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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY  
FOR WATER AND WETLANDS  
**A contribution to CBD COP11**

The Economics  
of Ecosystems  
& Biodiversity



Final consultation draft

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# The Economics of Ecosystems and Biodiversity for Water and Wetlands

## *Final Consultation Draft*

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**Standard disclaimer:** The contents and views contained in this report are those of the authors, and do not necessarily represent those of any of the contributors, reviewers or organisations supporting this work.

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*Thank you !*

# TEEB for Water and Wetlands<sup>1</sup>

## Executive Summary

### I. Introduction

The “nexus” between water, food and energy has been recognised as one of the most fundamental relationships and challenges for society. The importance of this nexus was re-emphasised at the recent UN Conference on Sustainable Development (Rio+20) in June 2012. Wetlands<sup>2</sup> are a fundamental part of local and global water cycles and are at the heart of this nexus.

Wetlands are essential in providing water-related ecosystem services, such as clean water for drinking, water for agriculture, cooling water for the energy sector and regulating water quantity (e.g. flood regulation). In conjunction with their role in erosion control and sediment transport, wetlands also contribute to land formation and therefore resilience to storms. Moreover, they provide a wide range of services that are dependent on water, such as agricultural production, fisheries and tourism.

Notwithstanding the high value of the ecosystem services that wetlands provide to humankind, wetlands continue to be degraded or lost due to the effects of intensive agricultural production, irrigation for food provision, water extraction for domestic and industrial use, urbanisation, infrastructure and industrial development and pollution.

In many cases, policies and decisions do not take into account these interconnections and interdependencies sufficiently. However, the full value of water and wetlands needs to be recognised and integrated into decision-making in order to meet our future social, economic and environmental needs. Using the maintenance and enhancement of the benefits of water and wetlands is, therefore, a key element in a transition to a sustainable economy.

#### Questions this report addresses

The report responds to the following questions by presenting insights from experience from across the globe:

- What are the values and benefits associated with water and wetlands?
- What are the roles of wetlands in terms of providing water and wetland related ecosystem services and what are their values?
- What are the wider set of ecosystem system services that water and wetlands provide and what are their values?
- What needs to be done to improve the consideration of the values and benefits of water and

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<sup>1</sup> The development of this report has been initiated by the Ramsar Convention Secretariat, supported by the Norwegian, Swiss and Finnish Governments and the International Union for Conservation of Nature (IUCN). A team comprising the secretariats of The Ramsar Convention on Wetlands and the Convention on Biological Diversity (CBD), the Institute for European Environmental Policy (IEEP), International Union for Conservation of Nature (IUCN), the Helmholtz Centre for Environmental Research UFZ (UFZ) and Wetlands International drafted the report.

<sup>2</sup> For the purpose of the Ramsar Convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. Article 1, Ramsar Convention (1971). The Ramsar Convention has 163 Contracting Parties.

wetland in policy developments and in practical decision making?

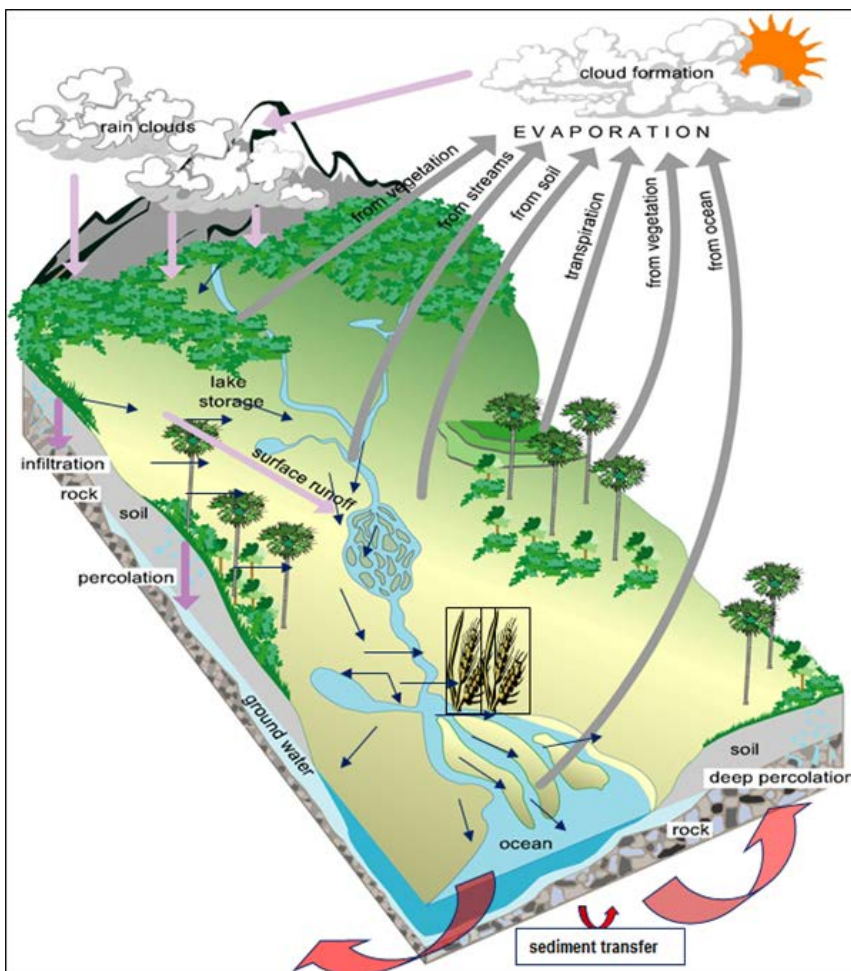
- What approaches have been successfully used to date to respond to the challenges and take account of the values of water and wetlands?
- What existing examples demonstrate how policy, investment and water and land use decisions can be based on the values and benefits associated with water and wetlands?
- What are the recommendations for transforming the regional, national and international approaches for managing water, wetlands and their ecosystem services?

## II. Water and wetlands: what benefits do we derive and what do we risk losing?

### Wetlands and the water cycle

**Water security is a major and increasing concern in many parts of the world**, including both the availability (including extremes) and quality of water. Understanding the value of water and wetlands helps provide a firm foundation for protection and enhancement of these resources, and thereby contributes to delivering secure water supplies, while improving water allocation and management decisions.

Figure E1 The water cycle



Source: redrawn from MRC (2003)

**The global and local water cycles are strongly dependent on wetlands** (Ramsar, 1971; MA, 2005b; SCBD, 2012). Land cover affects water retention and flows and hence the availability of surface and ground waters. Transpiration from plants affects rainfall patterns. Biodiversity plays a critical role in the nutrient cycle and carbon cycles (carbon stored, sequestered and released from biomass). A loss of biodiversity can compromise the functioning of these cycles, leading to major impacts on people, society and the economy. **Without wetlands the water cycle, carbon cycle and nutrient cycles would be significantly altered, usually detrimentally.** In turn, water cycles are of paramount importance to biodiversity and to the functioning of essentially all terrestrial and coastal ecosystems.

