive role in integrating biodiversity into other policies such as agriculture, forestry, water, transport and regional and cohesion policy,[107] as it demonstrates the contribution that biodiversity can make to these policy areas. The debate has important implications for biodiversity as the provision of the services relies on the ecosystems being in good condition requiring intervention to ensure they are of an appropriate size, condition and not impacted by fragmentation.

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[104] COM(2010) 672 final. The CAP towards 2020. Meeting the food, natural resources and territorial challenges of the future.
[105] IEEP (2010) IEEP's initial reaction to the Commssion's blueprint for the CAP post 2013. CAP2020. http://cap2020.ieep.eu/2010/11/19/ieep-s-initial-reactions-to-the-commission-s-blueprint-for-the-cap-post-2013?s=2&t=7
[106] 'EC workshop: towards a green infrastructure for Europe', March 2009. Workshop proceedings are available at: http://www.green-infrastructure-europe.org/
[107] http://ec.europa.eu/environment/nature/info/pubs/docs/greeninfrastructure.pdf

Green infrastructure has the potential to provide many services at a much lower cost than equivalent man-made solutions, thus providing benefits for society. When green infrastructure is replaced by artificial instalments, such as water treatment plants, it passes on a cost to society which may otherwise have been avoided. In addition, it offers the possibility of multiple benefits through attracting tourism and the diversification of the local economy providing benefits to rural communities (see Danube delta case study below).

Green infrastructure can also be important for the rural poor in developing countries through the services of water retention and wastewater treatement (see case study on Uganda below). However, a proper knowledge of cost savings throughout the life cycle of hard infrastructure projects compared to green infrastructure projects is lacking and an evaluation of the costs and benefits of green infrastructure at different scales is needed to ensure that those impacted by restrictions in development are adequately compensated by those who benefit, as the rural poor could suffer the most from the use of land for provisioning services for urban populations.

Examples of green infrastructure projects

The restoration of two polders in the Danube delta, which had been used for intense cropping and were suffering from declining profits, resulted in a diversification in livelihood strategies towards fisheries, tourism, reed harvesting on seasonal pastures. These activities earn an average US$37 per hectare and restored wetlands produce 34kg of commercial-sized fish per year, providing jobs for 20-25 jobs over an area of 36.8km^2. At Katlabuh Lake, improved water quality is expected to enhance access for 10,000 local residents to drinking and irrigation water. (Ebert et al, 2009).

In South Africa, an NGO, Water for Work, has initiated a payment for ecosystems services scheme to hire and train formerly unemployed local people to clear invasive alien plants from municipal watershed catchments, financed under contract from local authorities. In the De Bos Dam catchment, 3,387ha invasive alien plants were cleared between 1996 and 2001 at a cost of R4.9m. The contract generated 91 person years of employment, and prevents the loss of 1.1-1.6m m^3 of water per year (Turpie et al., 2008).

The Granollers urban wetland near Barcelona, Spain, carries out the final step of water treatment after it leaves the municipal wastewater plant (Garcia & Domingo, 2006). Operational since 2003, it costs €12,000 per year to maintain, freeing municipal budget funds for other measures. It was estimated to provide €59,940 worth of public benefit to the 18,000 visitors between June 2006 and January 2007, thereby improving the quality of life of local residents (Rosseau et al., 2009).

The Nakivubo Swamp, a 5.29km^2 wetland on the outskirts of Kampala, provides an example of the use of green infrastructure in Uganda. With more than 100,000 people living on the fringes of the wetland, largely in high-density slums, effluent is directly discharged into the swamp where it is purified before entering Lake Victoria. The value of the wetland to the local population is judged to be between US$1-1.75m per year (Emerton et al., 1999).

EU regional policy aims to reduce the gaps in well-being between regions and ensure coherent and fair economic development within the EU. The policy is financed through the *Structural Funds and the Cohesion Fund* and constitutes 35% of the EU budget for the spending period 2007-2013 (€348 billion)[108]. The funds finance a variety of measures, including transportation infrastructure, urban regeneration and rural development. While activities can cause deterioration of biodiversity through the fragmentation of landscapes and habitats (Kettunen *et al*, 2007), the funds provide important funding opportunities for biodiversity conservation such as the development of infrastructure linked to biodiversity and investments in Natura 2000. Projects must, however, demonstrate a contribution to the broader sustainable socio-economic development of the region in which they are based. Indeed, the prevention of environmental

[108] http://europa.eu/scadplus/glossary/structural_cohesion_fund_en.htm

risks is one of the priorities of the Structural Funds, offering the possibility for funding actions to maintain or restore the capacity of ecosystems to mitigate flooding, wild fires and drought risks (Kettunen *et al*, 2009). In other cases, opportunities exist for the investment in facilities to promote nature-based tourism, with potential positive impacts on economic development of disadvantaged areas and on biodiversity (see EEA, 2009).

Despite these opportunities, uptake of measures supporting biodiversity under the Structural and Cohesion Funds have been limited. This can be partly attributed to the bureaucracy and administration burden of accessing the funds (Torkler *et al*, 2008) and the lack of absorption capacity in recipient regions to utilise the funds (EA, 2009). An additional issue is that the decision on how the funds are to be spent is made entirely at Member State level, which means that despite the opportunities that exist to fund biodiversity and social cohesion projects, there is no means at the EU level to ensure this happens. Moving forward, the way in which the funds will be used will change in the next financing period (2013-2019).

12.2 Priority Actions for EU Policy Making

Based on the policy needs shown above and the different policies on EU and international scale highlighted, the following priorities in EU policy actions can be derived for better consideration of social aspects in biodiversity and related policies. The actions should be understood as necessary steps in the short and medium term that would allow for better integration of biodiversity and its social dimension in future policy making. Rather then providing a roadmap for policy making, the list should support a broader thinking among decision-makers who seek to find the right elements for a strategy of integrated biodiversity policy.

1. Increase efforts to raise the awareness of stakeholders and the wider public about benefits arising from biodiversity and eco-system services

Changes in policies or cuts in subsidies can only be justified and enforced if their necessity is well understood by the stakeholders affected and the wider public. On the other hand, there is still a lack of understanding of biodiversity and ecosystem services themselves and of their relationship to human well-being (and employment). Builiding on current initiatives such as "We are all in this together"[109] more efforts have to be put on awareness raising and communication of the threats of biodiversity loss and ecosystem degradation as well as on solutions to overcome these problems. Such campaigns should target a broader involvement of both business and consumers in protection of biodiversity and more sustainable production and consumption. Lessons learnt can be derived from communication practices on climate change that have led at least to a broad acknowledgement of the impacts climate change will have on society and that action is needed.

2. Support regional approaches for payments for ecosystem services (PES) and investigate potentials and obstacles for a wider application.

Best-practice examples of PES with involvement of private donors are still rare on a European scale, leaving the discussion of a wider application of PES a mere academic debate. A clearer understanding of obstacles and possibilities of PES approaches can only be gained if pilot projects in different regions and ecosystems are launched and evaluated. Good examples from countries outside the EU and experiences gained there can serve as a starting point to design similar projects in the EU, funded by relevant instruments such as LIFE+ or by research or regional development funds.

3. Determine a time-horizon by which subsidies and policy incentives harmful for biodiversity and vulnerable groups will be phased out

[109] http://ec.europa.eu/environment/biodiversity/campaign/index_en.htm

The COP 10 of the CBD in Nagoya in October 2011 established a new set of headline targets for future biodiversity policies. Target 3 foresees the phasing out of harmful subsidies and incentives for biodiversity by 2020 latest. Although voluntary the EU should take this target seriously and should start in the next few years to clearly identify such perverse incentives. Secondly, building on a robust analysis that also takes account of areas where EU policies lack coherence, a phasing out model should be established with a clear time frame. That would help stakeholders affected to adapt to diminishing support over time and will thereby alleviate the inevitable pressure from opposing forces. Such a phasing out model could follow the normal co-decision procedure of EU policies starting with a white paper on harmful subsidies to biodiversity.

4. Adopt the "Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization" and take effective and quick action for its implementation

The EU should swiftly adopt the Nagoya Protocol, which contains, in essence, legally binding rules on sharing the benefits of using biodiversity with those who have preserved biodiversity and developed traditional knowledge on how to use it. The Nagoya Protocol requires all parties to ensure that the access and benefit-sharing legislation of countries where genetic resources or associated traditional knowledge is accessed are complied with. The EU should take appropriate measures (e.g. in its patent legislation), paying particular attention to the rights of indigenous and local communities, and should establish a regulatory framework requiring member states to do the same. It should provide financial means for enabling other countries to implement the Nagoya Protocol.

5. Integrate the ecosystem-based approach in development aid policies and ensure a strong involvement of local communities in land-use decisions

Effective development aid - that supports local communities in economic development while taking into account a sustainable use of natural resources - has to follow new and long-term strategies. The ecosystem-based approach provides for a general framework ensuring that human activity does not decouple from the capacity and resilience of ecosystems. The ecosystem approach also acknowledges the involvement of local communities in land-use decisions via effective participation. This would ensure a better consideration of local and traditional knowledge as well as more sustainable implementation through higher acceptance. For a sound framework of applying the ecosystem approach in development cooperation, more research is needed (and has to be funded) and a process of rethinking current approaches has to be launched.

6. Establish a monitoring process that highlights the contribution and the negative effects of EU polices to the achievement of the Millennium Development Goals

With regard to existing evaluation measures in place such as the regular Eurostat report on the progress of EU Sustainable Development Strategy (SDS) or the evaluation of the Environmental Action Programme (EAP), it is surprising that no particular assessment is being conducted on the effects of EU policies on international development and poverty reduction, summarised and internationally acknowledged by the Millenium Development Goals (MDGs). Such an evaluation process would not only raise the awareness of unintended or counteracting effects of EU policies, it would also question policies that are currently not sufficiently debated regarding their impacts on natural resources and the rural poor in developing countries (e.g. trade, financial or agricultural policies).

7. Complement current EU policies for nature protection with measures focussing on the connectivity of landscapes

Many studies and indicators on biodiversity loss in Europe have shown that nature conservation policies cannot be restricted to protected areas but have to ensure a better connectivity of ecosystems on landscape level. Green infrastructure approaches can be seen as key for a European network of functioning ecosystems and habitats. Green infrastructure projects have to be well-understood in terms of their costs and benefits as well as their effective implementation. Building on current research initiatives, policy-makers should already think ahead how green infrastructure could be integrated in current policies, taking into account that it affects a wide range of policy fields such as regional policy, cohesion, nature protection, water, agriculture, forestry etc.

SECTION IV:

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ANNEX A – DETAILS ON THE EMPLOYMENT DATA

The following details the main issues arising from the EU and global employment data, as well as any assumptions that had to be made in order to aggregate the global data, and in the population of Table 2.

Global employment data

Global employment figures per main industry sectors were taken for each country from Laborsta (an International Labour Office database on labour statistics operated by the International Labour Organisation Department of Statistics - http://laborsta.ilo.org). Laborsta presents information on total employment by economic activity for all the world's economies. The data illustrates absolute figures on the distribution of the employed by economic activity, according to either the industry classifications ISIC-68 (http://laborsta.ilo.org/applv8/data/isic2e.html) or ISIC Rev.3 (http://laborsta.ilo.org/applv8/data/isic3e.html), or to both versions side by side, in cases where the latest revision of this international classification has been adopted during the 10-year time series covered in the Yearbook. Hence the figures used are the average over the 10-year time series period. Data sources employed by laborsta to compile employment statistics include either the population census and the Labour force survey.

Assumptions for data aggregation

There were some inconsistencies in the Laborsta data; reported stats are presented by the different countries statistical offices of each country using different levels of detail. Reporting requirements and level of detail shown on figures for each of the industry sectors under the international standard industry classifications (ISIC) differ between countries. Therefore, the following assumptions were necessary to ensure a minimum level of consistency for aggregation: i) ISIC-Rev 3 classification was employed, ii) only stats sourced from the Labour force survey were used and iii) averages from 1999-2008 were calculated and used for aggregation to achieve consistency between data for different years.

Employment figures are aggregated by World Bank region. The World Bank divides emerging economies into six different regions (South Asia, Europe & Central Asia, Middle East & North Africa, East Asia & Pacific, Sub-Saharan Africa and Latin America & Caribbean)[110]. Data for these regions are comprised of data for the following countries:

- **South Asia (SA)** – Bangladesh, Bhutan, Maldives, Nepal, Sri Lanka
- **Europe and Central Asia (E&CA)** – Armenia, Azerbaijan, Bulgaria, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, The former Yugoslav Rep. of Macedonia, Republic of Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Tajikistan, Turkey, Ukraine
- **Middle East and North Africa (MENA)** – Algeria, Egypt, Islamic Rep. Of Iran, Iraq, Morocco, Arab Rep. Syrian Arab Republic, West Bank and Gaza Strip, Rep. Of Yemen
- **East Asia and Pacific (EA&P)** – Cambodia, China, Indonesia, Malaysia, Mongolia, Papua New Guinea, Philippines, Samoa, Thailand, Tonga, Viet Nam
- **Sub-Saharan Africa (SSA)** – Botswana, Ethiopia, Lesotho, Madagascar, Mali, Mauritius, Namibia, Senegal, Sierra Leone, South Africa, United Republic of Tanzania, Uganda
- **Latin America and Caribbean (LA&C)** – Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Uruguay

[110] http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20421402~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html

A full breakdown of employment figures for the above regions is given below (employment figures are in thousands). Please note that further aggregation by industry sector is impossible as some countries have reported employment stats only in broad categories of the ISIC-Rev 3 classification (for example the A-C category covers jobs in Agriculture, fishing and manufacturing). There are some grounds to believe that some stats have been double counted between categories. As the totals in some cases are above a 100%.

Industry classification	Employment by Region (thousands)					
	LA&C	SSA	SA	MENA	E&CA	EA&P
Agriculture, Hunting and Forestry	30623.8	30261.3	29081.5	15169.9	29892.0	93971.3
Fishing	709.1	565.7	1091.3	297.3	251.8	4715.2
Mining and Quarrying	852.0	821.8	77.7	438.4	2128.6	6490.5
Manufacturing	27123.2	5435.6	6638.2	9063.8	24252.1	59705.5
Electricity, Gas and Water Supply	831.9	232.3	118.3	728.0	2952.9	3665.2
Construction	12132.5	2125.4	1912.2	7356.2	9512.4	19811.0
Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods	35411.0	6666.9	7936.1	9715.2	19976.4	40874.3
Hotels and Restaurants	7003.3	1546.1	887.9	1007.2	3013.7	8096.9
Transport, Storage and Communications	9789.2	1569.1	4058.7	5077.8	11602.0	16922.8
Financial Intermediation	2029.6	112.3	386.9	585.9	2181.7	5379.2
Real Estate, Renting and Business Activities	8894.1	256.7	249.7	1149.1	6751.8	8817.8
Public Administration and Defence; Compulsory Social Security	8103.3	1034.4	1525.6	6662.3	9981.8	19018.1
Education	9153.2	1007.3	1698.1	5104.7	12309.4	21615.2
Health and Social Work	9008.8	358.6	580.9	1604.0	9229.6	7272.9
Other Community,Social and Personal Service Activities	6489.5	1342.1	2645.7	1409.2	5101.1	5774.0
Households with Employed Persons	10236.8	2376.0	366.6	110.6	335.8	5165.8
Extra-Territorial Organizations and Bodies	39.0	80.7	8.2	19.9	22.1	15.2
Not classifiable by economic activity	885.9	547.2	315.6	312.8	21.2	3787.8

World Bank regions were used to aggregate data for employment in developing economies. However, employment data from Laborsta was limited to a subsection of those included in the World Bank regions; data was only available for 77 countries out of a possible 144 developing economies according to the World Bank's categorisation. In the case of some regions (for instance South Asia and Sub-Saharan Africa), the proportion of employment covered by Laborsta figures was low (as little as 10% in South Asia). In other cases however, Laborsta figures covered as much as 73% of the region's employment (in the case of Europe and Central Asia). As a whole, the Laborsta figures cover only 32% of all possible jobs in developing economies.

Consequently, a significant assumption has been made in order extrapolate the data to obtain employment figures for the entire World Bank regions, namely that the share of jobs for which Laborsta data was available were representative of the entire region. By multiplying the World Bank total employment per region by the percentages found for each sector according to the available Laborsta data for each region, it was therefore possible to obtain an indication of the total employment per sector, per region.

	All regions			Employment by Region (thousands)														
				LA&C			SSA			SA			MENA			E&CA		
Industry classification	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**	Laborsta	%	EST. Total**
Agriculture, Hunting and Forestry	229000	27%	708754	30624	17%	45293	30261	54%	177616	29082	49%	299433	15170	23%	25641	29892	20%	41203
Fishing	7630	1%	23616	709	0%	1049	566	1%	3320	1091	2%	11236	297	0%	503	252	0%	347
Mining and Quarrying	10809	1%	33454	852	0%	1260	822	1%	4823	78	0%	800	438	1%	741	2129	1%	2934
Manufacturing	132218	16%	409216	27123	15%	40116	5436	10%	31904	6638	11%	68349	9064	14%	15320	24252	16%	33429
Electricity, Gas and Water Supply	8529	1%	26396	832	0%	1230	232	0%	1363	118	0%	1218	728	1%	1230	2953	2%	4070
Construction	52850	6%	163570	12133	7%	17944	2125	4%	12475	1912	3%	19689	7356	11%	12434	9512	6%	13112
Wholesale and Retail Trade; Repair of Motor Vehicles, Motorcycles and Personal and Household Goods	120580	14%	373195	35411	20%	52373	6667	12%	39131	7936	13%	81713	9715	15%	16421	19976	13%	27535
Hotels and Restaurants	21555	3%	66713	7003	4%	10358	1546	3%	9075	888	1%	9142	1007	2%	1702	3014	2%	4154
Transport, Storage and Communications	49020	6%	151716	9789	5%	14478	1569	3%	9210	4059	7%	41790	5078	8%	8583	11602	8%	15992
Financial Intermediation	10676	1%	33041	2030	1%	3002	112	0%	659	387	1%	3984	586	1%	990	2182	1%	3007
Real Estate, Renting and Business Activities	26119	3%	80839	8894	5%	13155	257	0%	1507	250	0%	2571	1149	2%	1942	6752	5%	9307
Public Administration and Defence; Compulsory Social Security	46326	6%	143377	8103	5%	11985	1034	2%	6071	1526	3%	15708	6662	10%	11261	9982	7%	13759
Education	50888	6%	157498	9153	5%	13538	1007	2%	5912	1698	3%	17484	5105	8%	8628	12309	8%	16967
Health and Social Work	28055	3%	86830	9009	5%	13324	359	1%	2105	581	1%	5981	1604	2%	2711	9230	6%	12722
Other Community,Social and Personal Service Activities	22762	3%	70447	6490	4%	9598	1342	2%	7877	2646	4%	27241	1409	2%	2382	5101	3%	7031
Households with Employed Persons	18592	2%	57541	10237	6%	15140	2376	4%	13946	367	1%	3775	111	0%	187	336	0%	463
Extra-Territorial Organizations and Bodies	185	0%	573	39	0%	58	81	0%	474	8	0%	84	20	0%	34	22	0%	30
Not classifiable by economic activity	5871	1%	18169	886	0%	1310	547	1%	3212	316	1%	3250	313	0%	529	21	0%	29
TOTAL	841662	100%	2604943*	179316	100%	265211*	56340	100%	330679*	59579	100%	613447*	65812	100%	111238*	149516	100%	206091*
% represented			32%			68%			17%			10%			59%			73%

*Total employment numbers per World Bank region have been sourced from:
http://data.worldbank.org/about/country-classifications/country-and-lending-groups (Data downloaded 18-06-2010)
** Total employment figures per sector per region have been estimated by multiplying the percentages obtained for some countries by region in the Laborsta stat by the total figures obtained in the World Bank statistics.

EU employment data

EU employment figures were derived from OECD Input-Output tables and Eurostat for the year 2008. These figures had to be made consistent with the E3ME classification, which was more detailed, to obtain a total headcount employment. For more information, see Annex C of GHK 2007.

Assumptions for populating the typology table

Some assumptions had to be made in order to fit the figures into the typology laid down in Table3, as follows:

Type (from Typology)	Sector (from Typlogy)	**Combined sector categories on which the employment figure is based** (in some cases these are identical)
6. Primary Industries highly dependent on ecosystem services	Agriculture, forestry, fisheries	Agriculture, forestry, fisheries
	Water Supply	Water supply
7. Processing and Manufacturing industries dependent on ecosystem services for inputs and processes	Energy Supply	Electricity Supply ; Gas Supply
	Mining	Coal ; Oil and Gas ; Other Mining
	Food, drink, and tobacco	Food, Drink and Tobacco
	Textiles, clothing and leather	Textiles, Clothing and Leather
	Wood and paper	Wood and Paper ; Printing and Publishing
	Pharmaceuticals	Pharmaceuticals
	Other manufacturing industries	Manufactured fuels, Chemicals nes; Rubber and Plastics ; Non-metallic Mineral Products ; Basic Metals ; Metal Goods ; Mechanical Engineering ' Electronics ; Electrical Engineering and Instruments ; Motor Vehicles ; Other Transport Equipment ; Manufacturing nes.
8. Services activities dependent on cultural services	Hotels and catering	Hotels and Catering
	Media and creative industries (Communications)	Communications
	Education	Education
9. Services activities dependent on provision of raw materials and fuel	Construction	Construction
	Transport	Distribution ; Land Transport ; Water Transport ; Air Transport
10. Other activities		Retailing ; Banking and Finance ; Insurance ; Computing Services ; Professional Services ; Other Business Services ; Public Administration and Defence ; Health and Social Work ; Miscellaneous Services

ANNEX B – LINKS BETWEEN BIODIVERSITY AND ECOSYSTEM SERVICES

1. Provisioning services

Provision of genetic resources

Genetic resource provision, for example provision of genes and genetic material for animal and plant breeding and for biotechnology, is directly related to the current level of biodiversity. Genetic diversity is inevitably lost when biodiversity declines. In so far as the delivery of genetic diversity can be viewed as a service in itself, therefore, biodiversity is fundamental to it. The greatest focus on genetic diversity as a service is in the protection of gene pools for agriculture (EASAC, 2009)

Bio-prospecting also relies on the provision and availability of genetic resources, although it is rarely possible to predict which species or ecosystem will become an important source. A wide variety of species – microbial, plant and animal – have been a valuable source of biochemicals but the achievements so far are assumed to be only a very small proportion of what could be possible by more systematic screening (EASAC, 2009).

For further information and detail on the contribution of biodiversity to the provision of food and fibre, see Annex 10.1 and 10.2.

Provision of food and fibre

Intensive agriculture, as currently practised in Europe, is centred around crop monoculture, with minimisation of associated species such as insects and fungi, some of which are pathogenic and able to have large impacts on yield. However, some agricultural systems based on a diversity of varieties are more robust and responsive. More diverse production systems may allow farmers to:

a. respond to changing market demands or environmental variations that might affect crop production;
b. command price premiums for high-quality traditional varieties that compensate for lower yields;
c. meet social and cultural obligations;
d. improve dietary diversity and improve nutrition.