### Wetlands and water-related ecosystem services

**Biodiversity and ecosystems provide a range of services which benefit people, society and economy at large;** these are known as ecosystem services (MA, 2005a). Many of these ecosystem services are related to water and wetlands via water provision, regulation, purification, and groundwater replenishment, and are crucial in addressing objectives of **water security**, including personal water security. Other ecosystem services provided by wetlands play important roles in relation to **climate change** (local climate regulation, climate mitigation and adaptation), **food security** (provision of food and provision of habitats and nurseries for fisheries), **job security** (maintenance of fisheries, soil quality for agriculture) and a range of cultural benefits, including **knowledge** (scientific and traditional), **recreation and tourism**, and formation of **cultural values**, including identity and spiritual values.

**Wetlands are particularly important providers of all water-related ecosystem services** - they are essential sources of water for many rural areas, towns and cities. They regulate water quantity (including availability in surface water), groundwater recharge, and can contribute to flood and storm regulation. Lesser known, but no less important, wetlands particularly help in erosion control and sediment transport, thereby contributing to land formation and increasing resilience to storms in deltas and coastal areas. All these ecosystem services improve water security, security from natural hazards and climate change adaptation. The final Rio+20 declaration "*The Future We Want*", *inter alia*, recognised the role of ecosystems in the supply of water and its quality (para. 122, UNCSD, 2012).

**Values of wetlands ecosystem services are typically higher than for other ecosystem types.** The literature on the values of wetlands and other ecosystems underlines that wetlands ecosystems can have some of the highest values compared to other ecosystems due to the importance of clean water provision, natural hazards mitigation (e.g. mangrove forests and floodplains), and carbon storage (e.g. in peatlands, mangroves and tidal marshes) (see TEEB, 2010; de Groot *et al.*, 2012)<sup>3</sup>.

**The roles and values of water-related ecosystems and wetlands in providing key ecosystem services need to be fully appreciated and integrated into decision making at local, national and international scales.** Incomplete understanding of these can result in favouring the ecosystem services whose values are well reflected in markets (e.g. food, timber) over those which are largely invisible in markets (e.g. ecosystem based water purification, flood and storm protection, nutrient cycling).

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<sup>3</sup> It has to be noted that ecosystem functions, the flow of ecosystem services, and the economic value to society and the economy are site specific and depend on the ecological, social and economic systems and their interactions. As such, the values derived in particular valuation study are very site-specific and cannot be easily extrapolated to another site/location. For further discussion see value transfer in TEEB (2010) Chapter 5.

While the value of wetlands for water supply can be considerable, an additional advantage of maintaining them is that **wetlands also deliver multiple co-benefits of significant social and economic values, and hence can help address a wide range of needs and objectives.** Wetlands contribute to local climate regulation and act as carbon sinks, helping reduce **climate change**, and for this reason their degradation (e.g. draining peatlands) can lead to very significant GHG emissions. Wetlands also regulate sediment transport thereby contributing to **land formation** and **coastal zone stability**. Mangroves, for instance, can provide important fish nursery functions and provide a basis for local **food security** and **livelihoods** (fisheries), as well as sources of materials and fuel. These benefits merit a significant re-evaluation as to their importance and the misperceptions as to their lack of utility need to be challenged (MA, 2005b; TEEB, 2010; TEEB, 2011; TEEB, 2012a; TEEB, 2012b).

**Wetlands are some of the most important biodiverse areas in the world and provide essential habitats for many species.** The global Ramsar Convention network of “Wetlands of International Importance” (Ramsar Sites), which comprises over 2000 sites covering over 1.9 million km<sup>2</sup> (up to 15% of estimated global wetland area) supports unique biodiversity in ecosystems (e.g. coral reefs, peatlands, freshwater lakes and marshes and mangroves), species (e.g. waterbirds, amphibians and wetland-dependant mammals such as hippopotamus, manatees and river dolphins) and genetic diversity.

Examples of major wetlands in the Ramsar Site network include the Danube Delta in Romania and the Ukraine; the Waddensea across the Netherlands, Germany and Denmark; the Everglades in the USA; the Pantanal wetlands across Brazil, Bolivia and Paraguay; the Okavanga Delta in Botswana; the Sundarbans in Bangladesh; the Camargue in France; the arctic tundra of Queen Maud Gulf in Canada; the Volga Delta and southern Lake Baikal in the Russian Federation; Wasur National Park in Indonesia; Kakadu National Park in northern Australia; the forest, lake and river systems of Grands affluents and Ngiri-Tumba-Maindombe in Congo and Democratic Republic of Congo; and Lake Tchad across Tchad, Niger and Nigeria.<sup>4</sup>

### Meeting sustainable water management objectives cost effectively via ecosystem services from wetlands

**Wetlands provide natural infrastructure that delivers a wider range of services and benefits than corresponding man-made infrastructure and can do this at lower cost.** They are also an important, but poorly recognised, **complement to man-made infrastructure in river basin planning and management efforts.** Wetlands can, for example, provide protection against coastal and river flooding to (partially) offset the need for man-made infrastructure, whilst at the same time providing a multitude of other services (e.g. recreation and tourism, carbon storage, or a range of provisioning services). Nature-based solutions can constitute a lower cost approach than alternative built capital solutions, or offer significant cost savings where an integrated natural and man-made infrastructure approach is adopted.

**Strategies for integrated water resource management can take account of these wider benefits,** balance the needs of humans and nature and help enhance water security through maintaining biodiversity and ecosystem services, thereby providing cost-effective and sustainable options. These options can also be applied at larger scales (Vörösmarty et al., 2010). Examples include water provision and filtration, waste water treatment, and flood control. As regards waste water treatment, there are ecological engineering solutions that combine man-made approaches with nature, for example, by installing man-made wetlands/ponds. However, while nature provides

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<sup>4</sup> Information on all Ramsar Sites is available on: <http://ramsar.wetlands.org/>

important waste management services, care is needed to not breach ecological limits, both for biodiversity reasons and as the functions and services of the wetland itself may be impaired. **In addition to direct water services, wetlands can offer cost effective solutions for other global environmental challenges**, such as climate change mitigation through peatlands protection and restoration and climate change adaptation through mangroves which can help reduce damage from increasingly frequent storms. Peatlands cover 3 per cent of the world's land surface, about 400 million hectares (4 million km<sup>2</sup>), of which 50 million hectares are being drained and degraded, producing the equivalent of 6 per cent of all global CO<sub>2</sub> emissions (Crooks et al., 2011).

### **Wetlands degradation continues, despite their values**

**Status and trends of wetlands.** Inland wetlands cover at least 9.5 million km<sup>2</sup> (i.e. about 6.5% of the Earth's land surface) with inland and coastal wetlands together covering a minimum of 12.8 million km<sup>2</sup> (Finlayson et al., 1999; UNEP, 2012). Since 1900, the world has lost around 50% of its wetlands (UNWWAP, 2003). Recent coastal wetland loss in some places, notably East Asia, has been up to 1.6% a year (Gong et al., 2010), and is ongoing. Taking mangroves as an example, 20 per cent (3.6 million hectares) of total coverage has been lost since 1980, with recent rates of loss of up to 1% per year (FAO, 2007).