Failure to maintain sufficient genetic diversity in crops can incur high economic and social costs. For instance, barley mixtures may successfully reduce disease incidence in Europe, and so increase yields (EASAC, 2009)

Similarly to the provision of food, commercial production of plant fibres is mostly confined to the pulp and paper industry in Europe, with most raw pulp being produced from highly managed monocultures of fast-growing pine and eucalypts. Trees planted for pulp are grown at relatively high densities, resulting in limited scope for biodiversity. Such large-scale monocultures are vulnerable to pathogen attack. Such attacks have recently devastated pine forests in western Canada. Cropping systems which promote biodiversity may prove of value in terms in ensuring robust future productivity (EASAC, 2009).

For further information and detail on the contribution of biodiversity to the provision of food and fibre, see Annex 10.1.

2 Regulating services

Pollination and seed dispersal

Pollination is essential for the provision of plant-derived ecosystem services, as many fruits and vegetables require pollinators. Approximately 80% of angiosperms are pollinated by animals. Existing evidence indicates that species richness and composition of pollinators are linked with plant reproduction and establishment and thus with all the supporting, regulating, and provisioning services that stem from terrestrial vegetation. The direct impact of losing effective pollinators is primarily on plant reproductive success and fruit production. Thus, when agroecosystems are managed in a way that reduces a diverse assemblage of native pollinators, crops are at risk of suffering yield losses (MEA, 2005f).

Despite pollinators being very significant overall to plant production, it is worth noting that most pollination systems are ''somewhat generalized'', in that most flowers attract and can be pollinated by a range of pollinators, even if some are more effective than others. Rarely will plants completely fail to produce seed when their most effective pollinator is removed; they are more likely to produce fewer seeds or fruit of reduced viability or quantity (MEA, 2005f). Nonetheless, there is increasing evidence that diversity of pollinators, not just abundance, may influence the quality of pollination service Maintenance of biodiverse landscapes, as well as protecting pollinators by reducing the level of the use of agrichemicals (including pesticides) is an important means for sustaining pollinator service in Europe (EASAC, 2009).

Even though pollinators may be interchangeable, changes can significantly affect production. For instance, increasingly studies have pointed to pollen limitation as a cause of fruiting failure and pollination is now considered an essential agricultural input for optimal production (MEA, 2005f).

Despite the importance of pollinators, there have been worldwide declines in pollinator diversity (MEA, 2005o). Perhaps most significantly, the world's agricultural community is presently largely relying on the domesticated honeybee, Apis mellifera, to provide a complex and variable service, and that specific provider is faced with a number of disease and parasite challenges. According to some estimates, a third of food produced depends on Apis mellifera (MEA, 2005f). However, bee populations around the world, especially in Europe and the United States are being decimated by what has been dubbed Colony Collapse Disorder (CCD). CCD can eradicate up to 90% of a bee community. It has been variously attributed to Inadequate "biosecurity" - especially protecting against invasive species - and climate change, amongst others[111].

Seed dispersal is another key ecosystem service which is underpinned by biodiversity. Most plants, including those directly used and managed by humans, depend on seed dispersal by animals. Seeds can be dispersed by animals that eat the fruit and discard the seeds (frugivores) or by seed eaters. Fruit-eating animals include insects and vertebrates, ranging from ants to elephants, although in tropical forests a variety of frugivorous birds and mammals are the main vertebrate dispersal agents. Species that are important for forest regeneration include those of birds, bats, monkeys, opossums, fish, and ants. Flying seed dispersers (bats and birds) are the main vectors that promote forest regeneration in human-disturbed forests by carrying seeds from adjacent habitats to disturbed areas (MEA, 2005f).

Invasion resistance

Although areas of high species richness (such as biodiversity hot spots) are more susceptible to invasion than species-poor areas, within a given habitat the preservation of its natural species pool appears to increase its resistance to invasions by non-native species. Where ecosystems are invaded by non-native species, the economic and environmental impacts can be significant (MEA, 2005o).

The United States, for example, spends hundreds of millions of dollars each year controlling alien species that were initially rare and of little consequence but eventually became invasive (MEA, 2005o). In South Africa, the net annual loss of economic value associated with invasive species in the fynbos vegetation of

[111] http://environment.independentminds.livejournal.com/317851.html

the Cape Floral region has been estimated to be equivalent to a reduction of the potential economic value without the invasive species of more than 40% (MEA, 2005a).

In general, the available evidence and theoretical predictions suggest that higher species richness and functional type richness can increase the resistance of a community against invasion by exotic species (MEA, 2005f).

Climate regulation

The important components of biodiversity include plant functional diversity and the type and distribution of habitats across landscapes. These influence the capacity of terrestrial ecosystems to sequester carbon, albedo (proportion of incoming radiation from the Sun that is reflected by the land surface back to space), evapotranspiration, temperature, and fire regime—all of which influence climate (MEA, 2005o). For example, more biologically diverse—and hence more structurally complex—communities have lower albedo (MEA, 2005f). Overall, the functional characteristics of dominant species are a key element in determining climate regulation. For example, forests have a net moistening effect on the atmosphere and become a moisture source for downwind ecosystems (MEA, 2005o).

Terrestrial and marine biodiversity significantly affects carbon sequestration primarily through the effects on species characteristics. Terrestrial ecosystems accounted for about 20% of the total emissions (land plus fossil fuels) but were a sink for about a third of the total emissions (MEA, 2005h). Marine biodiversity influences the effectiveness of the biological pump that moves carbon from the surface ocean and sequesters it in deep waters and sediments. Some of the carbon that is absorbed by marine photosynthesis and transferred through food webs sinks to the deep ocean. The efficiency of this trophic transfer, and therefore the extent of carbon sequestration, is sensitive to the species richness and composition of the plankton community (MEA, 2005o).

Ecosystem changes account for about 10–30% of the radiative forcing of carbon dioxide from 1750 to present and a large proportion of the radiative forcing due to methane and nitrous oxide (MEA, 2005h). An example of ecosystem changes affecting climate, is provided by Western Australia. The replacement of native heath vegetation by wheatlands increased regional albedo. Air tended to rise over the dark (more solar-absorptive and therefore warmer) heathland, drawing moist air from the wheatlands to the heathlands resulting in a 10% increase in precipitation over heathlands and a 30% decrease in precipitation over croplands (MEA, 2005o).

Changes in the relative abundance of different functional types (such as shrubs versus grasses) may therefore have substantial impacts on sources and sinks of gases and on other ecosystem properties. Loss of biodiversity could further affect the adaptability and resilience of ecosystems as a result of a changing climate (MEA, 2005h). Overall, the current evidence suggests that biodiversity has a moderate impact in climate regulation (EASAC, 2009)

Indirect climate effects on human well-being include changes in water quality, air quality, food availability and quality, population displacement, and economic disruption (MEA, 2005h).

Pest control

There is evidence that the spread of pathogens is less rapid in more biodiverse ecosystems. There is also a consensus that a diverse soil community will help prevent loss of crops due to soil-borne pests and diseases. Higher trophic levels in soil communities can play a role in suppressing plant parasites and affecting nutrient dynamics by modifying abundance of intermediate consumers. In many managed systems, control of plant pests can be provided by generalist and specialist predators and parasitoids (EASAC, 2009). The maintenance of natural pest control services is therefore strongly dependent on biodiversity.

A large proportion of global food production is accounted for by just three crops: wheat, rice and maize. The relative scarcity of outbreaks of diseases on these three crops is a testament to the success of plant breeding, cultivation practices, and the use of agrochemicals. The rapid evolution of biocide-resistant organisms, however, means these successes may not be sustainable (MEA, 2005f). Increasing the associated biodiversity with low-diversity agroecosystems, however, can enhance biological control and reduce the dependency and costs associated with biocides (MEA, 2005o). For example, rice blast, a major and costly fungal pathogen of rice, was recently controlled in a large region of China by planting alternating rows of two rice varieties, which also increased profitability and reduced the use of a potent pesticide (MEA, 2005f).

Biodiversity is therefore important to maintaining agricultural production. Wild relatives of domestic crops provide genetic variability that can be crucial for overcoming outbreaks of pests and pathogens and new environmental stresses. For example, interweaving multiple varieties of rice in the same paddy has been shown to increase productivity by lowering the loss from pests and pathogens (MEA, 2005o).

Disease control and human health

Human health, particularly risk of exposure to many infectious diseases, may depend on the maintenance of biodiversity in natural ecosystems. Over 60% of human pathogens are naturally transmitted from animals to humans (MEA, 2005f). On the one hand, a greater diversity of wildlife species might be expected to sustain a greater diversity of pathogens that can infect humans (MEA, 2005o). Nonetheless, intact ecosystems play an important role in regulating the transmission of many infectious diseases (MEA, 2005i).

For instance, the spread of one disease for which there is data, Lyme disease, seems to be decreased by the maintenance of the biotic integrity of natural ecosystems (MEA, 2005f). Further examples that best illustrate the disease/ecosystem relationships include the following (MEA, 2005i):

- Dams and irrigation canals provide ideal habitat for snails that serve as the intermediate reservoir host species for schistosomiasis; irrigated rice fields increase the extent of mosquito breeding areas, leading to greater transmission of mosquito-borne malaria, lymphatic filariasis, Japanese encephalitis, and Rift Valley fever.

- Deforestation alters malaria risk, depending on the region of the world. Deforestation has increased the risk of malaria in Africa and South America (medium certainty).

- Intensive livestock agriculture that uses subtherapeutic doses of antibiotics has led to the emergence of antibiotic strains of Salmonella, Campylobacter, and Escherichia coli bacteria. Overcrowded and mixed livestock practices, as well as trade in bushmeat, can facilitate interspecies host transfer of disease agents, leading to dangerous novel pathogens, such as SARS and new strains of influenza.

Overall, available data indicate that human health is supported as an ecosystem service by biodiversity in some cases, but the generality of this service is poorly known (MEA, 2005f).

Waste management and detoxification

The capacity for an environment to assimilate wastes is highly dependent upon local conditions. The bacteria and other decomposing organisms that detoxify susceptible chemicals or reuse nutrient wastes are highly dependent upon local conditions such as oxygen availability, moisture, and temperature (MEA, 2005j).

Wetlands represent one of the major mechanisms to treat and detoxify a variety of waste products. Wetlands can improve water quality, provide flood control, provide habitat for young of commercially valuable fish, provide habitat for many types of wildlife, help prevent erosion, and help reduce waterborne disease. Some wetlands have been found to reduce the concentration of nitrate by 90%. Wetlands also act as a filter or trap for many waterborne wastes, including metals, organic chemicals, and pathogens (MEA, 2005j).

However, the impact of human activities on wetlands has been drastic, and it is speculated that some 50% of world wetlands have been lost, with the greatest changes occurring in industrial countries in the first half of the twentieth century (MEA, 2005j).

On a micro level, the marine microbial community provides critical detoxification services—filtering water, reducing effects of eutrophication, and degrading toxic hydrocarbons. Very little is known about how many species are necessary to provide detoxification services, but these services may critically depend on one or a few species (MEA, 2005f). American oysters in Chesapeake Bay were once abundant but have sharply declined—and with them, their filtering ecosystem services. Areas like the Chesapeake might have much clearer water if large populations of filtering oysters could be reintroduced. Some marine microbes can degrade toxic hydrocarbons, such as those in an oil spill, into carbon and water, using a process that requires oxygen. Thus this service is threatened by nutrient pollution, which generates oxygen deprivation (MEA, 2005o).

Water cycling, regulation and purification

Ecosystems constitute the ultimate source areas for freshwater provisioning services (MEA, 2005b). For instance, forests and wetlands can play an important role in determining levels of rainfall (at a regional and local level), the ability of land to absorb or retain that water and its quality when used (TEEB, 2008). As the supporting services of inland waters are the result of interactions among the ecological components within the system and those in the catchment, human well-being is inexorably linked to the maintenance of the ecological character of inland water systems, and therefore the biodiversity which underpins that ecological character (MEA, 2005l).

For instance, soil state and vegetation both act as key regulators of the water flow and storage. Although vegetation is a major determinant of water flows and quality, and microorganisms play an important role in purification and the quality of groundwater, the relationship of water regulation and purification to biodiversity is poorly understood. The role of species diversity is unclear as many of the processes can be performed by a wide variety of species. There appears therefore to be considerable scope for species to substitute for each other and biodiversity plays only a moderate role (EASAC, 2009).

Nonetheless, in terms of water cycling, both vegetation and soil organisms have profound impacts on water movements and the extent of biodiversity is likely to be important. Changes in species composition can affect the balance between water used by plants ('green water') and water flowing through rivers and other channels ('blue water'), and native flora may be more efficient at retaining water than exotic species. A key control on the water cycle is the ease with which water penetrates soil. Where penetration is low because of compaction or development of surface crusts, runoff is increased, which alters the blue:green balance. The main problems in Europe arise in the south because of deficit of water and in some central European areas which are frequently flooded (EASAC, 2009).

Four out of every five people live downstream of, and are served by, renewable freshwater services, representing 75% of the total supply. Mountains serve 3 times, forests 4 times, and inland waters 12 times as many people downstream through river corridors as they do through locally derived runoff. Urban areas nearly double the total service when tabulating downstream populations. Each of these systems still supplies 15–30% of global population with renewable and accessible runoff (MEA, 2005b).

Water use today is dominated by agricultural withdrawals (70% of all use), followed by industrial and then domestic applications. In the OECD however, the proportions differ, in that only 38% is used for agriculture, whilst 48% is of water use is dedicated o industrial uses (the remaining 14% goes to households). In terms of total freshwater withdrawals, as much as 10–25% could represent non-renewable use. Non-sustainable use expressed as a proportion of irrigated agricultural withdrawals shows an even higher degree of dependency on nonrenewable supplies. Estimates such as these illustrate the high and growing dependence on existing water services (MEA, 2005b).

Groundwater plays a key role, and serves as the source water for 40% of self-supplied industrial uses and 20% of irrigation (MEA, 2005l). In Europe nearly 60% of the cities with more than 100,000 people are located in areas where there is groundwater over-abstraction (MEA, 2005b). The ability of inland waters to recharge groundwater has been well established. However, flow regulation within and between inland waters and links between surface and groundwater are critical ecosystem services that have been degraded on a global scale (MEA, 2005l). The disruption of natural flooding regimes has devastated many riverine habitats and led to decreased sediment transport and a loss of flood buffering and nutrient retention (MEA, 2005l).

Wetlands are especially significant in regulating water supplies. Indeed, they have been estimated to account for up to 40% of the total value of global ecosystem services (TEEB, 2009a). It is estimated that wetlands on average intercept 80% of nitrogen flowing from terrestrial systems (MEA, 2005g). They help maintain the water cycle by capturing and holding precipitation, retaining sediments and purifying water. They are important biodiversity areas and provide breeding grounds for fish, grazing lands and the source of staple food plants. Wetlands also act as carbon sinks, provide protection from floods and storms, control soil erosion and even serve as a natural wastewater treatment system for some cities (TEEB, 2009a). An example of the value of water purification service of wetlands is illustrated by the Danube River floodplain, where approximately half of the total economic value (including values associated with timber, cattle, fisheries, recreation hunting and filtering of nutrients) could be accounted for in its role as a nutrient sink (MEA, 2005a).

Aquatic ecosystems ‘‘cleanse’’ on average 80% of their global incident nitrogen loading, however, the intrinsic self-purification capacity of aquatic ecosystems varies widely and is not unlimited (MEA, 2005b). There are potentially costly consequences of upstream anthropogenic activities on hydrological function that place downstream populations at risk, According to one estimate, a 32% conversion of forests to agriculture across the pan-tropics has led to a mean increase in annual basin yields of approximately 10%, with a concomitant rise in seasonal high flows (MEA, 2005b). Furthermore, the continued loss of cloud forests and the destruction of watersheds reduce the quality and availability of water supplied to household use and agriculture (MEA, 2005o). In Brazil, large-scale savanna clearance in the Tocantins basin in has been associated with increases of 24% in mean annual and 28% in wet season flows, independent of climate variations (MEA, 2005b)

Forest loss, watershed degradation, wetland drainage and infrastructure that accelerates water run-off all reduce the potential for this ‘natural infrastructure’ to store, purify and provide water (TEEB, 2009a).

Regulation of natural hazards

Under certain circumstances, ecosystem conditions may serve to alleviate the impacts of an extreme event on human systems (MEA, 2005k). For instance, mangrove forests and coral reefs—a rich source of biodiversity—are excellent natural buffers against floods and storms. Their loss or reduction in coverage has increased the severity of flooding on coastal communities (MEA, 2005o).

Forests provide several valuable services in relation to watershed protection. Tree roots pump water out of the soil, thereby reducing soil moisture and the likelihood of mudslides. Deforestation has also been linked to increased local risks of flooding (that is, within small catchments) but there are several uncertainties about the basic relationships between rainfall, watershed functions, deforestation, reforestation, and other aspects of land use change in the humid tropics (MEA, 2005n). Besides watershed regulation, mixed forests also reduce fire risk (TEEB, 2009a).

Alongside the services provided by coral reefs, forests, and mangroves in protecting against natural hazards, wetlands also act as buffers for floods. The risks of hazards thus increase along with the conversion of mangroves, deforestation and drainage of wetlands. (TEEB, 2009a)

Ecosystem integrity is important in providing protection from hazards, but less so to geological hazards, localised to a few vulnerable areas, such as volcanic eruptions and earthquakes. In alpine regions, vegetation diversity is related to ability to reduce the risk of avalanches. Soil biodiversity may play a role in flood and erosion control through affecting the surface roughness and porosity, and increasing tree diversity is believed to enhance the protection value against rockfall (EASAC, 2009).

Biodiversity, then, seems to play a relatively small part, although vegetation itself is very important, for example in preventing avalanches in mountain areas or protecting low-lying coastlines. The existence of a healthy soil community may control infiltration rate of water after heavy rain, modifying storm flows (EASAC, 2009).

It is also worth mentioning however, that in the face of major natural disturbances such as fire and flood and an increased probability of their occurrence due to global change, the buffering capacity attributed to biodiversity may play a key factor in ecosystem recovery (MEA, 2005k).

3 Supporting services

Biodiversity affects key ecosystem processes in terrestrial ecosystems including biomass production, nutrient and water cycling, and soil formation and retention, all of which govern and ensure supporting services. In turn, biodiversity indirectly supports the production of food, fiber, potable water, shelter, and medicines. The relationship between biodiversity and supporting ecosystem services depends on composition, relative abundance, functional diversity, and, to a lesser extent, taxonomic diversity (MEA, 2005o).

Nutrient cycling

Specific forms of biodiversity are critical to the performance of the buffering mechanisms that ensure the efficient use and cycling of nutrients in ecosystems. Nutrient cycling is enabled by a great diversity of organisms and leads to creation of a number of physical structures and mechanisms that regulate the fluxes of nutrients among compartments. Nutrient cycling requires a large number of different organisms from diverse functional groups. It is a prime example of ‘‘functional biodiversity’’ in action (MEA, 2005g).

Nutrient cycling and fertility are essential for supporting the supply of farmed and wild products and the benefits people derive from their consumption and use. They also increase of agro-ecosystems to respond to environmental, climatic, and economic risks by adapting to these stresses without decreasing their productive capacities. Changes in biodiversity of natural ecosystems brought about by land-use change, climate change or pollution alter the ability of ecosystems to retain nutrient stores, resulting in release of nutrients to other ecosystems with potentially damaging consequences (MEA, 2005g).

At a smaller scale, the effects of mycorrhizal fungi on plant communities are both profound and widespread. Arbuscular mycorrhizal fungi form symbiotic relationships with approximately 80% of the land plants on Earth, in which the AMF receive benefits from plants in the form of carbon and provides various benefits to plants, such as phosphorus absorption. The abundance, species composition, and richness of AMF communities influence the productivity, composition, and species richness of plant communities (MEA, 2005f).

Nutrient cycling is also influenced by soil erosion, and influences eutrophication. Erosion affects nutrient cycling and reduces the fertility of the soil through a reduction in the pool of available nutrients. Soil erosion results in drastic modifications to the structure as well as the biological and chemical properties of the soil matrix. In cases of nutrient excess, eutrophication leads to many changes in the structure and function of aquatic ecosystems and thus the services they provide. Eutrophication is detrimental to many water uses, including for drinking, fisheries, and recreation. In the case of coastal and marine systems, high anthropogenic nutrient loads have resulted in anoxia and loss of fisheries, declining productivity in some estuaries, and changes in species composition of the phytoplankton (MEA, 2005g).

Soil formation

Soil formation is fundamental to soil fertility, especially where processes leading to soil destruction or degradation (erosion, pollution) are active. Soil biodiversity is a major factor in soil formation. Loss of soil biota may reduce soil formation rate with damaging consequences. Intensive agriculture can also reduce soil quality in other ways, for example by removal of organic residues so that organic carbon incorporation into soil is less than the rate of decomposition, leading to reduced soil carbon, with nutritional and structural consequences for soil. There will be particular concerns on soils that are subject to intense erosion, by wind or water. Biodiversity of soil organisms plays a major part in creating soil and maintaining soil function (EASAC, 2009).

Ecosystem Resilience

There is established but incomplete evidence that reductions in biodiversity reduce the resilience of ecosystems (the ability of an ecosystem to recover from a perturbation) (MEA, 2005o). For instance, declines in genetic diversity of domesticated plants and animals in agricultural systems lower the resilience and adaptability of domesticated species. This loss reduces overall fitness and adaptive potential, and it limits the prospects for recovery of species whose populations are reduced to low levels. Many agricultural communities consider increased local diversity a critical factor for the long-term productivity and viability of their agricultural systems. (MEA, 2005o) Specifically with regard to fisheries, low diversity is associated with lower fishery productivity, more frequent “collapses”, and a lower tendency to recover after overfishing than naturally species rich systems (TEEB, 2008).

The benefits of diversity in increasing a system’s resilience are especially evident in the case of invasive species, where the threat of alien invasive species to timber stocks in is increasing due to increased global trade. For example, recent infestations in central North America by several invasive insects have resulted in the mortality of large numbers of deciduous trees, whilst such invasives as Dutch elm disease have virtually eliminated individual tree species in some areas (MEA, 2005d).

The impacts of reductions in biodiversity on ecosystems can be both spatially and temporally displaced. For instance, the losses in biodiversity as a result of the conversion of forest to agriculture in one region that affects river flows in downstream areas far removed from the conversion (MEA, 2005o).

Furthermore, the effects may not become clear until a threshold is reached, resulting in abrupt or nonlinear changes or regime shifts in a system in response to a gradual or linear change in the original drivers. This is particularly common in aquatic ecosystems and is often associated with changes in biodiversity (MEA, 2005o).

Once a threshold is surpassed and a regime shift occurs, the resulting ecosystem —though stable —is often less productive and less diverse. Consequently, human well-being is affected by, for example, reductions in food supply and decreased income from related industries. In some cases, as with coral reefs, there are also increased costs due to diminished ability of the ecosystem to protect against further shocks, such as coral reefs protecting shorelines (MEA, 2005o).