**Degradation of the remaining wetlands can lead to biodiversity loss, changes to ecological functions, and changes to ecosystem service flows with subsequent impacts on the health, livelihoods and wellbeing of communities and economic activity.** For example eutrophication of inland freshwater wetlands and coastal wetlands can lead to the ecosystem becoming algae dominated, which in turn leads to declines of fish availability, health risks and reduction in recreation and tourism opportunity, and where it concerns coastal reefs, also reductions in natural hazard management (SCBD, 2010). Pressures on wetlands include habitat loss (e.g. wetland drainage), invasive species, pollution, siltation, over-exploitation (e.g. unsustainable harvesting of fish), excessive water withdrawals (e.g. for irrigated agriculture), nutrient loading (e.g. from fertiliser use and urban waste water), and climate change (e.g. temperature rises changing ecosystem conditions).

**Human drivers of ecosystem change pose a threat to water security for 80% of the world's population and to global freshwater biodiversity** (Vörösmarty et al., 2010). In developed countries, costly technical solutions for water treatment are used to reduce some of these negative effects, but do little to address the source of the problem. Developing countries often cannot afford such capital costly approaches to water management.

**To address the economic drivers of ecosystem change, there is a need to mainstream ecosystem services into economic decisions.** The Millennium Ecosystem Assessment concluded that many water resource developments that have been undertaken to increase access to water have not given adequate consideration to the harmful trade-offs with other services provided by wetlands (MA, 2005b). An increased appreciation of the societal values of water-related ecosystem services from nature and the wider range of wetland ecosystem services will be essential to catalyse appropriate policy and business response.

**The continuing loss and degradation of wetlands and associated loss of ecosystem services can lead to significant losses of human wellbeing, biodiversity, and economic impacts on communities, countries and business.**

### III. Measuring to manage better

An improved evidence base on the **interconnections between wetland ecosystems and social and economic systems will support improved management** of wetlands. Furthermore, **assessing the value of water and wetlands** can help **demonstrate their importance** and be an essential new evidence base for decisions at different levels, across both public and private sectors. An extended evidence base will help in the good governance of natural capital and support wetlands in finding their due place in policy, planning and investment decisions. A diverse range of tools help identify, demonstrate and take account of the benefits of water and wetlands (TEEB, 2010; TEEB, 2011; De Groot et al., 2006). Valuation of these benefits can make use of a mix of qualitative, quantitative, spatial, and monetary approaches. Furthermore, there are different methods to derive monetary values and they often build on biophysical assessments.

- **Bio-physical assessments**

- **Measurement and indicators** of the state and trends of biodiversity, as well as the flow of ecosystem services - e.g. water quality and quantity, biodiversity or ecosystem service indicators such as carbon sequestration, water retention, and number of people benefitting from ecosystem-provided clean water;
- **Mapping** the location and extent of wetlands, along with their interrelationships with ecosystems, population centres and man-made infrastructure provides essential insights on their interdependencies. Communities can be dependent on the ecosystem service flows from a wetland and the wetland health and functions can be dependent on the management by the local community. Furthermore, flood management for cities can be dependent on a combination of wetlands and human-made infrastructure, and understanding their complementarity can be fundamentally important for land use planning, management and investment choices.
- **Natural capital and environmental-economic accounts** are systematic ways of collating the biophysical evidence base and associated values at regional or national levels, in order to give policy makers a tool to complement national economic accounts (Gross Domestic Product (GDP) calculations). Tools and approaches for environmental accounts at the national level include the UN System of Environmental-Economic Accounts (SEEA) initiative, the World Bank-led Wealth Accounting and Valuation of Ecosystem Services (WAVES), the Ecosystem Capital Accounts being developed by the European Environment Agency (EEA, 2011) and a range of national approaches. At the private sector level, emerging developments include corporate sustainability reporting and accounting - such as Environmental Profit and Loss Accounts and the Natural Capital Declaration of the financial sector (Puma, 2011; Natural Capital Declaration, 2012).

### IV. Integrating the values of water and wetlands into decision making

The Ramsar Convention signed in 1971, with its 163 government signatories (Contracting Parties) and its current Strategic Plan 2009-2015, commits Parties to implementing wise use principles for water and wetlands. Actions by Parties to deliver wise use provide important initiatives for protecting key water and wetland services. Integrating the values of water and wetlands can facilitate and inform decision making for wise use.

The globally agreed **Strategic Plan for Biodiversity 2011-2020** (launched at the Convention of Biological Diversity Conference of the Parties in Japan in 2010 and supported by the Rio+20



Declaration) **includes commitments to raise awareness of the values of biodiversity and to integrate them into plans, strategies, and accounts** (Aichi Biodiversity Targets 1 and 2). Parties to the CBD (193 parties from across the world) are currently revising their National Biodiversity Strategies and Actions Plans (NBSAPs) to take on board physical assessments of nature and flow of ecosystem services as well as growing number of initiatives to value nature by non-monetary and monetary means<sup>5</sup>.

**Policy synergies.** Working with nature can be a cost effective way of meeting a range of policy, business and private objectives. This includes water, food and energy security (ensuring water security for agriculture and energy production), poverty alleviation and meeting sustainable development goals collectively. Water and wetlands are at risk from climate change and sustainable management of these ecosystems can increase their resilience and hence reduce this risk. The sustainable use of water and wetlands by protecting the services they provide is also critical to enabling society to adapt to climate change and improving social cohesion and economic stability.

**Integrated decision making.** A range of tools have proved invaluable in helping to take the values of water and wetlands into account and realising synergies in policy, business and management decisions:

- **Land and water use planning and regulation** to manage, and where necessary designate and protect, areas to ensure the sustainable provision of services, as well as helping ensure connectivity between ecosystems within wider ecological networks and with social and economic systems. This can include designating wetlands for water regulation benefits for rural or urban centres, defining non-conversion zones to safeguard mangroves that provide important public goods benefits, or protecting coastal areas for fisheries nurseries. Effective regulation and careful land use planning helps control some critical pressures on wetlands, which in turn help avoid detrimental effects on provision of crucial local ecosystem services such as flood protection and water provision or global ones such as carbon storage;
- **Using wetland services to deliver investment and achieve management objectives**, by considering wetlands as natural water infrastructure that can offer solutions to meet water management objectives. Cost comparisons can often be favourable for the conservation of wetlands, even considering water management alone (e.g. flood risk), and particularly when factoring in co-benefits on offer (e.g., recreation, tourism). **Investment** to conserve and sustainably manage wetland ecosystem services can be critical to rural communities dependent on natural capital for food, water, fuel and livelihoods and global objectives of climate change mitigation and adaptation. It can be a means of cost effectively achieving a range of policy and development objectives, including the Millenium Development Goals (MDGs) and the future sustainable development goals;
- **Prices, subsidies and their reform** to encourage efficient use of resources and innovation. This can be done for example by moving to full cost recovery for water (paying for the costs of supply) and, where relevant, also by resource pricing (taking into account the value of the resource itself for society). Furthermore, making use of pollution charges, liability and compensation requirements (e.g. for pollution incidence or damage) can reduce the pressures on wetlands and help implement the polluter pays principle. Reforming subsidies (e.g. direct grants, preferential tax treatment, pricing) can encourage management practices that promote public goods, innovation, reduce technological lock-ins, and save public budgets for other objectives;

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<sup>5</sup> (see [www.teebweb.org](http://www.teebweb.org) for countries embarking on national assessments)

- **Payments for ecosystem services** to remunerate land owners or managers for the delivery of ecosystem services, through programmes funded either by government agencies to have public payments for public goods, private ecosystem services' users (e.g. water utilities, beverage companies, citizens) or foundations and NGOs. This supports the principle that the beneficiary pays and the provider of a service gets rewarded for sustainable practice.

**Synergies with policies aimed at enhancing livelihoods and alleviating poverty.** Good water and wetland management can provide co-benefits in terms of improving the health and livelihoods of local communities and reducing poverty, e.g. through sustainable fisheries, agriculture and tourism. When possible, projects aimed at improving wetland management should involve local communities and make use of traditional practices and local knowledge, as this both increases the local acceptance of the policy action and potentially provide more locally tailored techniques for ecosystem management. Good transition management is key to gaining wider acceptance and participation, and supports the creation of employment opportunities for those who may lose their jobs because of conservation/restoration policies.

## V. Recommendations: transforming our approach to water and wetlands

**There is a need to put wetlands and water-related ecosystem services at the heart of water management in the transition to a resource efficient, sustainable economy.** Key elements to transform our approach include:

- **Appreciating and taking account of the values of water and wetlands in public policy and private decisions.** This includes both investment in developing a more complete knowledge of the economic importance of water and wetlands (as some wetland types and geographic locations are less well understood than others) and committing to their integration into decisions (e.g. in policy and investment decisions);
- **Committing to fully integrate the management of wetlands and securing their wise use in water management** (integrated water resource management);
- **Prioritising avoiding further loss/conversion of wetlands** - by better and more comprehensive consideration of wetland ecosystem services in Strategic Environmental Assessment (SEA) of policies and programmes and project-level Environmental Impact Assessment (EIA); development of ecosystem capital accounts to develop a foundation for systematic response to systemic problems, assessment, land use planning, regulation, setting of appropriate incentives and enforcement;
- **Promoting the restoration of degraded wetlands** – to improve water, food and energy security, biodiversity conservation, climate benefits (mitigation and adaptation), natural protection against extreme events, and benefits for people and livelihoods. In places this will be done in conjunction with man-made infrastructure investments. For the public sector, restoration can be a critical means of ensuring the provision of public goods, addressing poverty (as the rural poor are generally more directly reliant on ecosystem services) and saving public finance (due to cost effective solutions of working with nature). For the private sector, it can be a means of securing resources for the future and reducing resource availability risks. Restoration can also help in minimising liabilities, be part of a licence to operate (e.g. where restoration or offsets are required) and in cases positive business opportunities (e.g. where water trading or PES schemes are in place); and

- **Ensuring equitable benefit sharing and social and economic efficiency** recognising that there will be winners and losers in the transition to a sustainable economy.

**There is a need for action at all levels and across stakeholders if the opportunities and benefits of working with water and wetlands are to be fully realised and the risks of losses appreciated and acted upon.**

### **Practical recommendations for stakeholders to respond to the value of water and wetlands in decision-making**

At the **global level** there is a need to ensure implementation of the Strategic Plan for Biodiversity 2011-2020, the Ramar Strategic Plan 2009-2015, the UNFCCC, the MDGs, and strategic planning and implementation of the many multilateral environmental agreements (MEAs). The role and value of water and wetlands should be interegrated in each of these. This is an awareness and governance challenge, with potential for significant synergies and efficiency gains.

#### **National and international policy makers**

- Integrate the values of water and wetlands into decision making and national development strategies – for policies, regulation and land use planning, incentives and investment, and enforcement;
- Regulate to protect wetlands from pressures that do not lead to improvements in public goods and overall societal benefits;
- Regulate to ensure that wetland ecosystem services options and benefits are fully considered as solutions to land and water use management objectives and development;
- Commit to and develop improved measurement and address knowledge gaps – using biodiversity and ecosystem services indicators and environmental accounts (notably SEEA & water accounts). This will require an improved science-policy interface and support for the scientific/research communities. The recently established IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services<sup>6</sup>) could contribute significantly in this area.;
- Reform price signals (*getting prices right*) via water cost recovery, resource pricing and reforming subsidies;
- Commit to restoration targets and/or programmes, improving ecosystem health and functioning, the water cycles, addressing poverty and development concerns and acheiving the mutliple benefits of working with nature.

#### **Local and regional policy-makers**

- Assess the interactions between wetland ecosystems, communities, man-made infastructures and the economy and ensure the evidence base is available to decision makers, whether spatial planners, permit authorities, investment programme responsables, inspectors or the judiciary;
- Integrate into river basin and coastal management the ecosystem functions and the interaction between hydrological, social and economic systems;
- Integrate planning systems - e.g. water supply and management to take into account both ecosystem-based infrastructure and man-made infastructures;
- Ensure due engagement/participation of communities (including indigenous peoples) and ensure that traditional knowledge is duly integrated into management solutions.

#### **Site managers**

- When possible and relevant, assess the values of sites and trade-offs of different land use

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<sup>6</sup> <http://www.ipbes.net/>

decisions to help inform site management decisions to protect and enhance the values of wetland ecosystems being managed;

- Communicate the values at the local level - to get buy-in for the site management, attract funding for protection and management measures, and reduce the pressures on wetlands, including risks of land use permit decisions that may undermine public goods.

#### **Valuation research and statistical communities**

- Systematically contribute to filling the gaps in knowledge on the the values of water and wetlands, on improved governance solutions, on measures and tools to support the development of environmental accounts;
- Improve the understanding of public goods and trade-offs between public goods and private benefits from policies and investment choices.

#### **Development cooperation community**

- Integrate the appreciation of the multiple values of wetlands and potential cost savings/to meet objectives of development cooperation:
  - e.g. ecosystem restoration to improve water security, poverty alleviation, local development and wellbeing;
  - e.g. investment in ecosystem-based adaptation to climate change.

#### **Business**

- Assess the dependency of the business on water and wetlands related ecosystem services from the short to long term;
- Assess the risks to operation inputs, eventual liabilities, risk to reputation and to the licence to operate from both resource availability and impacts, including pollution pressures;
- Develop corporate ecosystem valuation and environmental profit and loss accounts to improve disclosures;
- Explore synergies between private interests and public goods and realise opportunities for synergies whether via restoration activities, engagement in markets or wider commitments to no net loss of biodiversity (or net positive gain); commit to water footprint reduction, in order to safeguard future resource availability for private and public benefits.

# TEEB for Water and Wetlands

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# 1 INTRODUCTION

## TEEB context

The Economics of Ecosystems and Biodiversity (TEEB) study is an international initiative to draw attention to the benefits of biodiversity. It focuses on the values of biodiversity, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of action addressing these pressures. It draws together expertise from across the fields of science, economics and policy to enable practical actions to be developed and implemented.

The TEEB initiative has brought together over five hundred authors, reviewers and case studies from across the continents on the values of biodiversity by looking at the flow of ecosystem services. Ecosystem services are the benefits that people, society and the economy receive from nature. For example; water provision and purification, flood and storm control, carbon storage and climate regulation, food and materials provision, scientific knowledge, recreation and tourism (MA, 2005a; TEEB, 2010; TEEB, 2011; see also Chapter 2). The TEEB initiative has demonstrated the usefulness of presenting evidence on the values of nature and targeting the messages to different audiences. Understanding and communicating the economic, social and cultural value of ecosystem services (many of which nature provides for “free”) is crucial to fostering better management, conservation and restoration practices.