5 Cultural services

Biodiversity has considerable intrinsic, aesthetic and spiritual values. The role of biodiversity in providing cultural services greatly among but is likely to be particularly large for ecotourism and educational uses of ecosystems. For instance, over 40% of European travellers surveyed in 2000 included a visit to a national park (TEEB, 2009e). Such tourism can be an important source of local earnings and employment. Cultural services based on biodiversity are most strongly associated with less intensively managed areas, where semi-natural biotopes dominate. In many cases biodiversity may not be the typical identifier of the value being placed on the ecosystem, but nevertheless underlies the character recognised by the visitor. Typical landscapes in different parts of Europe are in part identifiable by the organisms, especially trees, growing there (EASAC, 2009).

The role of biodiversity is likely to be less important in providing many of the cultural services associated with urban areas. However, there is good evidence that biodiversity in urban areas plays a positive role in promoting human well-being. For example, studies have shown that the psychological benefits of green space in Sheffield increase with biodiversity, whereas a green view from a window increases job satisfaction and reduces job stress. Green spaces also promote health by encouraging exercise and have obvious educational benefits (EASAC, 2009)

ANNEX C – DETAILED EXAMPLES OF LINKS BETWEEN EMPLOYMENT, ECOSYSTEM SERVICES AND BIODIVERSITY IN SOME SECTORS

1 Sectors with Strong Links with Biodiversity through Ecosystem Services

The sectors discussed below rely heavily on biodiversity and related ecosystem services. The actual reliance on biodiversity as an input tends to be limited to a relatively small subset of species compared to the overall abundance of species available. This is especially the case in agriculture. This dependence has arguably decreased over time, but will likely increase again in the future. Instead, these sectors rely most heavily on the regulating and supporting services provided by ecosystem services.

Although largely focused in developing countries, employment in these sectors in industrial countries can also be significant. The agricultural labour force currently contains approximately 22% of the world's population and accounts for 46% of its total labour force. Specifically in industrial countries, exploitation of natural resources continues to be important for livelihoods and economies in rural regions (MEA, 2005o)

The global forestry sector is estimated to provide subsistence and wage employment equivalent to 60 million work years. However, 80% of which is in developing countries. Much of this involves people who work in an ''informal'' economy. Crucially for Europe, European enterprises with fewer than 20 employees are not included in formal employment surveys. Yet in the European Union it is estimated that over 90% of all firms have fewer than 20 employees (MEA, 2005d).

1.1 Agriculture

Although the reliance of agriculture on available genetic resources is high, this reliance tends to be limited to a very small subset of the total available resources. Of the estimated 10,000–15,000 edible plants known, only 7,000 have been used in agriculture and less than 2% are deemed to be economically important at a national level. Only 30 crops provide an estimated 90% of the world population's calorific requirements, with wheat, rice, and maize alone providing about half the calories consumed globally. Furthermore, the probability of developing new major staple crops is probably rather limited (MEA, 2005c).

With regard to livestock, of the estimated 15,000 species of mammals and birds, only some 30–40 (0.25%) have been used for food production, with fewer than 14 species accounting for 90% of global livestock production (MEA, 2005c).

Other areas of agriculture are more dependent on a greater variety of genetic inputs. One industry where this is especially the case is that of biological control, which is currently expanding through new knowledge of biodiversity. Another area is horticulture and seeds. The development of new seed varieties for agriculture is a major use of plant biodiversity, some of it from wild, native plants. However, much of it is from the wealth of crop varieties that have been bred to adapt crops to a host of local conditions worldwide. Thus, the current reliance on wild plant biodiversity in horticulture is still limited to a few areas, notably flowers harvested from native plants and genetic material taken from native plants to improve or establish new horticultural varieties (MEA, 2005e).

Interestingly, it appears from the evidence that the agriculture relies less on the inputs from genetic resources, than on regulating and supporting ecosystem services. For instance, while agriculture depends on relatively few species as direct inputs, the pollinating services provided by biodiversity are crucial to maintain productivity. Increasingly studies have pointed to pollen limitation as a cause of fruiting failure and pollination is now considered an essential agricultural input for optimal production (MEA, 2005f).

The impact of pollination on yields is illustrated by the coffee ecosystems in Costa Rica, where stingless bee pollinators contribute to 20% greater coffee yields within one kilometre of the forest, and 7% overall to the income of the coffee farms (MEA, 2005f). In Indonesia, pollination services are expected to decline continuously as a result of ongoing forest conversion, and directly reduce coffee yields by up to 18% and net revenues per hectare up to 14% within the next two decades TEEB, 2009a).

Agriculture also depends heavily on the provision of a considerable amount of good quality water. Indeed, agriculture in the OECD constitutes 38% of water use (MEA, 2005b). Perhaps one of the most important ecosystem services for agriculture however is nutrient cycling and the maintenance of soil integrity. Nutrient cycling and fertility are essential for supporting the supply of farmed and wild products and the benefits people derive from their consumption and use. They also increase of agro-ecosystems to respond to environmental, climatic, and economic risks by adapting to these stresses without decreasing their productive capacities (MEA, 2005g).

Agriculture also imposes significant costs on ecosystems through resource use and pollution. The external costs of agriculture in the UK for instance, were estimated to be 9% of the average yearly gross farm receipts (£1.56 billion), as a result of damage to water (pollution, eutrophication), air (emissions of greenhouse gases), soil (off-site erosion damage, carbon dioxide loss) and biodiversity (MEA, 2005a).

Overall, all jobs and livelihoods in agriculture depend on ecosystem services. The importance of biodiversity in sustaining these services is complex and not fully understood. Although the dependent on wild genetic resources is relatively low, agricultural production processes depend greatly on natural processes of pollination and biological control, hence playing an important role in supporting jobs and livelihoods. Also important is the role of biodiversity in maintaining the key supporting and regulating processes on which production depends

1.2 Fisheries

Fisheries are heavily dependent on certain ecosystem services. For instance, the economic importance of nutrient cycling is illustrated through coastal upwelling systems, which constitute only about 1% of the ocean surface but contribute about 50% of the world's fisheries (MEA, 2005g).

Climate regulation is also key, especially in ensuring the continued productivity of marine ecosystems. For instance, changes in climate can have drastic and irreversible impacts on coral reefs, which can have devastating effects given that reef-related fisheries constitute approximately 9–12% of the world's fisheries (MEA, 2005f). The stratification of the ocean at warmer temperatures may also reduce phytoplankton productivity and thus fish production (MEA, 2005h).

Waste regulation and detoxification is another key ecosystem service upon which fisheries rely. Eutrophication due to high anthropogenic nutrient loads, for example, leads to many changes in the structure and function of aquatic ecosystems, to the point where it can no longer support fisheries (MEA, 2005j). In coastal and marine systems, this has resulted in anoxia and loss of fisheries, changes in the composition of inorganic nitrogen, declining productivity in some estuaries, and changes in species composition of the phytoplankton (MEA, 2005g).

Invasive resistance is another ecosystem services that is critical to the successful continuation of certain fisheries. For instance, invasive eels reduce freshwater fisheries (MEA, 2005f), whilst the introduction of the invasive, carnivorous ctenophore Mnemiopsis leidyi (a jellyfish-like animal) in the Black Sea caused the rapid loss of 26 major fisheries species and has been implicated (along with other factors) in the continued growth of the oxygen-deprived “dead” zone. The species was subsequently introduced into the Caspian and Aral Seas, where it is having similar impacts (MEA, 2005o).

In some areas, the collapse of fisheries due to degraded ecosystem services can be drastic. Fishing and aquaculture provided jobs for almost 35 million people worldwide in 2000, the vast majority of whom are in developing countries (MEA, 2005n). However, the fact that effects on local economies in the industrial world can still be catastrophic is illustrated by the collapse the Northern Cod fishery due to overharvesting.

More than 40,000 people in Newfoundland lost their jobs and the cod fishery has still not recovered 15 years after a total moratorium on cod fishing (TEEB, 2009d).

1.3 Forestry

Forests are more commonly known for the role in supplying provisioning, regulating and supporting ecosystems. Nevertheless, forestry as a sector also relies on certain ecosystem services such as nutrient cycling, the maintenance of soil integrity, and the management of wastes.

As with agriculture, disease and pest regulation is another key ecosystem service in ensuring the continued provision of timber and forest products. For example, recent infestations in central North America by several invasive insects have resulted in the mortality of large numbers of deciduous trees, whilst such invasives as Dutch elm disease have virtually eliminated individual tree species in some areas (MEA, 2005d).

Perhaps one of the most important ecosystem services upon which forestry depends is that of seed dispersal. The seeds of a large proportion of woody plants are dispersed by animals (about 80–95% in the tropics and about 30–60% in temperate forests). Many tree crops of high economic importance depend on the seed dispersal services of animals, such as the Brazil nut (Bertholletia excelsa), which represents a multimillion-dollar business. Also, several cosmetics are based on nuts or seeds from tropical forests. Several tree species, such as figs and palms, are also some of the most important keystone species (MEA, 2005f).

2 Sectors with medium links to biodiversity through ecosystem services

2.1 Pharmaceuticals

The most significant link between pharmaceuticals and ecosystem services is that provided by genetic resources. Genetic inputs have historically, and still continue to, play a significant role in pharmaceuticals through bio-prospecting (MEA, 2005e):

- An average of 62% of new, small molecule, non-synthetic chemical entities developed for cancer research over the period 1982–2002 were derived from natural products. In anti-hypersensitive drug research, 65% of drugs currently synthesized can be traced to natural structures. This emphasizes the important role of many natural products as blueprints rather than the actual end points.
- Over 50% of modern prescription medicines were originally discovered in plants, and plants continue to be the source of significant therapeutic compounds to this day
- It is estimated that 25% of prescriptions from community pharmacies in the United States during the period 1959–80 contained a compound derived from higher plants. The contribution of wild species has not diminished, as 57% all prescriptions in the United States for the period January–September 1993 contained an active compound derived from biodiversity
- 10 of the 25 best-selling drugs in 1997, representing 42% of industry-wide sales, are either biological, natural products, or entities derived from natural products, with a total 1997 value of US$17.5 billion.
- A significant portion—between 10% and 50%—of the ten top-selling drugs of each of the top 14 pharmaceutical companies are either natural products or entities derived from natural products.'

However, the probability that any single discovery actually reaches the marketplace remains low, and large investments have yielded relatively few lead compounds for development. As a consequence, there has been a withdrawal of many of the largest pharmaceutical companies from bioprospecting during the last decade. Nonetheless, in recent years, several laboratories and some small companies, located in different parts of the world, have applied natural history knowledge and ecological and evolutionary criteria and theory to increase lead discovery. This has begun to change the traditional relationship where there has been a significant geographical mismatch between centres of biodiversity, which tend to be in the tropics, and centres of research and development, which are largely concentrated in the temperate zones (MEA, 2005e).

2.2 Fibre and forest products

Although the provision of fibre and forest products depends on certain ecosystem services, their reliance is considerably weaker than that of the actual forestry sector. For instance, there appears to be little evidence to suggest that changes in forest ecosystem condition will materially affect the availability of wood pulp globally in the foreseeable future. In fact, the evidence suggests that the increased harvest of young plantations will continue to keep supplies ample and prices low (MEA, 2005d).

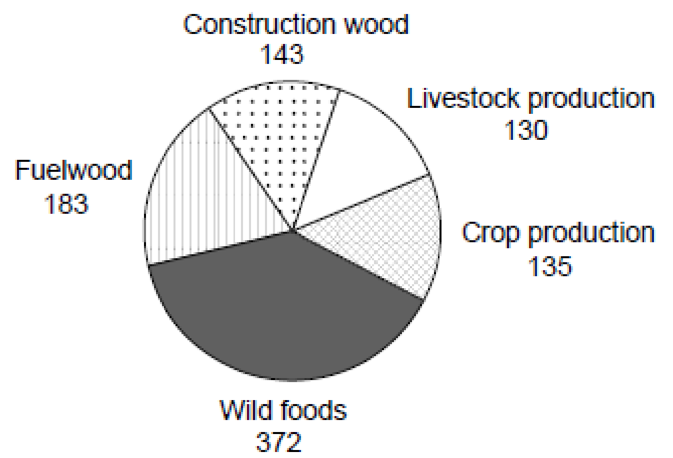
The reliance on genetic resources also appears relatively low in the case of certain products. For instance, it is estimated that only 20% of the known rattan species are of any commercial value (MEA, 2005d). Nonetheless, some ecosystem services are nonetheless crucial.

For example, the production of cotton is heavily reliant on certain regulating and supporting services, given that the water and fertilizer requirements for high yields of cotton under intensive production are high. Cotton is produced on both irrigated and rain-fed cropland, and cotton demand has been the basis for major irrigation projects over the past century. Further growth in cotton production is set to continue through either additional planting or irrigation or through increased yields from improved varieties, management techniques, or pest protection. The crucial role played by ecosystem services is highlighted in the fact that the reasons for declining production in some regions include increased competition for available irrigation water and the loss of productive soils to salinization (MEA, 2005d).

A further area where ecosystem services play a role is in the regulation of pests, which are one of the major challenges in cotton production. The cotton bollworm (Helicoverpa armigera) for example, causes millions of dollars worth of damage annually. This has led to major research efforts round the world to develop improved pest management techniques (including genetically modified cotton) (MEA, 2005d).

ANNEX D – FIGURES ACCOMPANYING GLOBAL CASE STUDIES

Figure A **Value of woodland products to households as derived through farm-gate prices**



Farm-gate values for tree products (Z$ per household per annum US$ 1 = Z$ 6.5 8 (Sept. 1993) and US$ 1 = Z$ 8.09 (Jan 1994))

Source: Campell et al (1991) cited by Campbell (1996)

Figure B Sources of household total income Zimbabwe, Shindi Ward

Table 5.2 Sources of household total income, expressed as percentages, across income quintiles: Shindi Ward, southern Zimbabwe, 1993-94 (Cavendish 1996).*

	Household quintile (total income ranking)					
	Lowest 20%	20-40%	40-60%	60-80%	Upper 20%	All households
Total cash income						
(excluding environmental cash income)	**21.9**	**19.0**	**24.8**	**29.7**	**46.5**	**33.8**
Crop income	2.8	1.8	3.3	3.2	12.5	6.9
Livestock income	1.7	1.9	1.0	1.5	3.7	2.4
Unskilled labour income	4.4	3.1	3.2	1.8	1.5	2.3
Skilled labour income (teaching)	.	.	.	.	12.0	5.0
Crafts and small-scale enterprises	3.1	1.5	4.4	4.3	1.6	2.7
Remittances, gifts, miscellaneous	9.9	10.6	13.0	18.8	15.3	14.5
Total own-produced goods	**43.5**	**44.8**	**41.6**	**42.0**	**30.8**	**37.8**
Consumption of own-produced goods	35.6	37.2	35.4	35.5	27.3	32.3
Input use of own-produced goods	7.9	7.6	6.1	6.5	3.5	5.5
Total environmental income	**34.6**	**36.2**	**33.6**	**28.3**	**22.6**	**28.4**
Gold panning	7.0	12.0	8.1	6.3	1.5	5.4
Natural habitat utilisation cash income						
(sales of products and woodland-based labour)	5.8	4.5	6.2	3.2	1.9	3.5
Consumption of own-collected wild foods	8.8	7.5	6.3	4.4	2.5	4.7
Consumption of own-collected fuelwood	9.7	8.1	7.1	6.0	3.1	5.6
Consumption of own-collected wild goods						
(e.g. thatching grass, bark, medicines).	1.4	0.8	0.9	0.7	0.3	0.6
Livestock browse and graze	1.9	3.4	5.0	7.8	13.3	8.5
Total income	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Miombo woodland-derived income (%) **	27.3	24.1	25.4	21.9	21.1	22.9
Ditto, minus livestock browse and graze (%)	25.5	20.8	20.4	14.1	7.8	14.4
Average total income						
(Z$ per household per year)***	1595	2297	2847	3555	7284	3528

* The values presented exclude certain direct woodland-derived values, namely the value of organic crop inputs, the (imputed) rental of woodland-derived housing and the (imputed) rental of woodland-derived durables (e.g. pestles and mortars), and also exclude all indirect values (ecological functions, cultural values etc.). Incorporating these would not change the cash income results, but would raise the importance of miombo woodland-derived resources in total income still further.

** Miombo woodland-derived income equals 'Total environmental income' minus environmental income that is not woodland-based (e.g. gold panning, pottery).

*** US$ 1 = Z$ 6.5 (September 1993); US$ 1 = Z$ 8.09 (January 1994).

Source: Campell et al (1991) cited by Campbell (1996)

Figure C Composition of gross income (%) Mozambique

Variable	Household quartiles				All
	Lowest 25%	25-50%	50-75%	Top 25%	households
Crop used at home	37.03 (14.19)	31.46 (12.04)	27.86 (13.30)	21.83 (14.56)	29.51 (14.58)
Sale of crops	1.86 (4.49)	2.31 (3.45)	4.14 (7.77)	3.27 (5.41)	2.90 (5.57)
Livestock use	1.98 (2.99)	3.77 (5.01)	2.94 (3.96)	1.54 (2.50)	2.55 (3.82)
Livestock sale	3.45 (6.51)	5.29 (7.94)	4.15 (7.97)	2.14 (3.84)	3.75 (6.84)
Use of unprocessed forest products	25.19 (11.29)	23.64 (11.74)	20.86 (10.98)	19.63 (12.03)	22.32 (11.67)
Sale of unprocessed forest products	0.81 (4.10)	0.42 (1.47)	0.87 (2.45)	1.38 (4.17)	0.87 (3.26)
Use of processed forest products	0.72 (1.74)	1.13 (2.44)	1.13 (2.67)	1.96 (7.46)	1.24 (4.22)
Sale of processed forest products	0.82 (3.88)	3.14 (8.00)	5.93 (13.09)	7.53 (18.83)	4.37 (12.54)
Fish use	3.84 (7.29)	4.43 (6.55)	6.09 (9.36)	10.67 (14.23)	6.27 (10.16)
Fish sale	0.71 (2.68)	0.75 (2.34)	1.88 (4.55)	4.12 (7.44)	1.87 (4.90)
Use of mineral products	0.18 (0.99)	0.23 (0.95)	0.34 (2.94)	0.32 (2.25)	0.27 (1.97)
Sale of mineral products	1.87 (6.76)	1.76 (5.72)	3.20 (8.00)	7.45 (12.63)	3.58 (8.97)
Wage	13.88 (14.29)	13.73 (12.19)	10.49 (9.81)	5.00 (4.48)	10.76 (10.88)
Business	0.92 (4.79)	2.89 (8.75)	4.45 (12.23)	9.52 (20.29)	4.46 (13.22)
Others	6.73 (8.84)	5.03 (8.83)	5.67 (10.84)	5.26 (8.95)	5.26 (8.95)
Total	100	100	100	100	100
Gross income (MTN)	10,866 (4,998)	15,507 (4,820)	18,857 (6,409)	31,760 (27,993)	19,284 (16,672)
N	82	82	83	83	330

(Figures in parenthesis are standard deviations)

Source: Hegde, R. and Bull, G (No Date)

Figure D Livelihood sources by income quartiles (Zambian Kwacha)

	Income source per income quartiles*			
	0-25%	25-50%	50-75%	above 75%
Total income per capita	113,750	262,832	462,828	2,021,277
Total forest income per capita	73,362 (64.5)	125,768 (47.8)	147,730 (31.9)	245,302 (12.1)
Total agric. income per capita	32,444 (28.5)	96,967 (36.9)	250,379 (54.0)	1,035,985 (51.3)
Total employ. income per capita	2,047 (1.8)	10,642 (4.0)	16,109 (3.5)	146,471 (7.2)
Total trading income per capita	5,242 (4.6)	28,140 (10.7)	46,929 (10.1)	588,843 (29.1)
Total remit. income per capita	655 (0.6)	1,315 (0.5)	1,681 (0.4)	4,676 (0.23)

* Values in brackets are percentages of total income

US$1.00 = Zambian Kwacha(ZMK) 4200 as of 2005

Source: Jumbe et al (No Date) cited by the World Bank (2008a)

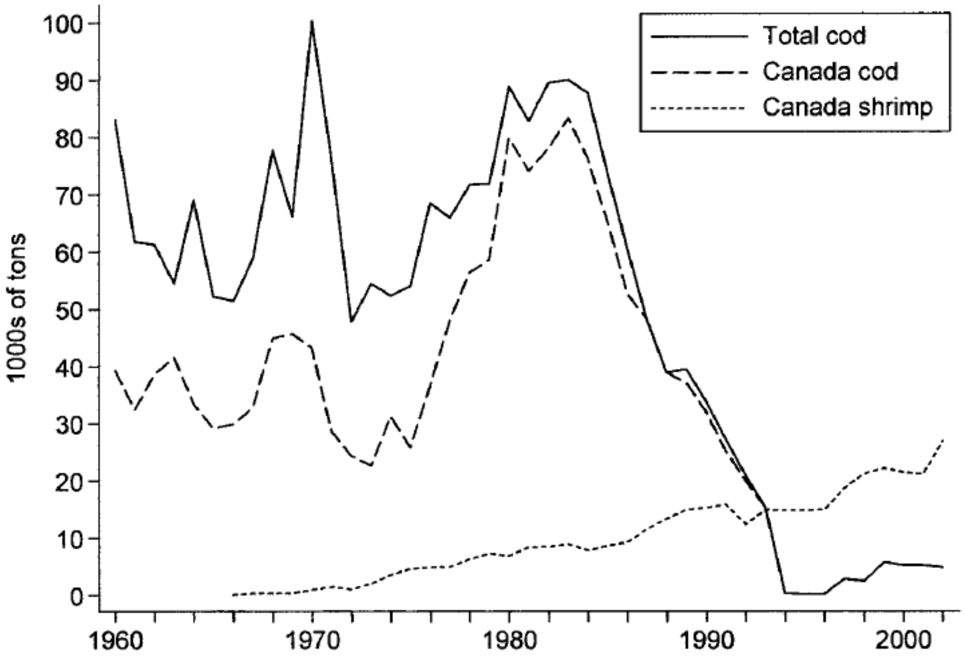
Figure E Deforestation rates in countries where miombo woodland predominates

	Total forest (2005)	Annual rate of change			
		1990–2000		2000–2005	
Country	1,000 ha	1,000 ha/yr	Percent	1,000 ha/yr	Percent
Angola	59 104	−125	−0.2	−125	−0.2
Malawi	3 402	−33	−0.9	−33	−0.9
Mozambique	19 262	−50	−0.3	−50	−0.3
Tanzania	35 257	−412	−1.0	−412	−1.1
Zambia	42 452	−445	−0.9	−445	−1.0
Zimbabwe	17 540	−313	−1.5	−313	−1.7

Notes: The similarity of the data between the two periods points to the lack of reliability of such estimates. Miombo and other forest types are not distinguished in the data.

Source: FAO (2007) cited by Dewees et al. (2010)

Figure F Cod and shrimp catches in the northern Gulf of St. Lawrence, 1960-2002.



Source: NAFO (2003) cited by Hamilton, Haedrich and Duncan (2004)

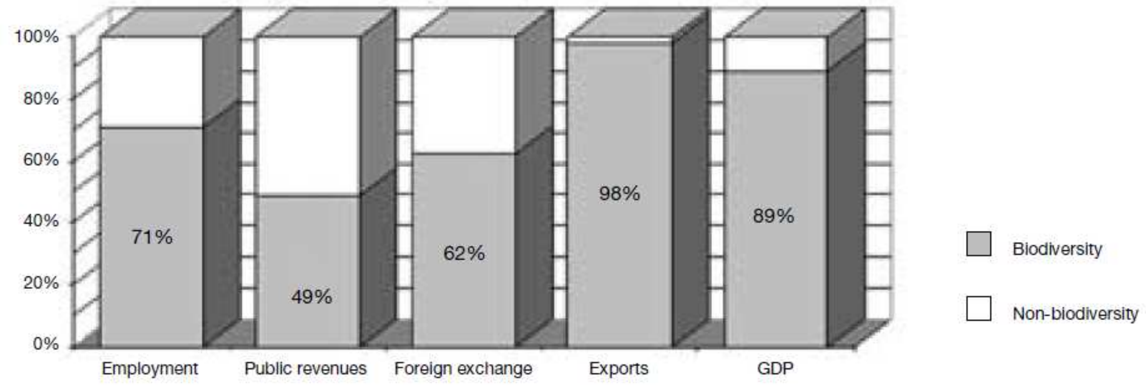
Figure G **Contribution of biodiversity to key Maldives national economic indicators, 2006**

		Tourism (a)		Fisheries (b)		Biodiversity (a+b)		Total In Maldives+
		Amount	% of total	Amount	% of total	Amount	% of total	
Employment	No. jobs	64,000	58.1%	14,500	13.2%	78,500	71.2%	110,231
Public revenue*	Rf mill	2,500	48.3%	12	0.2%	2,512	48.6%	5,172
Foreign exchange	US$ mill	434	62.1%	1	0.1%	435	62.2%	698
Exports	Rf mill	n/a	---	1,700	97.9%	1,700	97.9%	1,736
GDP**	Rf mill	9,741	82.0%	855	7.2%	10,596	89.2%	11,885

** tax and non-tax current revenue; ** at current market prices; + from MPND, 2007, Statistical Yearbook 2007. Ministry of Planning and National Development, Male'.*

Source: Emerton, Baig and Saleem (2009)

Figure H **Contribution of biodiversity to key Maldives national economic indicators, 2006**



Source: Emerton, Baig and Saleem (2009)

ANNEX E – DESCRIPTION OF ECONOMIC VALUATION METHODOLOGIES

Because most ecosystem services and environmental impacts do not have a monetary value expressed in a market-place, a diverse range of 'environmental valuation techniques' have been developed over the past thirty years. They originally evolved so that monetary values of environmental assets and impacts can be assessed alongside other economic and financial values for public decision-making purposes, to encourage more sustainable outcomes.

There are three main categories of environmental valuation techniques: **revealed preference** approaches; **cost-based** approaches; and **stated preference** approaches. In addition to these 'primary' valuation techniques, an alternative 'secondary' technique, '**benefits transfer'** has been developed. This approach involves searching for similar existing studies and adapting the results to apply to the local context. A brief description of the main categories of valuation techniques is included below. Further details are provided in Section 7.

Revealed preference techniques look at the way in which people reveal their preferences for ecosystem services through market production and consumption. Where direct markets for ecosystem goods or services exist—for example, timber or fish—the value people place on the good is revealed directly though market prices. Where markets do not exist, techniques such as travel cost and hedonic pricing use data on actual choices made by people to 'reveal' indirectly the value they place on an ecosystem service. Revealed preference techniques include 'Market Prices', 'Effect on Production', 'Travel Cost', and 'Hedonic Pricing'.

Cost-based approaches look at the market trade-offs or costs avoided of maintaining ecosystems for their goods and services. This may include, for example, examining the costs of building a man-made replacement for a degraded ecosystem service, such as filtration of drinking water or protection of the shoreline from storm damages. Or it can involve estimating the cost of damages to existing property or businesses that might be incurred if the existing ecosystem degrades. Cost based approaches include techniques such as 'Replacement Cost' and 'Damage Costs Avoided'.

Stated Preference Approaches ask consumers to state their preference directly. Survey questionnaires are used to determine the value people place an ecosystem service. For example, contingent valuation surveys ask respondents their willingness to pay (WTP) for a service or willingness to accept (WTA) compensation for its loss. These techniques can be especially useful in determining non-use values generated by an ecosystem. Stated preference approaches include 'Contingent Valuation' and 'Choice Experiments'.

Benefits Transfer involves transferring value estimates from existing economic valuation studies to the study site in question, making adjustments where appropriate. This technique has the advantage that it is relatively inexpensive and quick to implement, but must be carefully and transparently applied to avoid significant errors.

Value transfer method typically refers to the procedure of drawing inferences on the unobserved monetary value of an ecosystem good or service by borrowing existing valuation estimates from comparable sites. Value transfer makes thus use of results from earlier empirical studies and applies their conclusions – according to a well codified set of rules – to a context that differs from that of the study for which the values were originally estimated (Boyle and Bergstrom 1992). The ecosystem of current interest to which values are transferred is generally indicated as 'policy site'. The ecosystem for which values were originally estimated is known as 'study site'. Value transfer can be done across different sites – known as spatial value transfer – or at one specific site over time – temporal value transfer. In a broader sense value transfer can be seen as a subset in the context of the procedures used in scientific research for transferring accumulated knowledge generated by previous research to unexplored cases (Bal et al. 2002). In this case, value transfer is one type of information transfer (Spash and Vatn 2006, Brookshire and Chermak 2007), and its application is not restricted to directly produce estimates on benefit of ecosystem services. Transfer of numerical knowledge is commonly implemented, for instance, in the exchange of parameters and behavioral elasticities across study sites and conditions in distinct experiments (Bal and Nijkamp 2001). In addition, value transfer is often used in combination with primary studies in ecosystem service valuation.

Economists can work with three main approaches so as to perform value transfer. We refer to unit value transfer approach, function transfer approach and meta-analysis.

- Unit transfer is a very basic approach of transferring benefit estimates from one site to another. This approach assumes that the welfare gain (loss) associated with an environmental quality change experienced by an average individual at the *study site* is the same as that which will be experienced by the an average individual at the *policy site*. Therefore, mean monetary estimates – such as mean willingness to pay (WTP) per year per household – are directly transferred from the *study site* to the *policy site*.

Instead of transferring individual benefit/damage estimates, the entire benefit/damage function can be transferred. This approach is conceptually more appealing since more information is used in the process of value transfer. The benefit/damage relationship to be transferred from the study site to the policy site can be estimated using the CV method. For a CV study, the benefit function is:

$$WTP_i = b_0 + b_1 G_{ij} + b_2 H_i + e \qquad (1)$$

where WTP_i measures the willingness to pay of household *i*; G_{ij} depicts the characteristics of the environmental quality under consideration and site *j* and H_i the characteristics of household *i*. b_0, b_1, and b_2 are parameters and *e* is the random error. This approach requires finding a case study in the existing literature with estimates of the parameters b_0, b_1, and b_2. Then data has to be collected on the two groups of independent variables *G* and *H* at the policy site and added to equation (1) to calculate household's WTP at the policy site.

Meta-analysis. Instead of transferring the benefit/damage function from one valuation study's results from *several* valuation studies can be combined in a meta-analysis to estimate a one common benefit/damage function, i.e. meta-value-function. In this approach, estimation results from each study are treated as a single observation in a new analysis of the combined dataset. This allows the evaluation of the influence of (i) the characteristics of the environmental good, (ii) the features of the samples used in each analysis and (iii) the modeling assumptions. The resulting regression equations, explaining variations in unit of values, and data collected on the independent variables in the model that described the policy site, can be combined to construct an adjusted unit value. In formal terms, the meta-value-function would look like equation (1) but with one added independent variable C_s, which will denote the set of characteristics of the study *s*, and the dependent variable would be WTP_s as mean willingness to pay from the study *s*.

Many meta-analyses concern relatively homogeneous environmental goods and are not particularly useful for benefit transfer, being designed for methodological analysis. In fact, the use of methodological variables in the meta-regression – as independent variables – such as payment vehicle, elicitation format, response rates and model assumptions in CV studies are a limited value in predicting values for a specified change in the environmental quality at the policy site. Another important source of difficulty when using meta-analysis to perform value transfer refers to the availability and selection bias of the original valuation studies. The fact is that not all the original valuation studies are directly available to the researcher who is willing to perform a meta-analysis (e.g. not all are published in international journals). In addition, sub-sample of valuation studies that are directly available often contain insufficient or inadequate information on characteristics of the study site, the change in the environmental quality valued, and socio-economic characteristics of the sampled population. Particularly, the last class of variables would be necessary in international value transfer, assuming cross-country heterogeneity in preferences for environmental quality. Nevertheless, secondary information can be easily collected on some variables describing site and population characteristics whenever these are omitted from the original valuation studies. However, the use of secondary data – or proxy variables – adds uncertainty to the model and thus can reduce the validity and reliability of the unit value transfer estimate (e.g. using income data for a regional population to substitute for income data for residents at the study site).

ANNEX F – ECONOMIC VALUATION DETAILS FOR FOREST, FRESHWATER AND MARINE/COASTAL ECOSYSTEMS IN EUROPE

1. Economic valuation of European Forest Ecosystem

1.1 Introduction

This chapter explores the use of economic valuation so as to quantify the value of biodiversity and ecosystem services for a number of essential ecosystems in Europe, including forest ecosystems, marine/costal ecosystems and freshwater/wetland ecosystems. The results of the economic analysis will allow us to explicitly infer their magnitude in terms of their contribution to human wellbeing and therefore to the support of human livelihoods. In this context, this valuation exercise becomes of particular interest since it will shed light on the identification of the impacts of losing biodiversity and ecosystem services on amont vulnerable groups, including the rural poor. In addition, economic valuation also builds the basis for designing policy instruments that enhance the current allocation of market driven resources, improve the environmental sustainability of economic activities as well as contribute to a reallocation of resources from the high- and middle-income countries, where environmental costs arise overwhelmingly to the low-income countries, which borne the most consequences of resource degradation. In other words, the effort of making the values of biodiversity and ecosystem services explicit will contribute to reaching the United Nations' Millennium Development Goals (MDGs), including alleviating poverty, enhancing social structure and creating jobs.

Therefore, valuing ecosystem services, understanding their contributions to human livelihoods and identifying the beneficiaries and relevant stakeholders is important for any polity design targeting at (1) halting biodiversity degradation, (2) correcting the externalities, (3) compensating the losers of biodiversity loss, (3) creating incentives to more effective conservation of biodiversity, and (4) ultimately sustaining the long-term local economic development and human well-being, In conclusion, notwithstanding the direction of causalities, it is the poorer segments of society that are both assumed to be most vulnerable to, and affected by, biodiversity degradation.

1.2 Economic Valuation of European Forest Ecosystems

The forests of 34 selected European countries cover about 185 million ha (FAO, 2005), which accounts for about 32.7% of the combined territories, and the forest biomes are not uniformly distributed across different geo-climatic regions. For instance, forests in the Mediterranean Europe count for 30% of the total forest cover in Europe, and the predominant forest biomes are coniferous and broadleaved evergreen forests. The Central and Northern Europe are home to most of the temperate forests, and the total forests areas of the two regions take up 35% and 19% of the total European forests, respectively. Finally, forests in the Scandinavian Europe are mainly boreal, counting for the remaining 16% of total European forests. Due to the diverse climate conditions across latitudes, species diversity and dynamics of forest ecosystems differ considerably throughout Europe, as reflected in the numbers and composition of tree species. For instance, Ministerial Conference on the Protection of Forests in Europe MCPFE (2007) reported that about 70% of the forests in Europe are dominated by mixed forest consisting of two or several tree species, and the remaining 30% are dominated by one tree species alone, mainly by conifers. In addition to the natural conditions, the current European forest structure, in part, forest species composition has been heavily influenced by anthropophagic interventions, such as past land use and management (Ellenberg, 1986). It should be realized that different forest biomes deliver different ecosystem goods and services, so does the their associated welfare impacts. Therefore, the geographical characteristics of the forest distribution have an important role in interpreting the difference of economic valuation results across countries and understanding the across-country welfare effects due to biodiversity loss.

(1) Mapping the provision of ecosystem goods and services by European forests

A concise mapping of ecosystem goods and services (EGS) are basis for conducting high quality ecosystem assessment studies. For this reason, we adopt the MA approach (MEA, 2003), which provides a practical, tractable, and sufficiently flexible classification for categorizing the various types of ecosystem goods and services (EGS). In this context, all EGS can be generally classified into four main categories, i.e. *provisioning, regulating, cultural and supporting services* – see Table 1.

Table 1: A general classification of ecosystem goods and services for European forests

Types of Ecosystem Services		Examples
Supporting Services	Provisioning Services	Source of production inputs for a number of forestry sectors: wood pulp, industrial roundwood, recovered paper, sawnwood, wood-based panels, paperboard, woodfuel and other substantial goods, such as food and fruits, for supporting local livelihoods.
	Regulating Services	Climate regulation, water regulation, erosion regulation, etc.
	Cultural Services	Recreation and ecotourism, aesthetic values, spiritual and religious values, cultural heritage values, etc.

Source: adapted from MEA 2003

Provisioning Services

In this forest service category, we divide the forest products into seven main groups, including industrial roundwood, wood pulp, recovered paper sawnwood, wood-based panels, paper and paperboard, and wood fuel. For all products quantity information on the total annual removal from forests is available on the FAOSTAT-Forestry. We first collected quantity information for all 32 European countries under consideration - see Table 2. The physical quantification of provisioning services in turn, will be at the basis of the economic valuation exercise.[112]

Table 2: Total wood forest products provided by forestry sectors in Europe

Country	Wood pulp (Mt/yr)	Industrial Roundwood (Million M^3/yr)	Recovered paper (Mt/yr)	Sawn-wood (Million $M^{3/}$yr)	Wood-based Panels (Million $M^{3/}$yr)	Paper-board (Mt/yr)	Woodfuel (Million $M^{3/}$yr)
Albania	0	0.08	0	0.1	0.04	0	0.22
Austria	1.93	12.79	1.42	11.07	3.45	4.95	3.69
Belgium	0.51	4.3	2.14	1.29	2.8	1.9	0.65
Bosnia & Herzegovina	0.02	2.44	0	1.32	0	0.08	1.36
Bulgaria	0.14	3.18	0.08	0.57	0.35	0.33	2.68
Croatia	0.1	3.11	0	0.62	0.13	0.59	0.91
Czech Republic	0.75	14.29	0.48	4	1.49	0.97	1.23
Denmark	0	1.03	0.44	0.2	0.35	0.42	1.26
Estonia	0.07	5.5	0.05	2.2	0.41	0.07	1.3
Finland	11.13	47.12	0.6	12.27	1.99	12.39	4.48
France	2.5	31.62	5.95	9.95	6.4	10.33	2.8

112 The data report from FAOSTAT does not provide an efficient collection of data on non-wood forest products, for this reason, our figures of the forest provisioning services will not embed this provisioning service. We acknowledge that our estimation is underestimated compare to other studies in the literature, if there is less evidence to link the provision of with non-wood forest products climate change (e.g. Merlo and Croitoru, 2005).

Germany	2.88	50.91	14.41	22.12	16.98	21.68	6.04
Greece	0	0.52	0.35	0.19	0.87	0.53	1
Hungary	0	2.8	0.37	0.22	0.67	0.57	3.14
Ireland	0	2.63	0.44	0.89	0.88	0.05	0.02
Italy	0.52	2.69	5.49	1.59	5.61	10	5.36
Latvia	0	11.89	0.06	4.23	0.43	0.04	0.95
Lithuania	0	4.92	0.08	1.5	0.4	0.11	1.13
Luxembourg	0	0.26	0.06	0.13	0.45	0	0.01
Netherlands	0.12	0.82	2.46	0.28	0.01	3.47	0.29
Norway	2.46	8.49	0.44	2.33	0.58	2.22	1.18
Poland	1.05	28.53	1.2	3.93	6.74	2.73	3.41
Portugal	1.93	10.51	0.6	1.01	1.31	1.58	0.6
Romania	0.16	11.54	0.3	4.32	1.01	0.37	2.96
Serbia&Montenegro	0.02	1.32	0	0.5	0.07	0.23	1.85
Slovakia	0.61	9.01	0.21	2.62	0.61	0.86	0.3
Slovenia	0.15	1.79	0	0.46	0.41	0.56	0.94
Spain	1.97	13.35	4.32	3.66	4.84	5.7	2.18
Sweden	12.11	91.7	1.57	18	0.75	11.74	7
Switzerland	0.26	3.98	1.24	1.59	0.97	1.75	1.07
Turkey	0.23	11.2	1.02	6.45	4.77	1.15	4.98
United Kingdom	0.34	8.27	7.76	2.86	3.4	6.24	0.32

Source: FAOSTAT, 2005

Regulating Services

As far as regulating service is concerned, two types of ecosystem services are of particular importance provided by European forests: (1) climate regulation (i.e. carbon sequestration) and (2) water and erosion regulation (i.e. watershed protection). It is important to note that we will focus only on the carbon service due to the lack of understanding of the complex relationships involved between forest biodiversity, forest area, water and erosion regulation. For this reason we shall proceed with evaluating biodiversity benefits provided by forest systems by evaluating the capacity of forests ecosystem in mitigating climate change by storing carbon in forests and its soil. Table 3 reports the carbon stocked by European forests (FRA, 2005).

Table 3: Total forest area, forest area designated for recreational and passive uses and stocked carbon in forest ecosystems in Europe

Country	Forest Area (1000 ha)	Carbon Stock (Mt)	Forest Area designated for recreation (1000 ha)	Forest Area designated for passive use (1000 ha)
Albania	794	62.6	62	80
Austria	3,862	937.5	301	393
Belgium	667	72.8	52	68
Bosnia and Herzegovina	2,185	177.9	210	274
Bulgaria	3,625	274.8	283	369
Croatia	2,135	575.0	166	217
Czech Republic	2,648	712.2	206	270
Denmark	500	60.9	39	51
Estonia	2,284	304.9	178	232
Finland	22,500	1,040.1	1,757	2,295
France	15,554	1,702.2	1,214	1,586
Germany	11,076	1,257.5	865	1,129
Greece	3 ,752	293.2	293	382

Hungary	1,976	515.0	154	201
Ireland	669	71.3	52	68
Italy	9,979	1,315.5	779	1,017
Latvia	2,941	392.2	229	299
Lithuania	2,099	274.6	163	214
Luxembourg	87	23.5	6	8
Netherlands	365	52.1	28	37
Norway	9,387	1,770.7	733	957
Poland	9,192	2,446.8	717	937
Portugal	3,783	161.0	295	385
Romania	6,370	1,719.5	497	649
Serbia and Montenegro	2,694	215.7	210	274
Slovakia	1,929	518.8	150	196
Slovenia	1,264	334.6	98	128
Spain	17,915	987.4	1,399	1,827
Sweden	27,528	3,597.2	22,198	2,807
Switzerland	1,221	294.6	95.36	124
Turkey	10,175	818.5	794.67	1,037
UK	2,845	409.3	222.19	290

Source: adapted from FRA, 2005

Cultural Services

In Europe, forests are of particular importance in many countries in terms of cultural services. Among all others, recreational service represents the most important value (MCPFE 2007), including hunting, natural park visiting, forest landscape and other spiritual uses. Some of the services always involve both consumptive (e.g. consumption of animal meat) and non-consumptive (e.g. enjoyment derived from hunting activities and forest landscape) uses of forests. To avoid double counting, we refer cultural services to non-consumptive use of forests only. In addition, the passive use value of the forests has an essential role in assessing some particular forest areas. In the present study, we use forests areas that are designed to recreational and protective purposes, as described by the Global Forest Resources Assessment 2005 (FRA, 2005), as key variables when assessing the welfare changes in terms of changes in the provision of cultural services. Table 8 shows the forest areas that are preliminary designated for recreational and passive uses in all selected European countries, as well as the total carbon stocked in these countries' forests.

Supporting Services

Finally, with respect to the supporting service, indicators for measuring the respective forest ecosystem changes in response to climate change are not well developed and thus quantity data to measure them are not readily available (MEA 2005). For this reason, we will not directly tackle the valuation study for this service category. However, it is important to realize that the relevant values are implicitly reflected in the valuation of all other three categories of forest ecosystem goods and services.

(2) Economic valuation of the ecosystem goods and services provided by European forests

The hybrid valuation model is used to capture the values of three types of ecosystem services under consideration. First of all, for the provisioning services provided by European forests, we can infer that the economic values are the direct use values obtained from trading wood forest products in the market. Therefore, market prices are used to value this ecosystem service and its information is derived from Food and Agriculture Organization of the United Nations database (FAOSTAT) on forests. Second, in order to estimate the welfare changes associated to the carbon regulation we shall be using the avoided damage cost methods that were undertaken by the recent EC funded project, CASES[113] to estimate the marginal damage cost of per additional unit of CO_2 emission. Economic theory tells us the optimal emission level is determined by the intersection of the marginal damage cost of emissions and the marginal benefit from damage mitigation (or marginal abatement costs). Thus the crossing point is corresponding to the unit value of carbon sequestration, which gives rise to the optimal policy to incentivize the necessary abatement for achieving the global carbon stabilization goal, and can be used to calculate the total economic value of carbon stored in forests. Finally, with respect to the cultural service, meta-analysis and value transfer methods are jointly used. These two methods are anchored in non-market valuation methodologies and rely on the existing databases[114] of non-market valuation studies for forests in Europe. All values are expressed in 2005 US$. However, the specific nature and availability of data as well as the different valuation procedures embraced according to the nature of the ecosystems services under consideration will merit a separate discussion.

The Economic Value of Provisioning Services

Both total values of provisioning services of forest are estimated using the data derived from FAOSTAT. The total export values of WFPs are used as a proxy of total economic benefits derived from the annual removal of forest products. The export values used here are published by FAOSTAT in year 2005. The export values of all 7 forestry sectors are collected and summed up across all the 7 selected forestry sectors at country level and then divided by the forest size of the country – see equation (1). This gives rise to the productivity values (in $/ha term) of the forest biomes in terms of the profits associated with the types of WFPs to be delivered to the market (see Table 5). Note that the productive values vary across countries as they reflect the different contributions of various forest biomes to the national economies.

$$ProductivityValue_i^{WFPs} = \sum_{n=1}^{7} ExportValue_{ni} \Big/ ForestArea_{ni} \qquad (1)$$

where *i* refers to one of the European countries and *n* is the type of WFPs under consideration.