## TEEB Water and Wetlands

This TEEB for Water and Wetlands report underlines the fundamental importance of wetlands in the water cycle and in addressing water objectives as noted in the Millennium Development Goals and forthcoming Sustainable Development Goals stemming from the Rio+20 agreement. The report presents insights on both critical water-related ecosystem services and also on the wider ecosystem services from wetlands in order to encourage additional policy momentum, business commitment, and investment in the conservation, restoration, and wise use of wetlands (see Box 1.1 for the widely used and authoritative definition of wetlands). The report seeks to present how recognizing, demonstrating, and capturing the values of ecosystem services related to water and wetlands can lead to better informed, more efficient, and fairer decision making. Appreciating the values of wetlands to both society and the economy can help inform and facilitate political commitment to policy solutions.

### Box 1.1 Wetlands - a definition

Wetlands are areas where the water table is at or near the surface level, or the land is covered by shallow water. The Ramsar Convention defines wetlands as:

*“areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres” (article 1.1).*

Moreover wetlands *“may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands” (article 2.1).*

The Ramsar Classification of Wetland Types includes 42 types of wetlands, which belong to one of the three broad categories (Ramsar Convention Secretariat, 2011):

- Inland wetlands;
- Marine/coastal wetlands;
- Human-made wetlands.

Human-made wetlands covered by the Ramsar Convention include aquaculture, farm ponds, and permanently or temporarily inundated agricultural land - such as rice paddies, salt pans, reservoirs, gravel pits, sewage farms and canals.

There are a range of other wetland classifications used for different purposes, based on hydro-geomorphology and/or vegetation characteristics, such as :

- Marine (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
- Estuarine (including deltas, tidal marshes, and mangrove swamps);
- Lacustrine (wetlands associated with lakes);
- Riverine (rivers and wetlands along rivers and streams); and
- Palustrine (marshes, swamps and bogs).

**TEEB Water and Wetlands is about the “water - wetlands - ecosystem services” nexus** – it concerns the importance of water and its role in underpinning all ecosystem services and on wetlands’ fundamental role in global and local water cycles. It is also about the wide range of ecosystem services provided by nature to people and the economy that need to be taken into account to ensure that the full benefits of nature are not overlooked. It is about the “values” of nature which can be expressed in a number of ways and methods. In some cases, the values of biodiversity and ecosystems can be presented qualitatively (e.g. which cities benefit from which wetland for water purification or flood control). In other cases, they can be in quantitative terms (e.g. the number of people benefitting from clean water) and in others still, when appropriate, in monetary terms (e.g. the monetary value of sequestered carbon, avoided costs of water pre-treatment and supply, or avoided costs of potential flood damage). This report aims to support evidence-based decision making by presenting an array of ecosystem service values in varying contexts.

The Ramsar Convention on Wetlands (see Box 1.2), which has commissioned this work, is a multilateral environment agreement that embodies the commitments of its 163 Contracting Parties to maintain the ecological character of their Wetlands of International Importance and to plan for the “wise” (or sustainable) use of wetlands in their territories (see Box 1.3). TEEB Water and Wetlands aims to contribute towards the wise use of wetlands through creating better understanding of ecosystem services values and benefits and their integration in decision making at all levels.

### Box 1.2 Global intergovernmental agreements and initiatives concerning water and wetlands

Concerns in the 1960s over the loss and deterioration of wetlands and its impact on people and nature is what led to the first of the modern global intergovernmental environmental agreements (MEAs), the **Convention on Wetlands** – established in February 1971 in the town of Ramsar in the Islamic Republic of Iran and hence known as the „**Ramsar Convention**“. The now 163 Contracting Parties (member states) to the Convention commit to the „*Conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.*“ The Convention’s Strategic Plan recognizes that to achieve this „*...it is essential that the vital ecosystem services, and especially those related to water and those that wetlands provide to people and nature through their natural infrastructure, are fully recognized, maintained, restored and wisely used.*“ (COP11 Resolution XI.3, 2012).

The Convention covers all types of wetland from the mountains to the sea, including inland wetlands (both open water and vegetated), coastal and near-shore marine wetlands (e.g. coral reefs, mangroves, and tidal estuaries and marshes) and human-made wetlands (e.g. rice paddy, fish-ponds and reservoirs).

The Ramsar Convention, from its inception, has strongly recognized that „*wetlands constitute a resource of great economic, cultural, scientific, and recreational value, the loss of which would be irreparable*“; and „*the fundamental ecological functions of wetlands as regulators of water regimes*“ (Convention text). So, to deliver the conservation and wise use of wetlands requires an understanding of the value of wetlands, and landscape and waterscape-scale, ecosystem-based, approaches to decision-making and management. Managing wetlands to support basin-scale water management and delivery is essential.

There are three main pillars of Convention implementation: i. The wise use of all wetlands; ii. The designation and management of Wetlands of International Importance (Ramsar Sites); and iii. International Cooperation – including for transboundary wetlands and river basins, and migratory wetland-dependent species, notably waterbirds. In support of these, the Convention has adopted a comprehensive suite of implementation guidance, including a major set of water-related guidance, compiled as the Ramsar „*Wise Use Handbooks*“<sup>7</sup>.

The Ramsar Convention is the lead implementation partner on wetlands for the **Convention on Biological Diversity (CBD)**, and Ramsar’s wise use approach equates to that of the CBD’s overarching „ecosystem approach“. However, CBD implementation has so far been largely focussed on its range separate biome and cross-cutting programmes of work (PoWs). Whilst joint implementation to date has been focussed through the CBD PoW on inland water ecosystems, Ramsar implementation also directly supports many other CBD PoWs such as those on marine and coastal systems, dry and sub-humid lands, forests, mountains, islands and protected areas. All biodiversity-related Conventions have committed to jointly implementing the *Strategic Plan for Biodiversity 2012-2020* and its 20 Aichi targets (adopted by CBD COP10 in 2010). The Ramsar implementation will contribute to the achievement of many of these targets, including target 14 on ecosystem services, including water-related services<sup>8</sup>.

There are also key links between the water and wetlands agenda of Ramsar and CBD and those of other MEAs, notably with the **UN Convention to Combat Desertification (UNCCD)** concerning the key role of wetlands and water management in drylands; the **Convention on Migratory Species (CMS)** concerning key site networks for migratory wetland-dependent species; and the **UN Framework Convention on Climate Change (UNFCCC)**, concerning wetlands as natural water infrastructure for nature-based adaptation to climate change and in view of their equally important role in mitigating impacts of greenhouse gas emissions. .

<sup>7</sup> 4<sup>th</sup> edition, 2010 available on: [http://www.ramsar.org/cda/en/ramsar-pubs-handbooks-handbooks4-e/main/ramsar/1-30-33%5E21323\\_4000\\_0](http://www.ramsar.org/cda/en/ramsar-pubs-handbooks-handbooks4-e/main/ramsar/1-30-33%5E21323_4000_0)

<sup>8</sup> See Ramsar COP11 Resolution XI.3 Appendix 1, available on: <http://www.ramsar.org/pdf/cop11/res/cop11-res03-e.pdf>



Two other MEAs focus specifically on transboundary water management issues: the 1992 **UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes** (Water Convention)<sup>9</sup> is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwaters. Although originally focused on Europe, it is now open for accessions more widely. The Convention has *inter alia* adopted a Protocol on Water and Health, and prepared the 2007 *Recommendations on Payments for Ecosystem Services in Integrated Water Resources Management*. The 1997 **United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses** provides a framework of principles and rules that may be applied and adjusted to suit the characteristics of particular international watercourses. For the Convention to become legally binding, at least 35 nations must ratify it.