The Economic Value of Regulating Services

Forest conservation or prevention of deforestation in order to stabilize Green House Gas (GHG) emissions – questions not originally included in the Kyoto Protocol – have been officially recognized in COP13 in Bali in December 2007 as important issues. The estimation of economic value of climate regulating services (i.e. carbon storage) provided by forest ecosystem is therefore considered to have very important impacts on policy making for CO_2 stabilization in Europe. However, it is important to note that our economic value estimates for regulating service in the present paper are underestimated, as the present economic valuation exercise focuses only on carbon sequestration services provided by forests. Nevertheless, further investigation will lead to a much higher value estimates of this service, by taking into account other regulating services, e.g. watershed protection and soil nutrient cycling.

The methodological framework for valuing the regulating services consists of two steps: we first compute the marginal value of carbon storage in forests (2005US$/tC), which will then be used to estimate the total economic values that can be obtained in different forest ecosystems across Europe. The marginal value

113 CASES stands for "Cost Assessment of Sustainable Energy Systems" for EU countries and the selected non-EU countries, including Turkey, Brazil, India and China. The study aimed at providing a comprehensive and dynamic assessment of the full costs of electricity generation based on the state-of-the art methodologies, taking into account both geographical and temporal extend of the impacts and social economic impacts, such as health and safety, economic production and consumption, recreation, and environmental and natural assets caused by climate change.

114 The popular databases for non-market valuation study include: Environmental Valuation Reference Inventory (EVRI), Envalue, and the Ecosystem Services Database.

of carbon storage refers to the benefits from avoided damages[115] caused by incremental of CO_2 or CO_2-equivalent GHG emissions in the atmosphere due to the carbon sequestration function of forest ecosystem. In the present paper, we built our analysis upon an existing project, “Cost Assessment for Sustainable Energy Systems” - CASES[116], funded by EU but targeting at a worldwide study. One of the main features of CASES is that it is built upon the Integrated Assessment Models (IAMs), which by definition combine the dynamics of global economic growth with the dynamics of geophysical climate dynamics, to estimate the cost of GHG emissions under different energy evolution paths in 2020, 2030 and 2050. The existing literature on IAM has been used intensively reviewed under the project and various available estimates in the recent years were taken into account in its finally delivered value estimates. Among all others, the value of social costs of carbon estimated by UK’s Department for Environment, Food and Rural Affairs (DEFRA 2005) was adopted for it is reflexive to the policy context in which the values are used, and it combines the results of a number of IAM’s in a transparent matter. As a consequence, CASES project was able to obtain three levels of estimates of marginal damage costs, i.e. lower, upper and central estimates[117], respectively. For instance, as reported in CASES final report, the lower estimates of marginal damage costs of carbon (also known as the social costs of carbon) renage from € 4/tCO_2 in 2000 to € 8/tCO_2 in 2030; the upper estimates evolve from € 53/tCO_2 in 2000 to € 110/tCO_2 in 2030; and the central estimate evolves from € 23/tCO_2 in 2000 to € 41/tCO_2 in 2030.

For the present valuation exercise, the lower bound estimate of the social cost of carbon is adopted. The original value estimates was adjusted by discounting it to the real Euro value in 2005 at a discount rate of 3%, and was then converted to 2005US$ based on the real exchange rate of the year and the Purchasing Power Parity (PPP).

The value of cultural services

The cultural services provided by forest ecosystems consist of two components in our analysis: recreational use (e.g. nature-based *tourism* in forests) and passive use (e.g. existence and bequest value of forests and biodiversity). Not being traded in regular markets, recreation and passive use values are usually measured as willingness to pay (WTP) figures derived from revealed or stated preference valuation techniques, such as travel cost method, contingent valuation and choice experiment, etc. According to previous literature reviews on cultural values, a simple expected utility specification can be used to describe how individuals are willing to trade off wealth for increases or decreases in forest cultural services, under the assumption that the estimated marginal value of the service decreases with an increase in the size of the forest site, and increases with an increase of the income level of the country where the forest is located (e.g., Hammitt, 2000; Markandya *et al.,* 2008). The changes in future forest areas are driven by various forces, including the current concern of climate change. Under such circumstance, the expressed WTP estimate for trading off the forest resources also reflects the fact that individual’s preference to enjoy a certain kind of culture service may shift from one forest to another driven by the changed future climate conditions.

Due to the large scale of our study, we focus on estimating the average WTP (expressed in 2005$/ha) for the cultural services (either recreational use or passive use) from various forest ecosystems across

115 The avoided damage costs assessment method has been widely used in the literature (see Cline, 1992; Nordhaus, 1993a,b; Merlo&Croitoru, 2005; CASES, 2008) to calculate indirectly the benefits from carbon sequestrated in forests, but it is important to note that the concept is different from the market price of carbon (obtained via emission trading scheme) and the marginal abatement cost (involves the costs of technological R&D for facilitating the emission abatement), although under certain restrictive assumptions the three measures would be broadly equal, at the margin (DEFRA, 2007).

116 CASES, Project No.518294 SES6, (2006-2008).
Project official website: http://www.feem-Project.net/cases/

117 The values are based on full Monte Carlo runs of the FUND and PAGE models, in which all parameters varied to reflect the uncertainty surrounding the central parameter values in both models. The lower and upper bounds are the 5% and 95% probability values of the PAGE model, while the central guidance value is based on the average of the mean values of the FUND and PAGE models. A declining discount rates is use as suggested by the UK Government ‘Green Book’. The equity weighting of damages in different regions is applied to aggregate the regional damage costs to global damages, in other words, damages in richer regions receive lower weights and damages in poorer regions receive higher weights.

Europe. Value transfer has been conducted between the study sites, where original valuation has been carried out and the targeted policy sites, where forest biomes are found similar to those in the study sites.

Running a meta-analysis is the first step. The result of meta-analysis enables us to explain the variance of the available WTPs (Willingness-To-Pay) as a function of a few statistically significant explanatory variables[118]. In particular, main explanatory factors for forest recreation and passive use are: i) size of recreational forest sites; and for passive use, size of forest areas designated to biodiversity conservation; and ii) income level in the study area. The WTP figures included in the regression are selected from an extensive literature review process focusing on all existing valuable studies. The estimated coefficients are then used for the geographical value transfer across countries. The selected primary studies covering various types of forest biomes in Europe are presented in Table 4.

Table 4 Selected primary valuation studies at the study sites for geographical value transfer

Country	Reference study	Forest biome
United Kingdom	Garrod, G.D. and Willis, K. G. (1997)	Temperate forests
	Hanley, N., Willis, K, Powe, N, Anderson, M. (2002)	
	ERM Report to UK Forestry Commission (1996)	
Finland	Kniivila, M., Ovaskainen, V. and Saastamoinen, O. (2002)	Boreal forests
	Siikamaki, Juha (2007)	
Spain	Mogas, J., Riera, P. and Bennett, J. (2006)	Mediterranean
United Kingdom	Scarpa, R., S. M. Chilton, W. G. Hutchinson, J. Buongiorno (2000)	Temperate broadleaf and mixed forests
The Netherlands	Scarpa, R., S. M. Chilton, W. G. Hutchinson, J. Buongiorno (2000)	Temperate broadleaf and mixed forests
Finland	Bostedt, G. and L. Mattsson (2005)	Boreal forests
Italy	Bellu, L. G. and Cistulli V. (1994)	Mediterranean and Temperate Broadleaf

At the second step, the WTP estimates obtained in the selected primary studies[119] are transferred to the policy sites, i.e. other European countries where original valuation studies are absent. The value transfer function is shown in equation (2) below, where the coefficients of forest size (*S*) and per capita income (*PPP_GDP*) obtained in previous meta-regression analysis are used to correct the transferred WTP estimates. In addition, the number of households (*H*) is also in the value transfer function, as it is considered to be influential on the final WTP estimates in different regions. WTP estimates from recreational and passive uses of forests are transferred separately for each country and a sum of the two values give rise to the WTP for the cultural value of forests in the country.

$$V_i = V_j\left(\frac{H_i}{H_j}\right)\left(\frac{S_j}{S_i}\right)^{\beta}\left(\frac{PPPGDP_i}{PPPGDP_j}\right)^{\gamma}$$

where:
V_i = estimated *WTP*/ha/year for a country *i*
i = policy site, which refers to countries where value estimates of WTP is needed, but primary studies are absent.
j = study sites, where original valuation studies are found.

118 A similar approach is used by the authors in another recent research project (COPI) concerning a worldwide valuation of forest ecosystems in the context of policy inaction rather climate change (see Markandya et al. 2008 for more details).
119 When several representative case studies and values are available, the mean marginal value is used.

Finally, by multiplying the WTP estimates *V*($/ha) for recreational or passive use of forests by the sizes of forest area *S* that have been designated for recreation or conservation, we can obtain the total recreational or passive use value for each country. The total cultural value of a European country refers to the sum of the respective recreational and passive use value of the forests.

(3) Valuation results

In summary, the estimated economic values of three ecosystem services, i.e. regulating, cultural and provisioning services are presented in the Table 5, all expressed in 2005 US dollars.

Table 9.5 shows the weight of ecosystem service value in a country's total received forestry benefits may vary depending on the type and extent of the forests in the country as well as the ecosystem services under consideration. Finally, the last column of the table calculates the aggregated economic value that each European country can get from their forest ecosystems. Not surprisingly, highest aggregated economic values are mostly found in forests located in Central - Northern European countries where host (a) the largest forest areas, (2) the higher number of households, (3) high rates of forest recreationists among the households. In addition, high values are found also in two eastern European countries, i.e. Poland and Romania, due to the rich forest resources and large forest areas found in these countries. For an aggregated perspective, we can see that half of the biodiversity benefits from the European forests are mainly concentrated in the regulating services, which count for about half of the total value. Cultural values amount to 5% and the provisioning services 45%. In addition, if we take a closer look into the cultural value component, we can see that Germany, Italy, Spain, France, UK and Poland are the countries that show the highest economic values on this component. However the relative value composition is not the same among those countries.

As we can see, in Germany, forests are predominantly producing provisioning services. In fact, in this setting Germany is the country that has the strongest profile of provisioning services. On the other hand, Poland has the weakest profile in forest provisioning services. However, Poland has the strongest profile with respect to regulating services. Italy, France and Spain do not have any predominant profile with respect to any of the forest ecosystem services but show the strongest balance in terms of distribution of the economic value for each of the three dimensions under consideration. Finally, the UK show a profile closer to the France/Spain/Italy rather than Germany or Poland. In any case, the intensity of the forest values produced in the UK when compared to France/Spain/Italy are weaker: the UK profile lies inside all the individual maps of France/Spain/Italy.

Table 5: Economic values derived from three forest ecosystem services in Europe

Country	Regulating Service (2005 Million US$/yr)	Cultural Services (2005 Million US$/yr)	Provisioning services (2005 Million US$/yr)	Total (2005 Million US$/yr)
Albania	305	0.3	6	1,300
Austria	4,451	91	5,990	24,949
Belgium	344	75	4,807	6,339
Bosnia&Herzegovina	839	0.2	202	3,761
Bulgaria	1,393	40	256	6,200
Croatia	2,721	8.2	343	11,884
Czech Republic	3,375	73	1,568	15,946
Denmark	296	57	465	1,776
Estonia	1,465	2.3	510	6,723
Finland	4,913	3.3	12,067	32,897
France	8,137	831	7,204	42,529
Germany	5,933	2,440	16,636	44,228

Greece	1,442	89	141	6,341
Hungary	2,518	107	693	11,474
Ireland	370	0.03	506	2,072
Italy	6,557	1,734	3,225	32,753
Latvia	1,887	1.1	977	8,976
Lithuania	1,347	7.8	354	6,069
Luxembourg	111	5.2	216	691
Netherlands	249	166	3,693	4,915
Norway	3,744	1.2	1,863	17,737
Poland	11,714	224	2,127	52,007
Portugal	802	42	1,859	5,302
Romania	8,118	143	848	35,403
Serbia&Montenegro	1,035	0.3	137	4,525
Slovakia	2,458	35	1,025	11,481
Slovenia	1,611	17	684	7,529
Spain	5,078	1,034	3,337	25,897
Sweden	8,371	149	13,200	48,834
Switzerland	1,416	46	2,003	8,050
Turkey	3,909	0.02	256	16,827
United Kingdom	1,967	734	2,665	11,739

In addition, we can also explore the use of GIS tools so as to map the economic values of forest ecosystem services – see Figure 1.

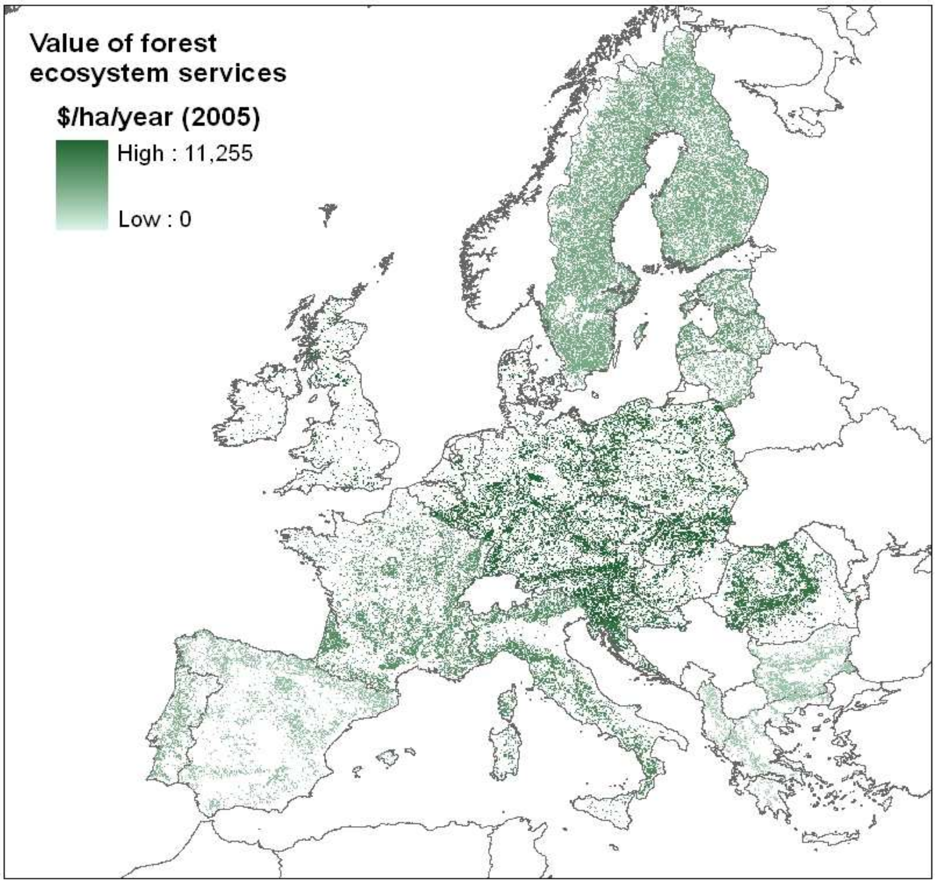


Figure 1: The productivity value of per hectare forests in Europe

The GIS map is created based on the geographical distribution of forests in Europe as identified in the Corine land use map. Within each country, the average per hectare values estimated in the economic valuation analysis described in this section are distributed over the forest grid cells in Corine, with a 100x100 meter resolution. These maps provide detailed information with respect to the spatial distribution of the economic values. Whereas Spain and France show again similar profiles, which are characterized by a balanced distribution of the values at stake, respectively provisioning, regulating and cultural, UK reveals to be the country with the highest forest productivity in terms of cultural values. Germany and Italy reveal to be the second and third most productive European forests, again when measured in terms of cultural values.[120] As far as the regulating services, all the countries show similar profiles where the differences account the differences of the forest type and geographical locations.

2. Economic Valuation of European Freshwater Ecosystems

Freshwater ecosystems have long been recognized as sources of important services and goods for humans. The range of benefits encompasses provisioning of goods such as water, fuel wood, materials, and fish for commercial exploitation, regulating flood events and water quality processes, providing the setting for recreational activities and amenity values, and supporting a rich biological diversity. Both the level of provisioning of ecosystem services and their impact on human welfare are threatened by a series of environmental stressors, such as habitat conversion and climate change, which have a potential to affect the ecological equilibriums services rely upon and the patterns of human exploitation.

In this study we develop a framework for the economic valuation of the flow of services from freshwater ecosystems (i.e., rivers, lakes and freshwater wetlands) at European scale and for assessing the distribution of such values within European countries. Meta-analysis is used as a tool (i) to investigate the provision of services of freshwater ecosystems from an economic perspective and (ii) to scale up freshwater ecosystem services values in 28 European countries. In particular, we investigate how climatic conditions, socio-economic characteristics of the population living in the surrounding of the valued sites, and biodiversity richness are mutually linked in determining the impact on human livelihood produced by the provision of ecosystem services. The aggregated values are subsequently geographically distributed within European countries based on the information on land cover provided by the Corine map (Büttner et al. 2002).

2.1 The dataset of freshwater ecosystems valuations

The impact of freshwater ecosystem services on human livelihood is predicted based on 236 independent observations from 103 valuation studies and concerning 123 distinct freshwater wetlands, riverine or lacustrine ecosystems. The dataset is not limited to European sites but includes valuation results from ecosystems worldwide. Figure 2 illustrates the geographical distribution of the ecosystems in the dataset.

120 The Netherlands is the most productive country in terms of cultural values provided by forests, well ahead the UK.

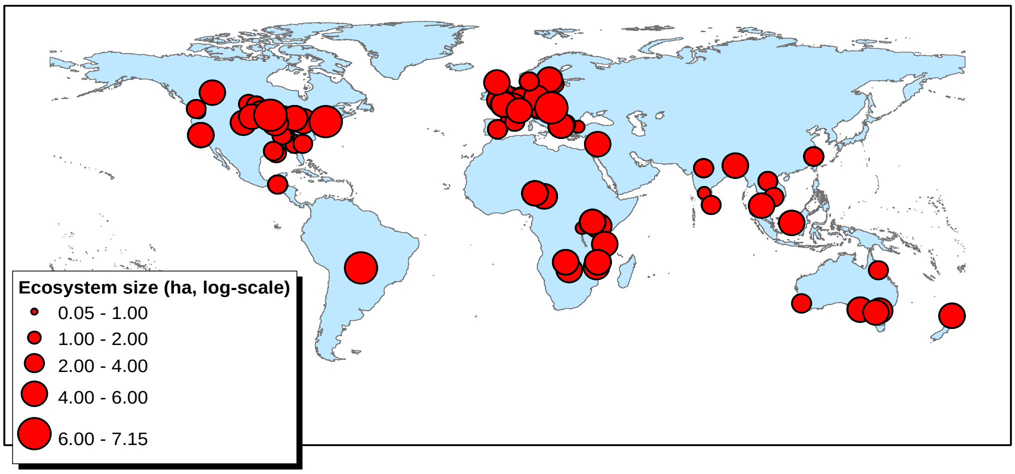


Figure 2 Geographical location of valued ecosystems and their size

All continents are represented in the data set. The largest number of observations pertains to North America (90) and Europe (63), but a significant fraction comes from Africa (37) and Asia (32). Australasia (8) and South America (6) are somewhat underrepresented.

All studies considered are primary valuation studies and no observation based on value transfer is included in the data set. In order to limit the risk of introducing publication bias, the investigation is not limited to the analysis of publications in the "official scientific literature", but also explores the "grey literature" (such as reports for both public and private institutions and consultancy studies) and unpublished research results. Efforts were also made to include studies that are not published in the English language. The average number of observations per study (2.3) and the maximum number of observations for a single study (12) are relatively low if compared to the total number of observations used in the analysis (236).

2.2 Specification of the meta-regression model

The meta-analytical regression model used in this study is a semi-logarithmic model where the dependent variable is the values standardized to 2003 US$ per hectare per year and corrected for purchase power parity across different countries. The explanatory variables are selected to represent characteristics of the valuation study, the specific valued ecosystem site and the socio-economic, geographical and climatic context in which the valued ecosystem is located.

Study variables

Study characteristics accounted for in the model include the valuation method used and a dummy distinguishing between marginal and average values. A range of valuation methods has been used in the primary studies for the assessment of the values of wetlands and freshwater ecosystems. Valuation methods are grouped in four categories: stated preference methods (i.e., contingent valuation method and choice experiment), revealed preference methods (i.e., travel cost method and hedonic pricing), market-based methods (i.e., market prices, replacement cost, net factor income, production function and opportunity cost), and mixed valuation methods, which combine different methodologies (e.g. contingent behaviour method). A dummy for each of the categories is included in the meta-regression model to account for the heterogeneity of methods, as they produce estimates of different welfare measures and not all of them have a strong basis in welfare theory. Market-based values are the omitted variable in the regression. Figure 3 illustrates the distribution of valuation methods according to the four categories of methods.

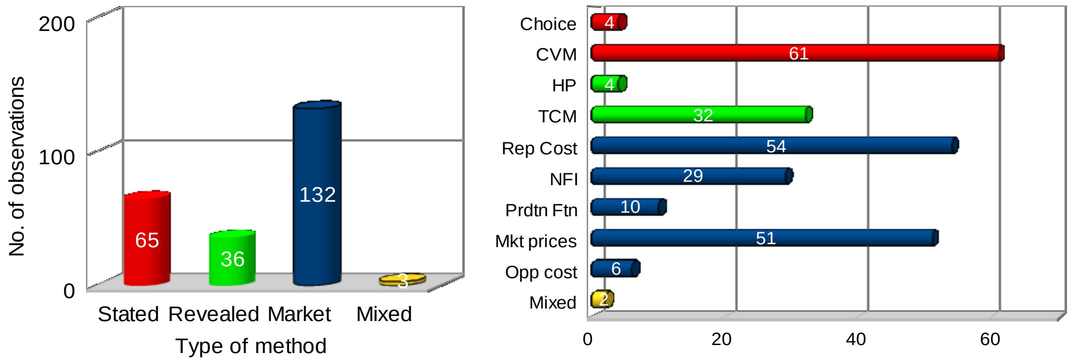


Figure 3 Number of observation per type of method and single valuation methods (Choice = choice experiment, CVM = contingent valuation method, HP = hedonic pricing, TCM = travel cost method, Rep Cost = replacement cost, NFI = net factor income, Prdtn Ftn = production function, Mkt price = market prices, Opp cost = opportunity cost)

The largest number of observations was derived using market-based valuation methods (132). The most frequently implemented market-based method is market prices (51) followed by net factor income (29). Production function and opportunity cost were used in respectively 10 and 6 observations. Some studies use a combination of market-based methods. Stated preference methods were used in 65 observations, contingent valuation method (61) being more frequently implemented than choice experiment (4). Revealed preference methods (i.e., travel cost method (32) and hedonic pricing (4)) were used in 36 observations.

To distinguish between marginal and average per hectare values, a dummy variable is introduced, which assumes a value equal to one for marginal values (34) and equal to zero otherwise (202).

Site variables

Characteristics of the valued ecosystem that are accounted for in the meta-regression model are the type and size of the ecosystem, and the services provided. Three dummies identifying rivers and floodplains (106 observations), lakes (89 observations) and other types of freshwater wetlands (93 observations) are introduced in the model. Some value observations may pertain to several ecosystem types.

Three types of freshwater ecosystems were considered: rivers (and river floodplains), lakes, and other types of freshwater wetlands, such as palustrine wetlands, swamps, peat bogs and wet forests. River deltas, estuaries, coastal salt marshes and lagoons were not included in the dataset. Figure 4 illustrates the distribution of the observations across the three main ecosystem types considered. Since a value estimate may pertain to an ecosystem with mixed characteristics of to a group of ecosystems of different types, the sum of observations for the categories in Figure 9.4 is larger than the total number of observations.

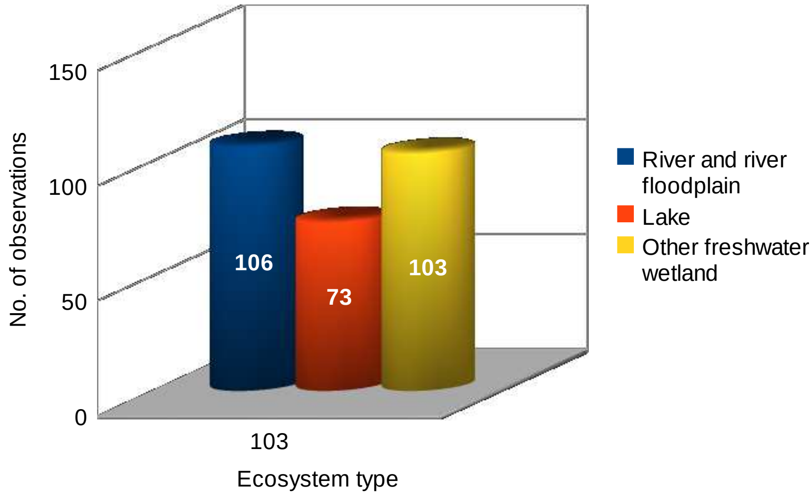


Figure 4. Number of valuations for rivers, lakes and freshwater wetlands ecosystems

The services and goods provided by the investigated ecosystems are classified according to the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005) approach into the categories of provisioning, regulating and cultural services. Within the category of cultural services a distinction is made between recreational services (i.e., recreational hunting, recreational fishing, and other non-consumptive recreational activities such as walking, cycling, swimming and boating) and passive uses (i.e., amenity value and provision of natural habitat and biodiversity). The number of observations for the identified ecosystem services is illustrated in Figure 5. The largest number of observations is for recreational cultural services as well (98). A relatively large number of observations are available for provisioning services (88) such as commercial fishing and hunting, harvesting of natural materials, water supply and fuel wood. Regulating services such as flood control and storm buffering and water quality improvement provided by 63 observations. Slightly less information is available in the literature for passive uses (54 observations).

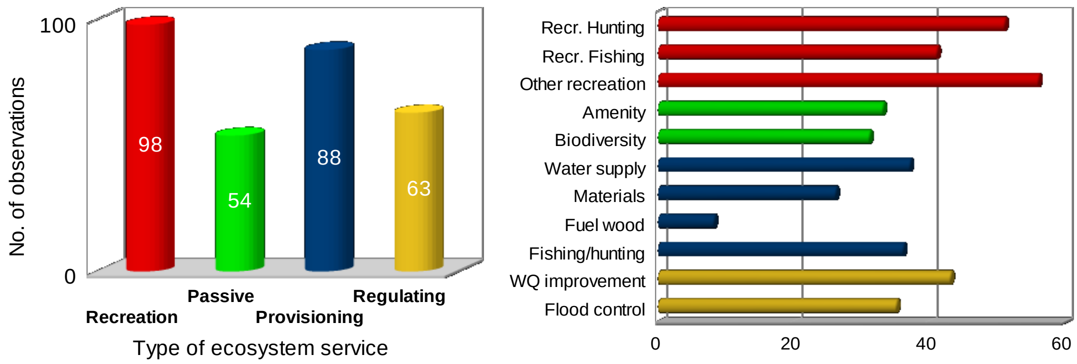


Figure 5. Number of observation per type of ecosystem service and single services (Recr. Hunting = recreational hunting, Recr. Fishing = recreational fishing, Fishing/hunting = commercial fishing and hunting, WQ improvement = water quality improvement, Flood control = storm buffering and flood control)

The size of the ecosystems has been estimated in hectares and shows large variability. The ranked distribution in the size of the valued ecosystems is illustrated in Figure 6. The median size is 3,455 ha, while the average size is 187,875 ha with a standard deviation equal to 1,299,594 ha. Examples of large valued sites, covering hundreds of thousands of hectares are the wetlands of Louisiana (Gosselink et al. 1974), the Pantanal (Shrestha et al. 2002), and the Danube floodplain (I. M. Gren et al. 1995). Although the majority of the valuation studies so far has comprehensively focused on large sites, small-size ecosystems are also represented. Some examples are small wetlands in the North Dakota prairie (Leitch

& Hovde 1996), Louisiana (Leitch & Hovde 1996), Italy (Marangon et al. 2002) and England (Ledoux 2003). All these wetlands are below hundred hectares in size. Although there is no clear *a priori* expectation of the influence of size on its value, previous meta-analyses of ecosystem values agree on the relevance of size as a significant factor to explain the variability of values.

Finally, the latitude at which the valued ecosystems are located is included in the model as a categorical predictor with four levels. The four categories considered are chosen so as to distinguish between different biomes in European countries: Mediterranean (between 35°N and 45°N), temperate (between 45°N and 55°N), and Baltic-Scandinavian ecosystem types (at latitudes higher than 55°N). The omitted category in the regression identifies freshwater ecosystems that are located at latitudes equal to or lower than 35°N.

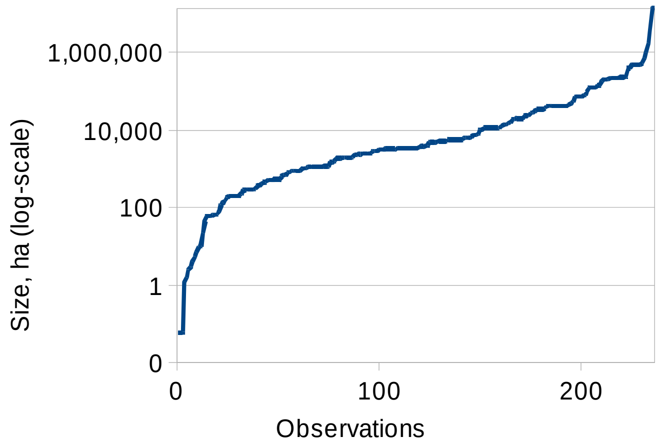


Figure 6 Ranked distribution in the size of the valued ecosystems

Context variables

Environmental valuation studies carried out at different geographical sites and involving populations with different socio-economic characteristics and consumer preferences generally produce different outcomes (Brouwer 2000). Context characteristics are expected to significantly influence the valuation estimates.

A series of context variables are included in the meta-regression model. Gross Domestic Product (GDP) per capita and the population living in the surroundings of the valued ecosystem are introduced to capture some characteristics of the socio-economic context where the valued sites are located. The presence of income effects and the influence of population density in the surrounding of the valued environmental asset in determining the results of the valuation study were identified in previous meta-analyses (Brander et al. 2006). The GDP value is calculated at country level for all countries but European countries and the USA, where it is estimated at NUTS2[121] and state level respectively. GDP per capita values were expressed in Purchase Power Parity (PPP) units and standardized to I$ 2003 per year following the procedure described in (Ghermandi et al. 2008). The population density and total area of freshwater ecosystems abundance of wetland ecosystems at country level are included in the meta-regression model in order to capture the fact that a high population density around the valued sites may contribute to transform potential values into actual benefits as well as potential substitution effects (Ghermandi et al. 2008). The total area of wetlands for each country is calculated based on the georeferenced information provided in the Global Lakes and Wetlands Database (Lehner & Döll 2004).

A series of geo-climatic and biodiversity variables were considered for their possible influence on the estimated values. The biodiversity variables considered include the total number of bird (mammal)

[121] NUTS2 is one of the Nomenclature of Territorial Units for Statistics levels used in the European Union to identify regional administrative divisions within member states.

species and of threatened bird (mammal) species at country level as derived from the Little Green Data Book (World Bank, The 2007). The geo-climatic variables evaluated for inclusion in the model include the average, minimum and maximum monthly temperature and the average yearly precipitation at country level. The geo-climatic and biodiversity data used in the model refers to the baseline year 2003.

Standardization of values

To allow for a comparison between ecosystem values that have been calculated in different years and expressed in different currencies and metrics – e.g. willingness to pay (WTP) per household per year, capitalized values, and marginal value per acre – standardization to common metric and currency is needed. WTP per household per year cannot be used as a common metric since several of the valuation methods used in the literature – e.g. net factor income, opportunity cost, replacement cost, and market prices – do not produce WTP per person estimates. On the other hand WTP per person can be converted to a value per hectare per year if the relevant population is known. Values were thus standardized to 2003 I$ per hectare per year. Values referring to different years were deflated using appropriate factors from the World Bank Millennium Development Indicators (World Bank 2006), while differences in purchase power among the countries were accounted for by the PPP index provided by the Penn World Table (Heston et al. 2006).

2.3 Valuation results

Most of the explanatory variables included in the model are statistically significant in explaining the current values of freshwater ecosystems. Of the study characteristics, revealed preference methods produce significantly lower results than market-based methods and marginal values are higher than average ones. If compared with the results of previous meta-analyses of wetland values, such result is consistent with the findings of Brander et al. (2006) and Ghermandi et al. (2008) who found high values for studies with stated preference methods and marginal values, and only partially contrasts with those of Woodward & Wui (2001), who observed high values for studies using hedonic pricing and replacement cost as valuation method.

Site-specific characteristics significantly affect ecosystem values. The coefficient on wetland size indicates decreasing returns to scale (cf. Brander et al. 2006; Ghermandi et al. 2008; Woodward & Wui 2001). Ecosystems located at temperate Northern latitudes between 35°N and 45°N provide statistically higher values than ecosystems at higher latitudes, in proximity of the Equator or at temperate climates in the Southern hemisphere. Of the ecosystem services, the coefficient of provisioning services is negative indicating low values for commercial fishing and hunting, and provision of materials and fuel wood, while both regulating services and passive values have positive – though not statistically significant – coefficients.

All context variables are significant in explaining the values of freshwater ecosystems. Both real GPD per capita and population density are positively related to ecosystem values indicating an inelastic income effect and high values where a large population may easily access the sites. The negative value on the total area of freshwater ecosystems suggests that substitution effects may take place and thus high values for ecosystems that are more unique in their environment. Such results confirm the previous findings in Ghermandi et al. (2008).

An important additional contribution of this meta-analysis is the recognition of the role of geo-climatic and biodiversity variables in determining ecosystem values. Both the coefficients of the maximum monthly temperature and total number of bird species are significant. Values tend to be high in areas of high biodiversity and decrease at high temperatures.

As second step in the analysis, we apply benefit transfer techniques to use the results of the meta-regression and scale up the values of freshwater ecosystem services at country level in 28 European countries. For this purpose, we evaluated the values of the explanatory variables in the meta-regression model in each of the 28 countries. Each country was classified within one of the latitude categories following the distribution of biome types within Europe. Mediterranean and South European countries include Bulgaria, Croatia, Greece, Italy, Portugal and Spain, (35°N - 45°N); Central-Northern European countries include Austria, Belgium, Czech Republic, France, Germany, Hungary, Ireland, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, and Switzerland (35°N - 45°N); Northern European and Scandinavian countries are Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden, and the United Kingdom (latitude higher than 55°N). The context variable accounting for the total area of freshwater ecosystems in each country was evaluated by means of GIS analysis from the Global Lakes and Wetlands Database (Lehner & Döll 2004). The average size of freshwater ecosystems in European countries was derived from Brander et al. (2008), who created a dataset of 50,533 individual European coastal and freshwater wetlands with GIS analysis from the Corine land cover. The binary variables identifying valuation methods and ecosystem services were estimated at the sample mean for the scaling up of values with exception of the variable 'marginal' which was set equal to zero in order to estimate average values.

Table 6: Estimated value of freshwater ecosystem services in Europe

Country	Mean value [$/ha year]	Total area [ha]	Aggregated value [Million US$2003/year]
Austria	17,969	95,685	1,719
Belgium	113,286	24,762	2,805
Bulgaria	69,497	111,972	7,782
Croatia	166,508	71,551	11,914
Czech Republic	14,589	60,688	885
Denmark	11,266	90,495	1,020
Estonia	1,205	396,919	478
Finland	1,779	5,396,898	9,599
France	10,851	400,351	4,344
Germany	14,935	518,158	7,739
Greece	81,645	132,851	10,847
Hungary	5,867	279,976	1,642
Ireland	9,155	1,271,368	11,640
Italy	200,278	233,984	46,862
Latvia	2,396	272,944	654
Lithuania	1,789	182,333	326
Luxemburg	121,994	733	89
Netherlands	20,734	226,065	4,687
Norway	3,672	1,005,407	3,692
Poland	6,150	556,487	3,423
Portugal	275,265	55,567	15,296
Romania	4,495	683,155	3,071
Slovakia	12,728	30,435	387
Slovenia	30,095	10,307	310
Spain	117,314	342,307	40,157
Sweden	5,926	6,523,231	38,658
Switzerland	19,624	52,326	1,027
UK	8,819	747,987	6,596

To aggregate the values and scale them up at country level we multiplied the per hectare values estimated for each country with the benefit transfer exercise by the total area of freshwater ecosystems in the investigated countries. Since the Corine dataset provides a more refined land use classification for European countries, the total area for the aggregation of the values was estimated based on the categories of inland marshes, peatbogs, water courses and inland water bodies in the Corine classification. Table 6 presents the mean value per hectare, the total area per country and the estimated aggregated value of ecosystem services provided by freshwater ecosystems for each of the 28 European countries.

On average, Mediterranean countries (Italy and Portugal in particular) show high mean values per hectare. This is partly due to the relative scarcity of freshwater ecosystems compared to Northern European countries. Countries with high population density such as Belgium or high values of GDP per capita such as Luxembourg also show high values. The lowest mean values per hectare are found in Scandinavian countries and Ireland, i.e., where the largest total area of freshwater ecosystems is concentrated and population density is low. We estimate thus that the highest aggregated values are in countries with high mean values per hectare, such as Italy and Spain, or with very large total ecosystem areas, such as Sweden. Despite the large area in Finland and Norway, the aggregated values for these two countries are relatively low.

To investigate the spatial distribution of values within each country, we combined the results of the meta-analysis and value transfer exercise with the information on land use from the Corine land use map. The spatial location of inland wetlands and freshwater ecosystems is identified and the average per hectare value estimated with the meta-regression is attributed to each pixel according to the country where the pixel is located. Since the resolution of the Corine map is 100 m x 100 m (i.e., every grid cell has an extension of one hectare), the value thus attributed coincides with the yearly flow of value from each grid cell. The distribution of values thus obtained is presented in Figure 7 below.

Figure 7 illustrates how the spatial distribution of economic values does not necessarily follow the geographic distribution of freshwater ecosystems. While most freshwater ecosystems are concentrated in North Europe (i.e., in Scandinavian and Baltic countries, United Kingdom, and Ireland), such sites are characterized by low per hectare values (bright blue in the map). Ecosystems with substantially higher per hectare values are scattered in Southern European and Mediterranean countries (dark blue in the map).

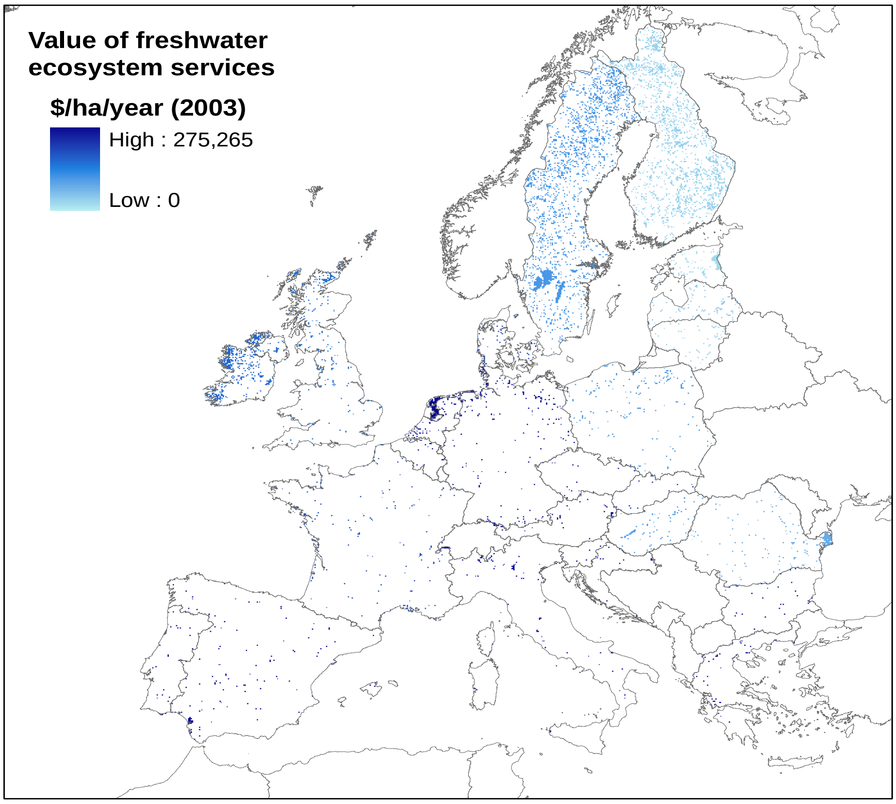


Figure 7: The distribution of values of freshwater ecosystem services in Europe

3 The Recreational Value of the European Coastal and Marine Ecosystems

Marine and coastal areas host biodiversity-rich ecosystems that are among the world's most valuable. Apart from their ecological value, coastal ecosystems deliver a series of goods and services that are of benefit to humanity. These include cultural values that support tourism and recreational activities such as beach leisure (Bin et al. 2005; Freeman III 1995), wildlife watching (Loomis et al. 2000), diving (Depondt & Green 2006), bathing (Georgiou et al. 1998) recreational fishing and boating (Freeman III 1995). Market failures induced by the public good character of many of the aforementioned goods and services or from ill-defined property rights result in many of the benefits delivered by coastal and marine ecosystems being overlooked in the policy-making process. While the number of published primary valuation studies focusing on the cultural values of marine and coastal ecosystems is rapidly growing, there is still a limited understanding of what the principal drivers of coastal recreation values are and how human welfare may be affected by disappearance of habitats and species due to anthropogenic pressure and shifting environmental conditions (Brander et al. 2007; Liu & Stern 2008).

In this section we develop a meta-analytical value transfer function that will be applied to map the current economic value of the recreational services provided by European coastal ecosystems. For this purpose an extensive dataset of valuation studies is created and a series of explanatory variables such as biodiversity richness and geo-climatic variables are included in the model. These variables are selected in order to get a better and more economically oriented explanation of observed differences in ecosystem valuations. After inferring the main determinants of the willingness to pay (WTP) per person per year for cultural ecosystem services, values are aggregated to the entire relevant population of recreationists in order to estimate the current recreational value of coastal ecosystems in European countries.

3.1 The dataset of coastal and marine ecosystems values

A large data set of non-market valuations of coastal and marine ecosystems was constructed for the purposes of this study. In total, 320 primary valuation studies were retrieved and investigated. Online valuation databases constituted an important source of primary valuation studies or references to relevant papers. The investigation was not limited to the analysis of publications in the official scientific literature, but also explored "grey literature" (such as reports for both public and private institutions, consultancy studies, and unpublished working papers). Only primary valuations were considered and care was taken not to include more than once in the data set estimates that were published in multiple papers.

Of all studies, 79 were found to contain sufficient information for the meta-analysis. The total number of observations in the data set is 315. The average number of observations per study is 4.0 and the maximum number of observations per study is 24 (Downing & Ozuna 1996). The number of studies and observations is considerably larger than in previous meta-analyses of coastal and marine ecosystem values. A study on recreational value of coral reefs (Brander et al. 2007) counted 52 studies and 73 usable observations. A meta-analysis of contingent valuation studies in coastal and near-marine ecosystems (Liu & Stern 2008) collected 39 studies and 120 observations. Figure 8 presents the geographical distribution of the ecosystems in the dataset. Although all the continents are represented in the dataset, by far the largest number of observations (197 observations) is from the United States.

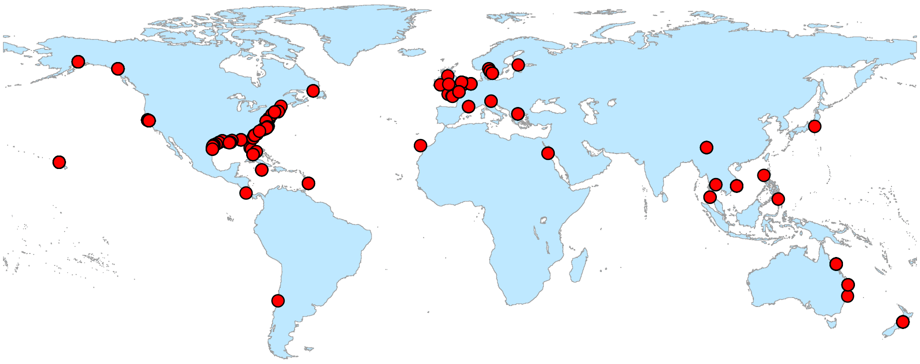


Figure 8: Geographical location of valued coastal ecosystems

All studies considered are primary valuation studies and no observation based on value transfer is included in the data set. In order to limit the risk of introducing publication bias, the investigation is not limited to the analysis of publications in the “official scientific literature”, but also explores the “grey literature” (such as reports for both public and private institutions and consultancy studies) and unpublished research results. Efforts were also made to include studies that are not published in the English language. The average number of observations per study (4.0) and the maximum number of observations for a single study (24) are relatively low when compared to the total number of observations used in the analysis (315). As such, multiple sampling bias is expected to have a limited influence on the results of the investigation.

A large number of valuation studies focused on recreation, protection from erosion, and reduction of tourists congestion in sandy beaches (n=147). A number of observations are also available for conservation of biodiversity hotspots and recreation in coral reefs areas (n=25). A significant fraction of the total observations focused on marine and coastal protected areas (n=86). The largest valued ecosystem in the data set in terms of length of coastline is the Great Barrier Reef in Australia (Carr & Mendelsohn 2003) but smaller sites such as single beaches are also represented in the dataset.

Due to the focus on non-market values, the valuation methods included in the data set are either revealed or stated preference ones. Among the former, the contingent valuation method provided the largest number of observations (n=137), but choice experiments are also represented (n=18). The observations that were obtained with the travel cost method are 128. Finally, 32 values were estimated with the contingent behavior method, which combines both revealed and stated preference methods.