**The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA)** was adopted by the international community in 1995 and “aims at preventing the degradation of the marine environment from land-based activities by facilitating the realization of the duty of States to preserve and protect the marine environment”. It is the only global initiative directly addressing the connectivity between terrestrial, freshwater, coastal and marine ecosystems.

**UN-Water** is the United Nations (UN) inter-agency coordination mechanism for all freshwater-related issues. It was formally established in 2003 building on a long history of collaboration in the UN family and comprises 34 UN agencies and entities and 22 partners ), The World Water Development Report (WWDR), Coordinated by the World Water Assessment Programme of UN-Water, provides a global strategic outlook on the state of freshwater resources, trends in use of the resource in the various sectors (*inter alia* agriculture, industry, energy) and management options in different settings and situations, such as urbanization, natural disasters, and impacts of global climate change.

### Box 1.3 “Wise Use” of Wetlands

The “wise use” concept adopted by the Ramsar Convention’s Contracting Parties is widely recognized as the longest established example amongst intergovernmental processes of the implementation of ecosystem-based landscape-scale approaches to the conservation and sustainable development of natural resources, including wetlands (Finlayson et al., 2012).

Wise use of wetlands is now defined by Ramsar as “the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development<sup>1,2</sup>”.

In turn, “ecological character” is “the combination of ecosystem components, processes and services that characterize the wetland at any given point of time”.

Wise use and the maintenance of the ecological character of wetlands form the guiding principles for wetland management planning under the Convention.

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<sup>9</sup> <http://www.unece.org/env/water/>

## The report's target audience and questions addressed

This report is for:

- Policy makers at the international level to offer an evidence base and arguments to help promote synergies between MEAs (multilateral environmental agreements) and foster international collaboration between countries, including those with transboundary watersheds;
- Policy makers at the regional and national level interested in understanding the value of wetlands under their jurisdiction, and taking account of this value in policy development and investment decisions;
- Decision makers at local and regional level looking to ensure that the best decisions are taken in light of a fuller evidence base (e.g. municipalities and land use zoning and investment choices; permit authorities and land use change permit decisions);
- Businesses wishing to appreciate the importance of wetlands to their activities and bottom lines;
- Environmental authorities and others involved in the management of wetlands who wish to know, demonstrate and manage the many values of the site for which they are responsible;
- In addition, it is also of relevance to community organisations, NGOs and the scientific community interested in understanding, demonstrating and communicating the full picture of the values of wetlands – both the water-related ecosystem services and the wider set of ecosystem services from wetlands.

### Questions this report addresses

The report responds to the following questions by presenting insights from experience from across the globe:

- What are the values and benefits associated with water and wetlands?
- What are the roles of wetlands in terms of providing water and wetland related ecosystem services and what are their values?
- What are the wider set of ecosystem system services that water and wetlands provide and what are their values?
- What needs to be done to improve the consideration of the values and benefits of water and wetland in policy developments and in practical decision making?
- What approaches have been successfully used to date to respond to the challenges and take account of the values of water and wetlands?
- What existing examples demonstrate how policy, investment and water and land use decisions can be based on the values and benefits associated with water and wetlands?
- What are the recommendations for transforming the regional, national and international approaches for managing water, wetlands and their ecosystem services?

## Structure of the report

Chapter 2 explains the importance of the water cycle, the setting of wetlands within this, and the ecosystem services provided by wetlands, including presenting an overview of the values of wetlands. It discusses the present state of water-related ecosystem services and wider wetlands ecosystem services, the impact of their loss and degradation on human welfare and the stakeholders particularly concerned with their degradation.

Chapter 3 discusses the importance of monitoring the state of wetlands and understanding the value of the flow of ecosystem services. It covers indicators, mapping, accounting, and valuation of ecosystem services using qualitative, quantitative, and monetary methodologies.

Chapter 4 deals with the integrated management of land, water and wetlands. It goes through the different policy instruments that can be used to foster conservation and restoration including; site management, regulation and land use planning, property rights and market-based instruments.

Chapter 5 illustrates how to transform our approach to water and wetlands in order to avoid wetland loss, encourage restoration and ensure the benefits they provide to society are increasingly applied in water and wetlands management. It underlines the importance of transition management, the role of traditional knowledge and presents synergies between wetlands restoration/conversion and poverty alleviation. Finally, it presents recommendations for different stakeholders on how to respond to an improved understanding of the wide array of ecosystem service benefits from wetlands.

This is complemented by Annexes, presenting the additional case studies and an overview literature on the multiple ecosystem service values of wetlands.

## 2 THE IMPORTANCE OF WATER AND WETLANDS

### KEY MESSAGES

- *The availability of water in the appropriate quantity (including avoiding scarcity and overabundance) with the appropriate quality and at the appropriate time is a fundamental requirement for sustainable development.*
- *Water security is widely regarded as the key natural resource challenge facing humanity.*
- *Wetlands are crucial in maintaining the water cycle which, in turn, underpins all ecosystem services and therefore sustainable development.*
- *Wetlands provide vital water-related ecosystem services at different scales (e.g. clean water provision, waste water treatment, groundwater replenishment, habitat for commercial food species), which are critical for life and also contribute to the economy.*
- *Wetlands provide a network of important infrastructures that deliver significant benefits to people.*
- *Wetlands are of importance to the livelihood and cultural identity of many diverse, indigenous peoples.*
- *Wetlands provide ecosystem services that are needed for man-made infrastructures to deliver water supply, sewage treatment and energy - among others benefits.*
- *In many cases, wetlands can offer ecosystem services that deliver benefits to humans more cost effectively and sustainably than alternative man-made infrastructures.*
- *Water-related ecosystem services and wetlands are being degraded at an alarming pace. Loss and degradation of water and wetlands have an enormous social and economic impact (e.g. increased risk of floods, decreased water quality - in addition to impacts on health, cultural identity, and on livelihoods). Indeed, many water resources interventions have not given adequate consideration to the trade-offs with other ecosystem services.*
- *The restoration of wetlands and their water-related services offers significant opportunity to address sustainable and cost-effective solutions to water management problems.*
- *Wetlands restoration is already at the forefront of ecosystem restoration in most countries because of the hydrological functions of wetlands.*

## 2.1 The water cycle and wetlands

Water moves around the earth through the water cycle, and wetlands are a crucial part of it. The water cycle is influenced by both physical (e.g. topography, geology) and ecological factors (e.g. transpiration from plants, the effects of land cover on water flows). The water cycle also underpins and is influenced by nutrient cycling (which influences water quality) and carbon cycling (which influences land cover and organic carbon in soils, including in high carbon ecosystems such as peatlands, which also influence water flows). This functioning supports the delivery of all ecosystem services from land (including those from land-based wetlands) and greatly influences those delivered by coastal ecosystems. Figure 2.1 illustrates this cycle and highlights only some of the water-related and water dependent ecosystem services in play.