3.2 Specification of the meta-regression model

A semi-logarithmic model specification is assumed for the regression of the willingness to pay (WTP) per person per year for recreational activities in the valued sites. The final set of explanatory variables of the value function is chosen based on the experience gathered from previous meta-analyses of ecosystem values (Ghermandi et al. 2008). The explanatory variables are classified into three principle categories: valuation study characteristics, site characteristics, and context characteristics.

Study variables

The study characteristics that are accounted for in the meta-analytical value function are the type of valuation methods used in the primary study, the type of welfare measure elicited, and a dummy distinguishing whether values in the primary study are estimated for individuals or households. Valuation methods are classified into two categories according to the distinction between stated and revealed preference methods. Observations derived with stated preference method include contingent valuation, choice experiment, and contingent behaviour estimates. Revealed preference estimated by means of the travel cost method is the omitted category for valuation methods in the meta-regression. The type of welfare measure elicited in the primary valuation study is accounted for in the model by a dummy variable which reflects whether the observation is (i) a total WTP or total consumer surplus, or (ii) the WTP to achieve an increase (to forego a decrease) in the level of provision of a specific ecosystem service as compensating variation (equivalent variation). Finally a dummy is included to distinguish between values estimated for individuals and households since most primary valuation studies do not provide information on the average household size.

Site variables

The site characteristics that are accounted for in the meta-analytical value function are the type of ecosystem and the type of ecosystem service provided. A series of dummy variables is included in the model to distinguish between recreational activities that take place in sandy beaches (n=147), coral reefs (n=25) and other types of coastal ecosystems (n=143) (for example the latter include coastal marshes, rocky coastlines, and coastal forests).

Two types of cultural recreational ecosystem services are considered, i.e., recreational fishing (n=164) and non-consumptive recreation (n=206). The latter identifies activities such as swimming, snorkeling, diving, bathing, boating and beach leisure. Since the two types of services are not mutually exclusive, i.e., one value observation may reflect a combination of both, no reference category is defined in the analysis of this variable.

Context variables

Building upon the results of previous meta-analyses, context variables are introduced to capture the possible influence of income effects, population density, richness in biodiversity, and geo-climatic variables on ecosystem values. All variables are evaluated at a country level, with the exception of GDP per capita which is calculated at the state and NUTS2 levels for the United States and EU countries respectively. GDP per capita values were expressed in Purchase Power Parity (PPP) units and standardized to US$ 2003 per year following the procedure described in Ghermandi et al. (2008). The population density at country level is included in the meta-regression model in order to capture the fact that a high population density around the valued sites may contribute to the transformation of potential values into actual benefits as previously observed by Brander et al. 2006 and Ghermandi et al. (2008).

A series of geo-climatic and biodiversity variables were considered for their possible influences on the estimated values. The biodiversity variables considered include the total number of bird and mammal species and of threatened bird and mammal species at country level as derived from the Little Green Data Book (World Bank, The 2007). The geo-climatic variables evaluated for inclusion in the model include the average, minimum and maximum monthly temperature and the average yearly precipitation at country level. To reduce the negative effects of correlation between variables in the meta-regression, for the final set of variables we selected from this group the total number of bird species, threatened bird species, minimum and maximum monthly temperature only.

3.3 Valuation results

The estimated coefficients of the explanatory variables are mostly statistically significant and with the expected sign. Among study characteristics, the results of the regression confirm the *a priori* expectations that the value attributed to marginal changes in the level of provision of recreational services is lower than its total value, and that values expressing the WTP of a household are statistically higher than those referring to single individuals. No significant difference is found between stated and revealed preference valuation studies.

With respect to site characteristics, the coefficient for recreational activities in coral reefs is higher than in sandy beaches or in other coastal ecosystems, but the difference is not statistically significant. The value attributed by individuals to the recreational fishing experience is higher than that of non-consumptive recreational activities.

The coefficient of the variable ‘Real GDP per capita’ indicates the presence of income effects (Ghermandi et al. 2008; Brander et al. 2006). The coefficient of the population density variable is statistically significant but has a negative sign, which is in contrast with the findings of previous meta-analyses of the values of ecosystem services (Ghermandi et al. 2008; Brander et al. 2006). Both biodiversity variables have the expected signs, which indicate a higher value for recreational sites with high biodiversity and lower values where biodiversity is threatened. Finally, both coefficients on the temperature variables are positive and suggest that coastal recreational activities are more highly valued in warm climates.

Table 7: Values of context variables in baseline year regression (2003)

Country	Population density, inhab./km^2	GDP per capita, US$	Number of birds species	Number of threatened bird species	Min monthly temperature, °C	Max monthly temperature, °C
Belgium	340.81	32,808	427	10	2.12	16.94
Bulgaria	69.78	9,354	379	11	-3.14	21.82
Croatia	80.49	13,342	365	9	-2.45	19.90
Denmark	125.70	34,669	427	10	-1.32	15.13
Estonia	29.71	16,127	267	3	-15.36	15.20
Finland	15.59	32,678	421	10	-15.47	12.09
France	111.49	29,276	517	15	3.17	17.56
Germany	231.50	29,550	487	14	-1.53	17.29
Greece	84.13	24,399	412	14	12.90	24.11
Ireland	58.95	41,492	408	8	2.05	13.97
Italy	194.69	29,502	478	15	10.06	20.89
Latvia	35.64	13,540	325	8	-15.36	15.20
Lithuania	52.45	14,569	227	4	-9.11	15.91
Netherlands	393.20	33,198	444	11	5.99	14.58
Norway	14.31	41,630	442	6	-10.19	11.14
Poland	122.15	13,741	424	12	-5.22	17.58
Portugal	114.97	21,791	501	15	5.52	20.38
Romania	90.73	9,056	365	13	3.68	15.05
Slovenia	98.62	22,261	350	7	-2.45	19.90
Spain	85.96	26,296	515	20	3.69	20.87
Sweden	20.09	32,325	457	9	-0.40	4.37
UK	246.08	33,314	557	10	2.07	14.75

The value of WTP per person per year for coastal recreational activities for 22 European countries during the baseline year 2003 was estimated based on the regression coefficients reported in Table 8 below. The calculated values reflect the total WTP for the provision of recreational services, i.e., the coefficient of the variable ‘variation’ is set equal to zero, and individual values, i.e., coefficient of ‘household’ equal to zero. The coefficients of the study method and the type of recreational activity reflect the sample average for the 315 observations. Values are calculated for a generic coastal ecosystem, i.e., the coefficients of both 'beach' and 'reef' are equal to zero. The value of the context variables during the baseline year is illustrated in Table 7.

Table 8. Aggregated WTP for coastal and marine recreation in Europe

Country	Average individual WTP [US$ /person year]	Arrivals in coastal NUTS2 (thousands) [a]	Aggregated value [Million US$/year]
Belgium	159.24	1,691	269
Bulgaria	103.58	1,330	138
Croatia	127.07	3,466	440
Denmark	144.73	2,951	427
Estonia	120.48	1,315	158
Finland	74.48	6,256	466
France	172.19	37,298	6422
Germany	110.12	9,385	1033
Greece	447.54	12,019	5379
Ireland [b]	250.55	8264	2071
Italy	282.54	48,662	13749
Latvia	49.70	659	33
Lithuania	104.54	560	59
Netherlands	153.51	9,199	1412
Norway	183.37	9,437	1730
Poland	71.40	975	70
Portugal	204.88	9,619	1971
Romania	70.56	907	64
Slovenia	195.08	1,015	198
Spain	176.64	47,383	8370
Sweden	110.62	12,911	1428
UK	178.24	39,334	7011

[a] Source: Total arrivals of residents and tourists according to Eurostat (2010) and referring to year 2003; [b] Number of arrivals refers to year 2000.

Table 8 presents the mean baseline values of WTP per person per year and the aggregated values of coastal recreational activities in the 22 European countries investigated. The total number of visitors per year represents the total number of domestic and international tourist arrivals in coastal NUTS2 regions in each of the considered countries, as estimated by Eurostat (2010) for year 2003.

The highest WTP per person per year is found in the Mediterranean countries, Greece and Italy in particular. This is partly due to the fact that both minimum and maximum yearly temperatures are observed to be positively correlated with the values of WTP per person per year. WTP for tourism in Ireland and Norway is also high in spite of the low temperatures with respect to Mediterranean countries. This suggests that a different type of tourism may take place there, where climatic conditions are less crucial and tourists may be willing to pay more in order to enjoy the values of the natural landscape in a more pristine and less densely populated environment. Finland and Sweden have the lowest values of WTP per person per year, which suggests that in these countries the cold climate plays a crucial role in determining tourist demand.

Table 8 also provides estimates of the aggregated WTP values for all yearly visitors in the coastal regions of each considered country. High aggregated values are found in Mediterranean countries due to the fact that the estimated individual WTP in those countries is high and the tourism industry particularly developed there. High values are found in particular in Italy, France, and Spain. One of the highest total recreational values is found in the United Kingdom due to the high number of domestic and international arrivals reported for the reference year.

To spatially disaggregate the total values at country level, Figure 9 presents the values estimated for coastal NUTS2 regions in Europe. The values are obtained multiplying the individual WTP estimated at country level by the total number of arrivals in each region during year 2003, as reported by Eurostat.

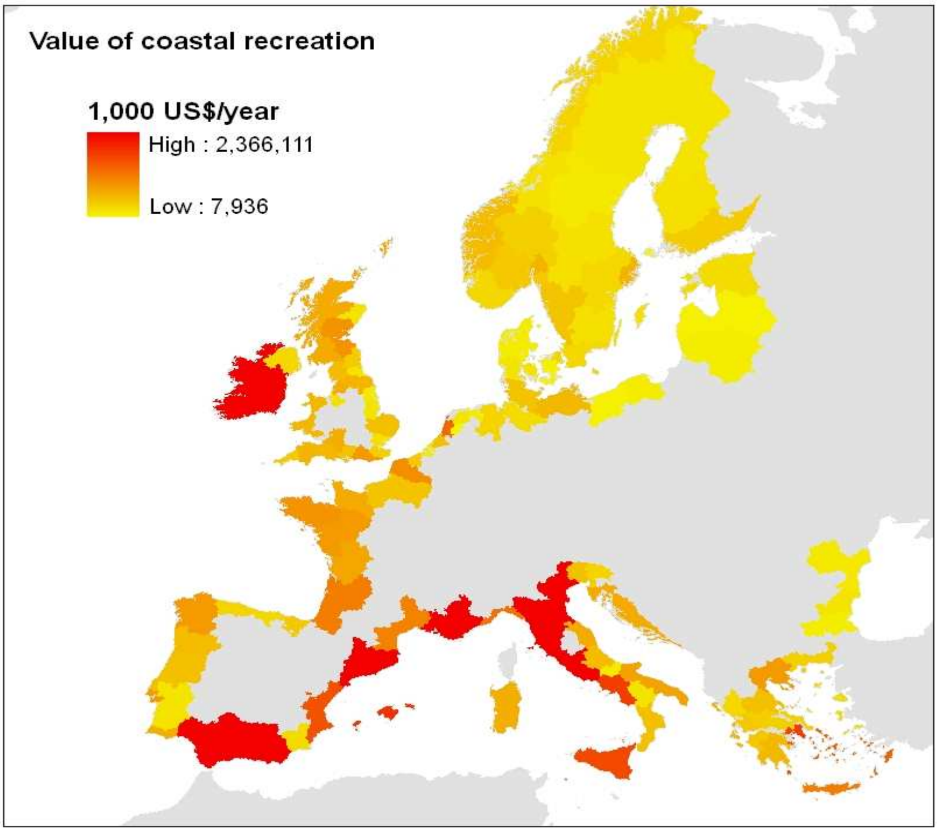


Figure 9: Aggregated values of recreation in coastal NUTS2 regions of Europe

The NUTS2 regions with the highest recreation values are those located in the Mediterranean coast of Italy, Spain, and France. Relatively high values are found also in the western coast of France and in the United Kingdom. A high aggregated value is found also for Ireland, although one should notice that due to lack of data relative to the number of visitors in NUTS2 regions of Ireland, it was not possible to disentangle the total country value into smaller units. Low aggregated recreation values are found in the Baltic and Scandinavia countries, and along the Black Sea coastline.

ANNEX G - THE ECONOMETRIC SPECIFICATIONS IN THE VALUATION

1. Meta-analysis of cultural services provided by European forest ecosystems:

The utility model used in the report is expressed as follows:

(1) $\log V = \alpha + \beta \log S + \gamma \log I$

where:
V is the marginal value of a given forest site designated to recreation or conservation of biodiversity.
S is the size of the forest area designated to recreation or conservation (hectares).
I is the income level of the country where the forest is located (measure as PPP_GDP).

By regressing the utility model expressed above, we estimate the marginal effect of the forest size (β) and the income level of the country where the site is located (γ) on the marginal WTP (*V*). In fact, the results of the meta-analyses confirm our expectations both for forest recreation and passive use values: income level and size of forest areas are the main statistically significant factors explaining variation in WTP estimates for changes in forest cultural services (Table1). The β coefficient on forest recreation size (logSIZE) is negative and significant for both recreation and passive use, showing that the marginal value of these services decreases with a marginal increase in forest area. The coefficient on income γ (logINCOME) is positive and significant, revealing a negative correlation of marginal values and income. The coefficients on passive use values are higher compared with those of recreation, showing a higher sensitivity of forest size and income on marginal values.

Table 1. Results of the meta-regression function for recreational and passive use values

Dependent variable		***Recreation use***		***Passive use***
LogWTP	Coefficient (std.error)	T-value	Coefficient (std.error)	T-value
Explanatory factors:				
constant	3.274 (3.698)	0.89	3. 972 (2.835)	1.40
LogSIZE	-0.445 (0.073)	-6.14	-0.603 (0.079)	-7.58
LogINCOME	0.599 (0.352)	1.70	0.889 (0.255)	3.49
Nobs	59		23	
R^2	0.452		0.797	
Adj R^2	0.433		0.797	

2. Meta-analysis of the values of freshwater ecosystem services

Table 2 presents the valuation studies on European freshwater ecosystems that were included in the dataset together with the name and location of the valued sites.

Table 2. European freshwater ecosystems in the valuation dataset

Country	Site name	Reference
Austria	Donau-Auen	Kosz 1996
Czech Republic	Wetland in Jihovýchod	Gren & Soderqvist 1994
France	Plaine alluviale de la Bassée	Bureau d'Etudes ACSA 1996
	Plaine alluviale de la Marne	Bureau d'Etudes ACSA 1996
	Nogentais	Bureau d'Etudes ACSA 1996
	Basse vallée de la Vire	Bureau d'Etudes ACSA 1996
	Saone floodplains	Bureau d'Etudes ACSA 1996
	Moyenne vallée de l'Oise	Bureau d'Etudes ACSA 1996
	Forets riveraine de la Garonne	Amigues & B. Desaigues 1999
	Cotentin	Bonnieux & Le Goff 1997
	Lac du Der	Scherrer 2003
	Lac de la Forêt d'Orient (Etang de la Morge)	Desaigues 1991
	étang du Canet - Saint Nazaire	Dabat & Rudloff 1999
	Ile de Rhinau	El Yousfi et al. 2006
Germany	Elbe river	Meyerhoff & Dehnhardt 2007
	Sandau	Meyerhoff & Dehnhardt 2007
	Rogaetz	Meyerhoff & Dehnhardt 2007
	Donau floodplain (Straubing and Vilshofen	Hanusch et al. 2000
Greece	Cheimaditida	Birol et al. 2006
	Lake Kerkini	Oglethorpe & Miliadou 2000
	Zazari-Cheimaditida	Ragkos et al. 2006
Italy	Vincheto di Cellarda	Marangon et al. 2002
	Oasi dei Quadris di Fagagna	Marangon et al. 2002
Netherlands	De Vechtstreek	Bos & Bergh 1998
	Oostvaardersplassen	de Groot & Velthuijsen 1998
	de Wieden	Hein et al. 2006
Norway	Lake Vegår and river Storelv	Navrud 1993
Spain	Aiguamolls de l'Empordà	Seguì-Amórtegui 2004
	Parc national des Tablas de Daimiel	Júdez et al. 1998
Sweden	Wetlands in Sweden	Byström 2000
	Martebo mire	Folke 1991
	Oxeloesund	Cravener 1995
UK	Flow country	Hanley & Craig 1991
	Halvergate marshes	Turner & Brooke 1988
	River Ancholme	Posford Duvivier Environment 1999
	River Nar	Posford Duvivier Environment 2000
	Somerset Levels and Moors ESA	Garrod et al. 1994
Various countries	Danube floodplain	Gren et al. 1995

The meta-analytical regression model used in the study is specified as follows:

$$\ln(y_i) = a + b_V X_{Vi} + b_S X_{Si} + b_C X_{Ci} + u_i \qquad (1)$$

where the dependent variable (*y*) is the value standardized to 2003 US$ per hectare per year; X_{Vi}, X_{Si} and X_{Ci} are the vectors of the explanatory variables and b_V, b_S and b_C the respective coefficients; *a* is a constant term; and *u* is an error term that is assumed to be well-behaved. The subscript *i* is an index that characterizes the 236 independent value observations that are used for the regression.

Table 3 illustrates the explanatory variables that are considered for inclusion in the meta-regression model.

Table 3. Explanatory variables of the meta-regression model

Group	Variable	Units and measurement	Mean (SD)
Study (X_{Vi})	Stated preference method	Binary (range: 0 or 1)	0.28 (0.45)
	Revealed preference method	Binary (range: 0 or 1)	0.15 (0.36)
	Market-based method	Omitted category	0.56 (0.50)
	Mixed valuation method	Binary (range: 0 or 1)	0.01 (0.11)
	Marginal	Binary (range: 0 or 1)	0.13 (0.34)
	Average	Omitted category	0.87 (0.34)
Site (X_{Si})	River and river floodplain [a]	Binary (range: 0 or 1)	0.45 (0.50)
	Lake [a]	Binary (range: 0 or 1)	0.38 (0.49)
	Other freshwater wetland [a]	Binary (range: 0 or 1)	0.39 (0.49)
	Provisioning [a]	Binary (range: 0 or 1)	0.37 (0.48)
	Regulating [a]	Binary (range: 0 or 1)	0.27 (0.44)
	Cultural services: recreation [a]	Binary (range: 0 or 1)	0.42 (0.49)
	Cultural services: passive [a]	Binary (range: 0 or 1)	0.23 (0.42)
	Ecosystem size	Natural log of hectares	8.29 (3.06)
	Latitude below 35°N	Omitted category	0.56 (0.50)
	Latitude within 35–45°N	Binary (range: 0 or 1)	0.34 (0.47)
	Latitude within 45–55°N	Binary (range: 0 or 1)	0.23 (0.42)
	Latitude above 55°N	Binary (range: 0 or 1)	0.05 (0.21)
Context (X_{Ci})	Real GDP per capita [b]	Natural log of 2003 I$ (PPP)	9.51 (1.30)
	Total freshwater ecosystems area [c]	Natural log of hectares	16.44 (2.76)
	Population density per country [c]	Natural log of inhabitants per km^2	3.90 (1.22)
	Total known bird species [c]	Natural log of number of species	6.58 (0.34)
	Threatened bird species [c]	Natural log of number of species	3.41 (0.86)
	Minimum monthly temperature [c]	Degrees Celsius	3.59 (12.05)
	Maximum monthly temperature [c]	Degrees Celsius	21.51 (4.29)

[a] The variables identifying ecosystem types and services are not mutually exclusive, since individual observations may pertain to two or more ecosystem types or services; [b] At country level, but for the USA and EU countries where it is evaluated at state and NUTS2 level respectively; [c] At country level.

The results obtained with the meta-regression model described in equation (1) using ordinary least squares (OLS) are presented in Table 4. In the model, the coefficients measure the constant proportional or relative change in the dependent variable for a given absolute change in the value of the explanatory variable. For the explanatory variables expressed as logarithms, the coefficients represent elasticities, that is, the percentage change in the dependent variable given a one-percentage change in the explanatory variable.

Some of the variables listed in Table 4 were dropped from the model after a preliminary meta-regression analysis because statistically insignificant. This is the case of the number of threatened bird species and the minimum monthly temperature. The total number of mammal species and the number of threatened mammal species were excluded from the model because highly correlated with the bird biodiversity variables.

Table 4. Results of the basic meta-regression model

Type	Variable	Coefficient		St.error
	Constant	–0.182		5.052
Study	Stated preference	0.518		0.363
	Revealed preference	–1.206	**	0.532
	Mixed	–0.899	*	0.545
	Marginal	0.891	**	0.421
Site	Size (ln)	–0.356	***	0.051
	Latitude 35°N-45°N	1.124	**	0.538
	Latitude 45°N-55°N	–1.966	***	0.664
	Latitude higher than 55°N	–2.576	***	0.907
	Cultural services: recreation	–0.536		0.401
	Cultural services: passive	0.649		0.429
	Provisioning	–1.051	**	0.434
	Regulating	0.452		0.407
Context	Real GDP per capita (ln)	0.444	*	0.228
	Population density (ln)	0.519	***	0.170
	Total freshwater ecosystem area	–0.380	**	0.154
	Total known bird species	1.900	*	1.066
	Maximum monthly temperature	–1.432	**	0.056

OLS results. R^2 = 0.45; *Adj.* R^2 = 0.40. Significance is indicated with ***, ** and * for 1, 5 and 10% statistical significance levels respectively. Robust standard errors calculated with Huber-White estimators.

A series of diagnostic tests were performed in order to investigate the robustness of the regression results. The normality of residuals was investigated by analyzing the Kernel density plot of the residuals (see Fig. 1), the standardized normal probability plot and quantiles of residuals plotted against the quantiles of a normal distribution (see Fig. 2), and by means of the Shapiro-Wilk W test for normality.

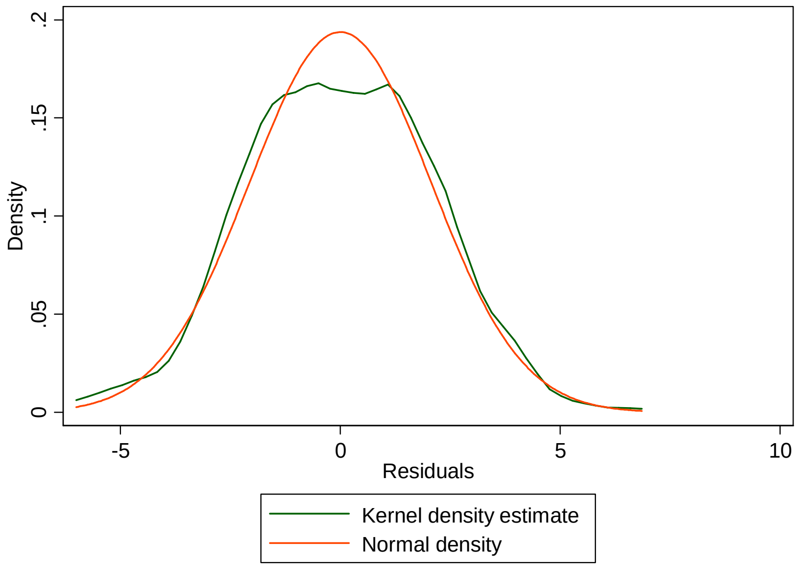


Fig. 1. Kernel density plot of residuals

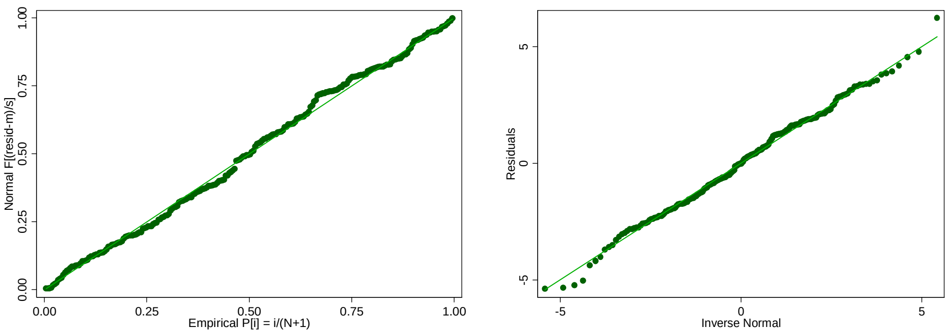


Fig. 2. Standardized normal probability plot (*left*) and quantiles of residuals plotted against quantiles of normal distribution (*right*)

The Kernel density plot and quantiles of residuals show a certain deviation from the normal distribution in the middle range of data and in the lower tail. Nevertheless the distribution seems quite close to a normal distribution. This is confirmed by the Shapiro-Wilk test, which does not reject the hypothesis of normal distribution (Prob > z = 0.6518).

The homoskedasticity of the distribution of residuals is investigated by visual investigation of plot of residuals versus fitted values (Fig. 3) and by means of both White's test and Breusch-Pagan test. Both tests do not reject the hypothesis of homoskedastic distribution of residuals (p-level = 0.7097; Prob > F = 0.9117).

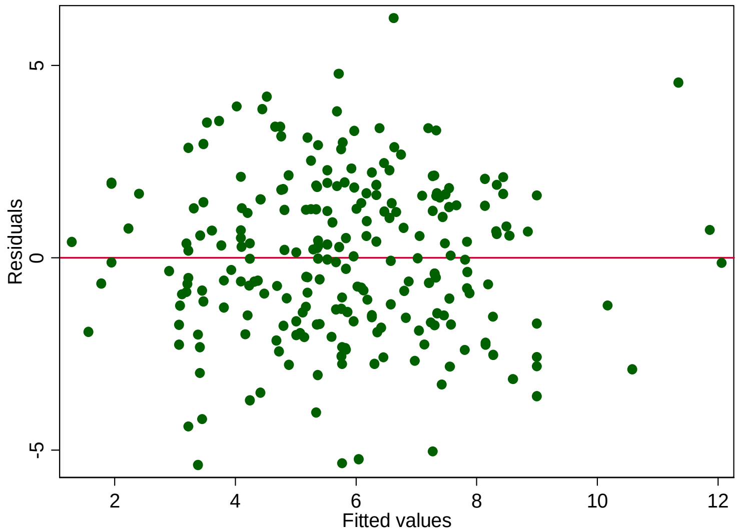


Fig. 3. Plot of residuals versus fitted predicted values

The presence of multicollinearity between predictor variables was investigated by means of the variance inflation factor (VIF). Table 5 illustrates the values of VIF and tolerance (1/VIF) for the regression variables. All values of VIF are lower than 10 and tolerance is higher than 0.1, which suggests that none of the variables can be expressed as a linear combination of other variables.

Table 5. Variance inflation factor (VIF) and tolerance

Variable	VIF	1/VIF
Stated preference	2.06	0.486
Revealed preference	2.10	0.475
Mixed	1.16	0.864
Marginal	1.37	0.730
Size (ln)	1.28	0.782
Latitude 35°N-45°N	3.88	0.258
Latitude 45°N-55°N	4.43	0.225
Latitude higher than 55°N	2.30	0.434
Cultural services: recreation	1.97	0.508
Cultural services: passive	1.71	0.584
Provisioning	2.02	0.496
Regulating	1.58	0.632
Real GDP per capita (ln)	4.31	0.232
Population density (ln)	2.00	0.500
Total freshwater ecosystem area	6.97	0.144
Total known bird species	5.06	0.198
Maximum monthly temperature	2.85	0.351
Mean VIF	2.77	

For what concerns model specification, both the link test for model specification (p-value of _hatsq = 0.669) and the regression specification error test for omitted variables (Prob > F = 0.167) do not suggest specification errors. Finally, we tested for dependencies between observations from the same study by running the regression clustering for studies. Overall, the results are consistent with what shown in Table 3, but for the standard error of some of the variables, which is modestly enlarged making the coefficients not statistically significant. Such variables are 'Latitude 35°N-45°N' (p-level = 0.104), 'mixed' (p-l evel = 0.179), 'Real GDP per capita' (p-level = 0.110), and 'Total known bird species' (p-level = 0.160).

3. Meta-analysis of the value of recreation in coastal ecosystems

The meta-regression model used in the analysis of recreation values of coastal ecosystems is specified as follows:

$$\ln(y_i) = a + b_V X_{Vi} + b_S X_{Si} + b_C X_{Ci} + u_i \qquad (1)$$

where $\ln(y_i)$ is the natural logarithm of the endogenous variable (US$/person/year); the subscript *i* is an index for the value observations; *a* is a constant term; b_V, b_S and b_C are vectors containing the coefficients of the explanatory variables X_V (valuation study characteristics), X_S (site characteristics), and X_C (context characteristics); and *u* is an error term that is assumed to be well-behaved. In the meta-regression the value observations are assumed to be independent. In the semi-logarithmic model the coefficients measure the constant proportional or relative change in the dependent variable for a given absolute change in the value of the explanatory variable. For the explanatory variables expressed as logarithms, the coefficients represent elasticities, that is, the percentage change in the dependent variable given a one-percentage change in the explanatory variable.

To allow for a comparison between values that have been calculated in different years and expressed in different currencies and metrics, values are standardised to the common metric of 2003 US$ per person per year. Values referring to different years were deflated using appropriate factors from the Millennium Development Indicators (World Bank 2006), while differences in purchase power among the countries were accounted for by the Purchase Power Parity index provided by the Penn World Table (Heston et al. 2006).

Table 6 illustrates the final set of explanatory variables used in the meta-regression.

Table 6. Explanatory variables of the meta-regression model

Group	Variable	Units and measurement	Mean (SD)
Study (X_{Vi})	Stated preference method	Binary (range: 0 or 1)	0.59 (0.49)
	Revealed preference method	Omitted category	0.41 (0.49)
	Marginal variation	Binary (range: 0 or 1)	0.57 (0.50)
	Total value	Omitted category	0.43 (0.50)
	Household value	Binary (range: 0 or 1)	0.14 (0.34)
	Individual value	Omitted category	0.86 (0.34)
Site (X_{Si})	Beach	Binary (range: 0 or 1)	0.47 (0.50)
	Coral reef	Binary (range: 0 or 1)	0.08 (0.27)
	Other coastal ecosystem	Omitted category	0.45 (0.50)
	Recreational fishing [a]	Binary (range: 0 or 1)	0.52 (0.50)
	Non-consumptive recreation [a]	Binary (range: 0 or 1)	0.65 (0.48)
Context (X_{Ci})	Real GDP per capita [b]	Natural log of 2003 I$ (PPP)	10.36 (0.53)
	Population density [c]	Natural log of inhabitants per km^2	3.66 (1.11)
	Total known bird species [c]	Natural log of number of species	6.59 (0.32)
	Threatened bird species [c]	Natural log of number of species	3.75 (0.83)
	Minimum monthly temperature [c]	Degrees Celsius	13.40 (8.60)
	Maximum monthly temperature [c]	Degrees Celsius	23.03 (5.83)

[a] The variables identifying ecosystem services are not mutually exclusive, since individual observations may pertain to two or more services; [b] At country level, but for the USA and EU countries where it is evaluated at state and NUTS2 level respectively; [c] At country level.

The results obtained from the meta-regression with ordinary least squares (OLS) are presented in Table 7. In the model, the coefficients measure the constant proportional or relative change in the dependent variable for a given absolute change in the value of the explanatory variable. It is reminded that for the explanatory variables expressed as logarithms, the coefficients represent elasticities, i.e., the percentage change in the dependent variable given a one-percentage change in the explanatory variable.

Table 7. Results of the meta-regression

Type	Variable	Coefficient		St.error
	Constant	–3.724		0.175
Study (X_{Vi})	Stated preference method	–0.550		0.189
	Marginal variation	–0.992	***	0.192
	Household value	0.903	***	0.195
Site (X_{Si})	Beach	–0.007		0.175
	Coral reef	0.587		0.432
	Recreational fishing	0.884	***	0.228
	Non-consumptive recreation	–0.530	**	0.221
Context (X_{Ci})	Real GDP per capita	0.538	**	0.211
	Population density	–0.225	*	0.134
	Total known bird species	0.779	*	0.398
	Threatened bird species	–0.921	***	0.223
	Minimum monthly temperature	0.060	***	0.023
	Maximum monthly temperature	0.079	**	0.031

OLS results obtained with STATA® statistical software. R^2 = 0.49; *Adj.* R^2 = 0.47. Significance is indicated with ***, ** and * for 1, 5 and 10% statistical significance levels respectively. Robust standard errors calculated with Huber-White estimators.

A series of diagnostic tests are performed in order to investigate the normality and homoskedasticity of residuals. Normality is investigated by means of the Kernel density plot of the residuals, the standardized normal probability plot and quantiles of residuals plotted against the quantiles of a normal distribution (see

Fig. 4), and with the Shapiro-Wilk W test for normality. The homoskedasticity of the distribution of residuals is investigated by plotting residuals versus fitted values (see Fig. 5) and by means of both White's test and Breusch-Pagan test.

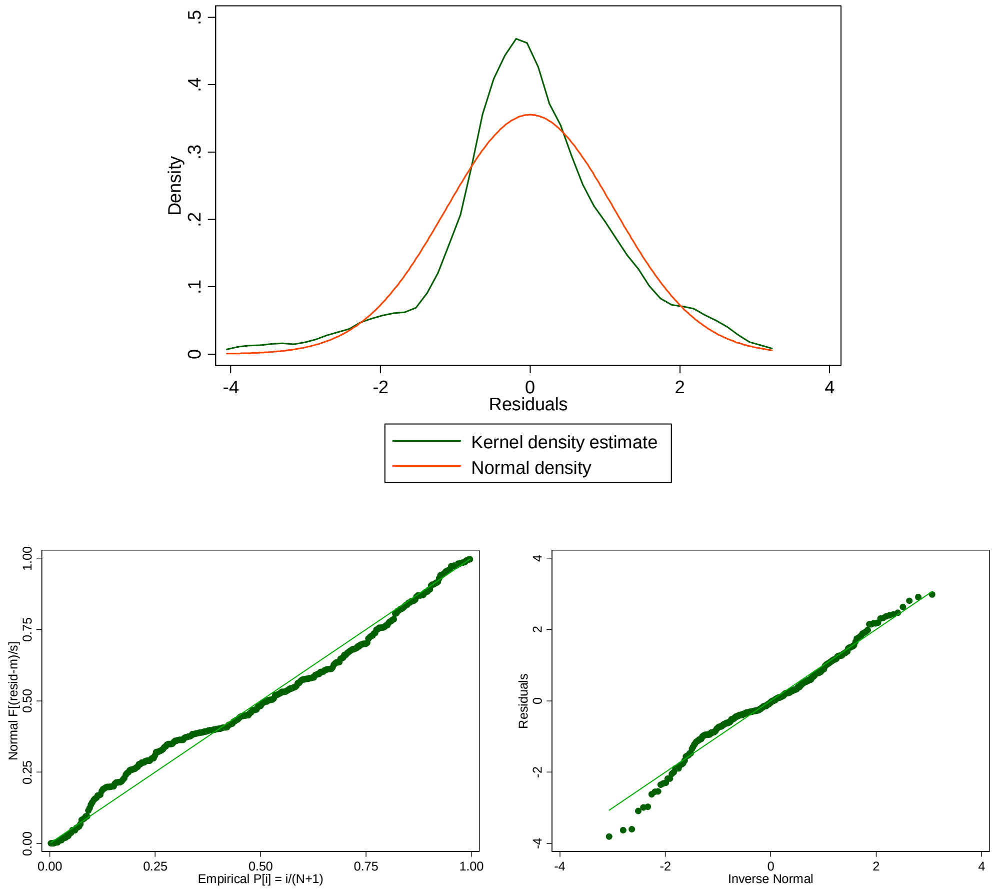


Fig. 4. Tests of normality of residuals: Kernel density plot of residuals (*above*); standardized normal probability plot (*below left*) and quantiles of residuals plotted against quantiles of normal distribution (*below right*)

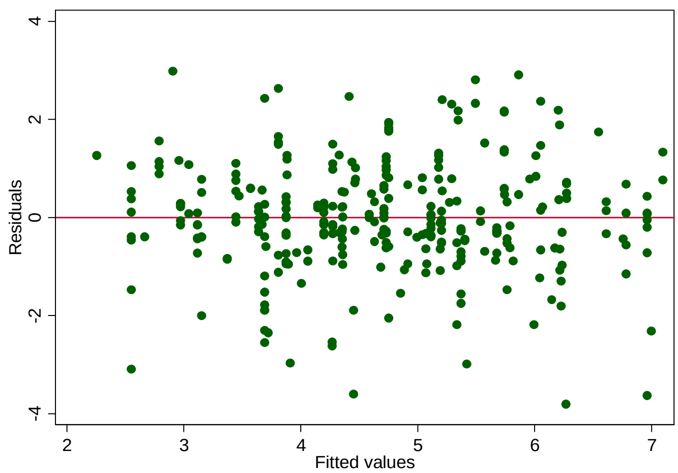


Fig. 5. Test of heteroskedasticity of residuals: plot of residuals versus fitted predicted values

Fig. 3 illustrates a deviation of the distribution of the residuals from the normal distribution. This is confirmed by the Shapiro-Wilk test, which rejects the hypothesis of normal distribution (Prob > z = 0.0001). Visual investigation of Fig. 4 does not reveal evidence of heteroskedasticity in the distribution of residuals. The hypothesis of homoskedasticity is not rejected by the Breusch-Pagan test (Prob. > chi2 = 0.1782), but is rejected by White's test (p = 0.0000). Deviation from normality and heteroskedasticity in the distribution of residuals does not introduce bias into the coefficient estimates but compromises the reliability of the p-values in the regression. In order to mitigate the effect of non-normality and heteroskedasticity, we estimated in Table 2 standard errors obtained with the Huber-White estimators, which are more robust to the failure to meet assumptions concerning normality and homoskedasticity of the residuals.

The presence of multicollinearity between predictor variables was investigated by means of the variance inflation factor (VIF). Table 8 illustrates the values of VIF and tolerance (1/VIF) for the regression variables. All values of VIF are lower than 10 and tolerance is higher than 0.1, which suggests that none of the variables can be expressed as a linear combination of other variables.

Table 8. Variance inflation factor (VIF) and tolerance

Variable	VIF	1/VIF
Stated preference method	2.43	0.411
Marginal variation	2.47	0.404
Household value	1.33	0.752
Beach	2.06	0.486
Coral reef	2.22	0.450
Recreational fishing	2.97	0.337
Non-consumptive recreation	2.57	0.390
Real GDP per capita	2.58	0.388
Population density	2.39	0.419
Total known bird species	4.04	0.247
Threatened bird species	5.86	0.171
Minimum monthly temperature	7.69	0.130
Maximum monthly temperature	7.85	0.127
Mean VIF	**3.57**	

With respect to model specification, both the link test for model specification (p-value of _hatsq = 0.781) and the regression specification error test for omitted variables (Prob > F = 0.183) do not suggest specification errors.

ANNEX H - GIS MAPS

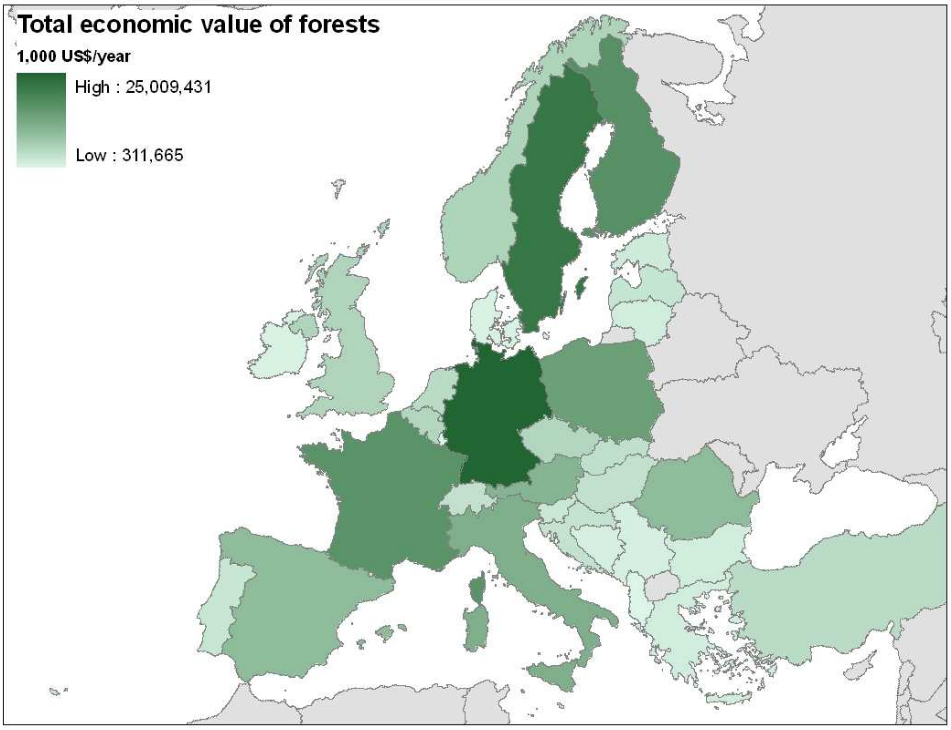


Fig. A. The total economic value of forest ecosystem in Europe

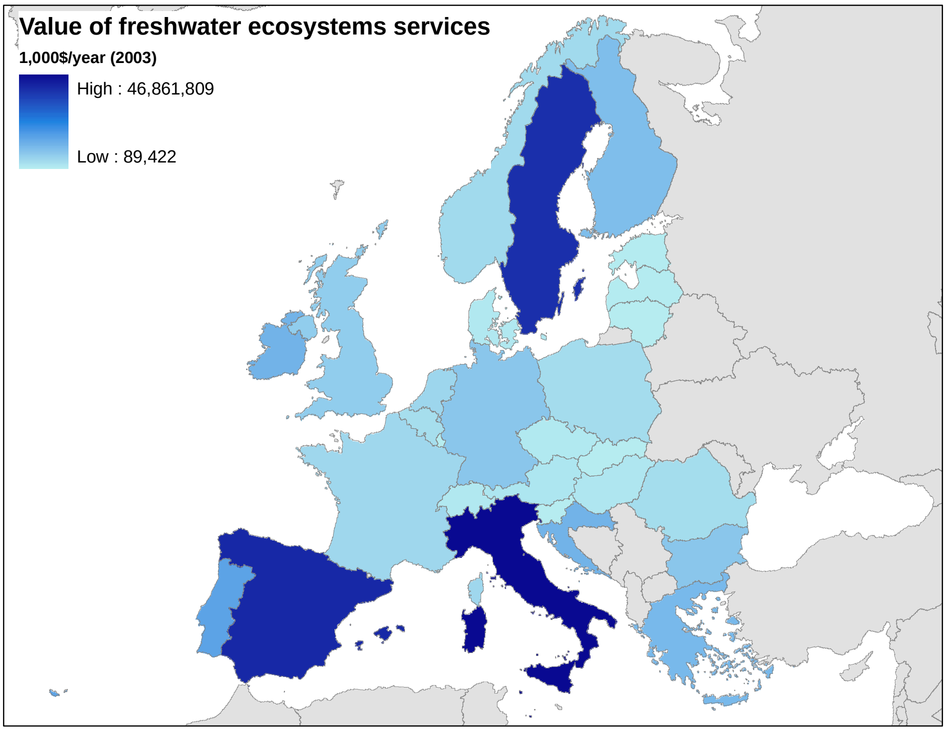


Fig. B. Aggregated values of freshwater ecosystem services in European countries

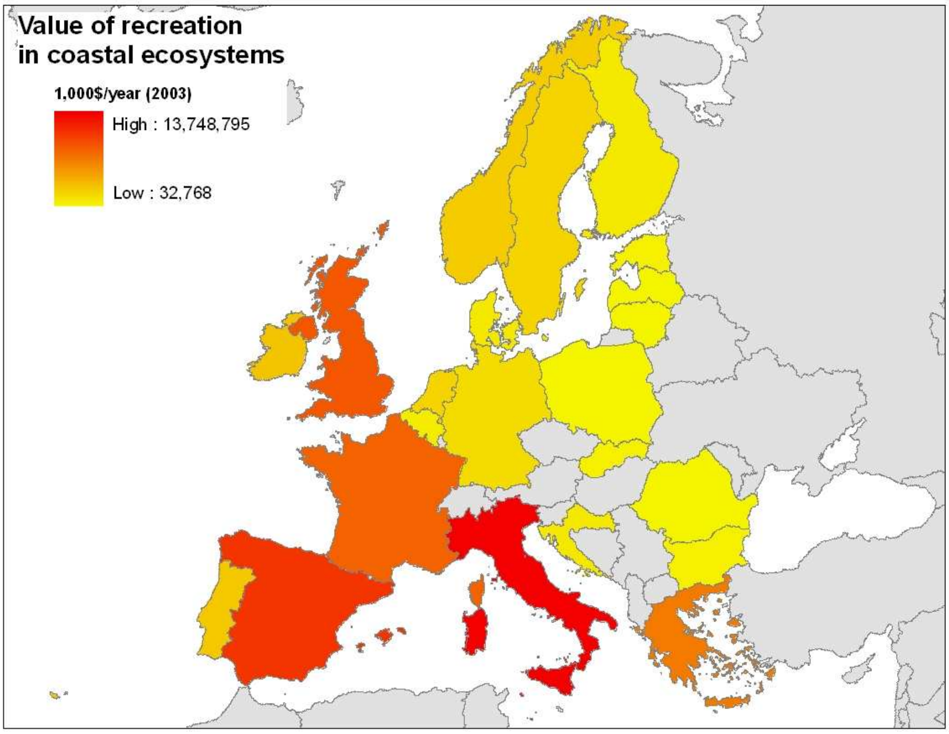


Fig. C. Aggregated values of coastal recreation in European countries