Wetlands are a conspicuous and important part of this cycle and therefore a key determinant of the type and level of ecosystem service delivered - particularly regarding surface water flows (most of which occur through wetlands). Whilst this report focuses on the role of wetlands in delivering ecosystem services, it is important to keep in mind this landscape/ecosystem setting of wetlands. Usually, but not always, wetlands receive water from the landscape and deliver it, generally through rivers, to the coast and onwards into the sea. There are exceptions: some wetlands deliver water back into the landscape (through groundwater and soil moisture recharge) while other inland wetlands can be the final destination of water (e.g. salt pans where there is no onward flow towards the sea). In some cases wetlands cannot be distinguished from land, such as wetlands dominated by vegetation cover (such as forest).

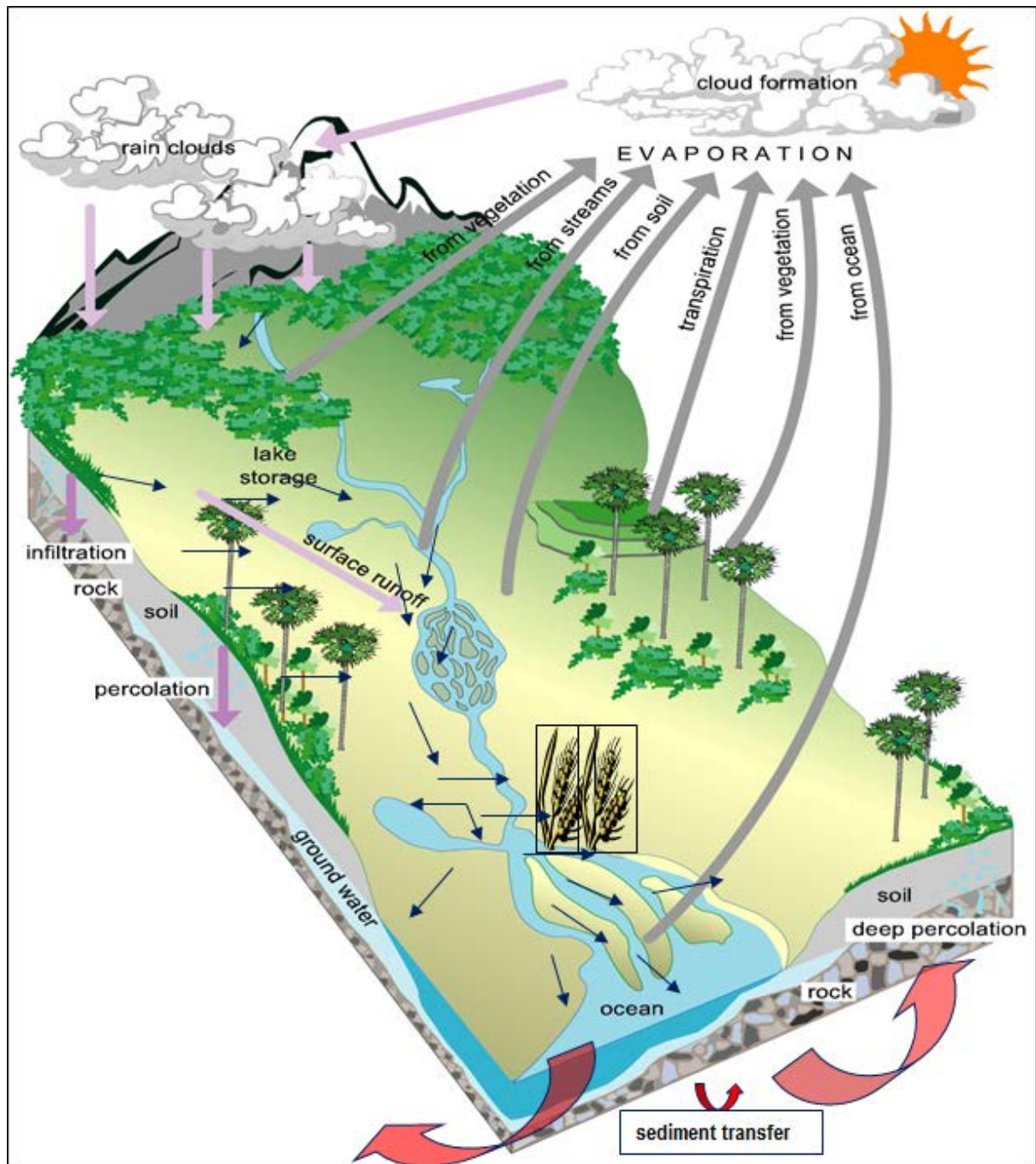
One major implication of this intimate relationship between wetlands and the landscape is that neither can be managed independently. In some cases, particularly in deltas, wetlands are responsible for creating land itself through sediment transfer.

Also, in many instances the services delivered by wetlands are underpinned by a combination of ecosystem functions arising both within and beyond the wetland and the surrounding landscape. For example, the hydrology of wetlands is determined by the physical and ecological features of the wetland itself and that of its catchment within which it is located.

A second important feature is the inter-connectivity between ecosystem components, particularly via wetlands, which results in disturbances in one area having a potential impact in another - often a long distance away. The benefits of flood regulation provided by wetlands can be realised a long distance downstream, up to thousands of kilometres.

Figure 2.1 provides an overview of the hydrological pathways and the ecosystem services provided by the water cycle.

Figure 2.1 The water cycle: hydrological pathways and ecosystem services



Source: redrawn from MRC (2003)<sup>3</sup>

## 2.2 The values of water and wetlands

### The values of water

Water itself has a value; this is most notable for drinking, irrigation, food production, sanitation, energy use, for food and beverage, forestry, tourism, housing etc. Indeed, for some activities it is a commercially supplied product (e.g. IT and medical sectors requires

high purity waters). It is fundamental for society and for the economy and underpins most of our activities.

The lack of water or sanitation can have significant effects on health, livelihoods, the economy, and on the operations and efficiency of industry across most sectors. The Rio+20 final declaration recognised water as a fundamental right and underlined its core role in sustainable development (see Box 2.1).

#### **Box 2.1 The Rio+20 Global Commitment: The Future We Want - Water and Sanitation**

119. We recognize that water is at the core of sustainable development as it is closely linked to a number of key global challenges. We therefore reiterate the importance of integrating water in sustainable development and underline the critical importance of water and sanitation within the three dimensions of sustainable development.

120. We reaffirm the commitments made in the Johannesburg Plan of Implementation and Millennium Declaration regarding halving by 2015 the proportion of people without access to safe drinking water and basic sanitation and the development of integrated water resource management and water efficiency plans, ensuring sustainable water use. We commit to the progressive realization of access to safe and affordable drinking water and basic sanitation for all, as necessary for poverty eradication, to protect human health, and to significantly improve the implementation of integrated water resource management at all levels - as appropriate. In this regard, we reiterate these commitments in particular for developing countries through the mobilization of resources from all sources, capacity building and technology transfer.

121. We reaffirm our commitments, regarding the human right to safe drinking water and sanitation, to be progressively realized for our populations with full respect for national sovereignty. We also highlight our commitment to the 2005-2015 International Decade for Action "Water for Life."

122. We recognize the key role that ecosystems play in maintaining water quantity and quality and support actions within the respective national boundaries to protect and sustainably manage these ecosystems.

*Source: UNCSD (2012)*

All sectors of the economy depend on water directly and/or indirectly. The agricultural sector depends on water for crop production and livestock production; the energy sector for hydropower and for cooling at thermoelectric power plants; the tourism sector for the natural beauty provided by rivers, lakes and the sea. Where water is scarce, water security concerns can arise between users or between countries (in trans-boundary contexts). Water pollution can diminish the value of water in a similar way to scarcity by making the water unusable. For all these reasons, the wise use of water and management of the resource and its sources is of critical importance.

#### **Wetlands, the water cycle and ecosystem services**

Inland wetlands cover at least 9.5 million km<sup>2</sup> (i.e. about 6.5% of the Earth's land surface), with inland and coastal wetlands together covering a minimum of 12.8 million km<sup>2</sup> (Finlayson *et al.* 1999). They deliver a range of Ecosystem Services; i.e. benefits that people obtain from ecosystems (Finlayson *et al.*, 1999, MA 2005a). The most well-known and widespread definition of ecosystem services is the one proposed by the Millennium

Ecosystem Assessment report (MA, 2005a), which categorised them into four groups: provisioning, regulating, cultural and supporting ecosystem services<sup>4</sup> (see Box 2.2).

#### **Box 2.2 Classification of Ecosystem Services by the Millennium Ecosystem Assessment**

1. Provisioning services: products obtained from ecosystems, e.g. fresh water, food, fibre, fuel, genetic resources, biochemical, natural medicines and pharmaceuticals.
2. Regulating services: benefits obtained from the regulation of ecosystem processes, e.g. water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation (e.g. droughts, floods, storms).
3. Cultural services: nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, e.g. cultural diversity, knowledge systems, educational values, social relations, sense of place, cultural heritage and ecotourism.
4. Supporting services: those that are necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some services, like erosion regulation, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people. Supporting services include primary production, nutrient cycling and water cycling.

*Source: derived from MA (2005a)*

First and foremost, wetlands are a key factor in the global water cycle and in regulating local water availability and quality. Wetlands contribute to water purification, denitrification and detoxification, as well as to nutrient cycling, sediment transfer, and nutrient retention and exports. Water is not only a provisioning ecosystem service itself, but it is also necessary to all other provisioning ecosystem services (e.g. food, fibre, timber) and most regulating ecosystem services (e.g. water purification, flood protection), supporting ecosystem services (e.g. photosynthesis, primary production, nutrient cycling), and cultural ecosystem services (e.g. recreation, aesthetic experience, spiritual enrichment). The role of wetlands in water provisioning and regulating is one of the fundamental factors in both ensuring water security and maintaining the other ecosystem services provided by wetlands. To cite an example of the importance of wetlands, while vegetative wetlands occupy only 2% of seabed area, they represent 50% of carbon transfer from oceans to sediments, often referred to as 'Coastal Blue Carbon' (Sifleet et al., 2011). Degradation of coastal wetlands generally leads to a high level of carbon emissions - in the order of 2,000 tCO<sub>2</sub>/km<sup>2</sup>/yr, taking an average over 50 years (Duarte et al., 2005 and Crooks et al., 2011).

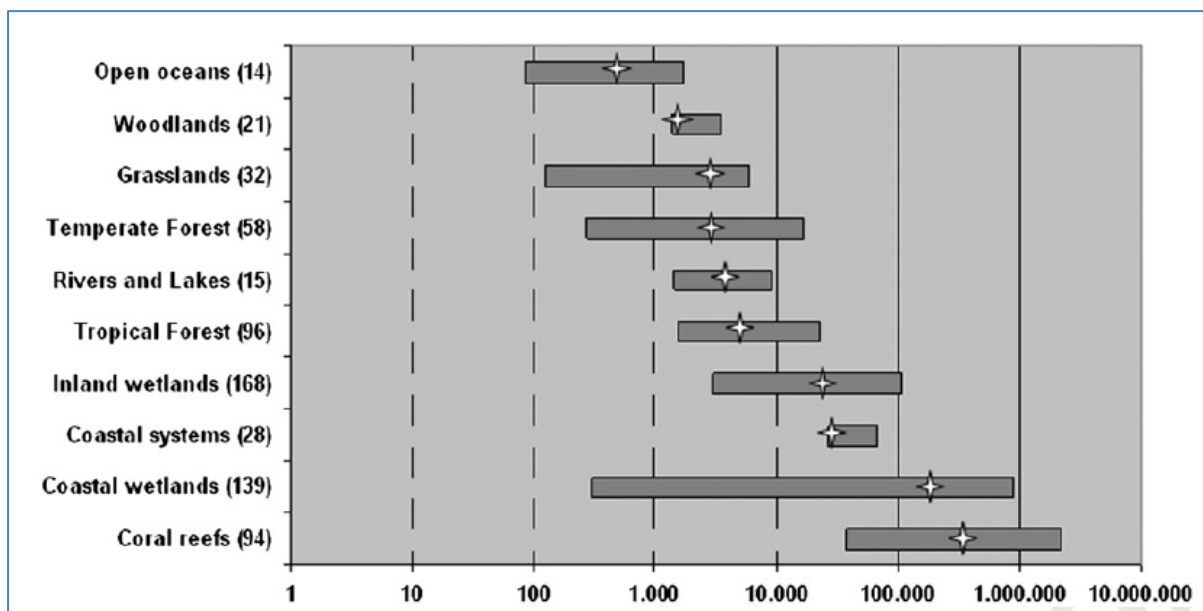
Other provisioning ecosystem services delivered by wetlands include food (e.g. fish, rice and other agricultural products), timber, fibre and non-timber forest products, and hence often play an important role in the livelihood of many communities. For example, global inland capture fisheries production in 2010 was 11.2 million tonnes and inland aquaculture production was 41.7 million tonnes (FAO, 2012a).



Figure 2.2 presents a summary of the literature on the monetary values of wetlands and other ecosystems, showing that wetland ecosystems can have among the highest values. Wetland ecosystems can be of particularly high value where they regulate water quality and flow, provide clean water, and mitigate natural hazards to nearby towns and cities. Coral reefs are the ecosystems with highest monetary value often due to associated high recreation and tourism importance, community benefits (e.g. fishery nursery), as well as their role in protecting from natural hazards.

Ecosystem functions, the flow of ecosystem services, and the economic value to society and the economy are site specific and depend on the ecological, social and economic systems and their interactions. For this reason the value ranges in Figure 2.2 and Table 2.1 further below needs to be considered as indicative.

**Figure 2.2 Range of values of all ecosystem services provided by different types of habitat (Int.\$/ha/yr2007/PPP-corrected)<sup>5</sup>**



Note: The figure above shows range and average of total monetary value of bundle of ecosystem services per biome. The total number of values per biome are indicated in brackets; the average value of the value range is indicated as a star sign.

Source: de Groot et al. (2012) building on TEEB (2010).

Table 2.1 presents an overview of the literature on the monetary values of ecosystem services provided by wetlands, taken from TEEB 2010. These tables present the range of values from the literature and a number of estimates available in the ecosystem service category (for full tables see Annex 3; for further discussion see TEEB, 2010, Appendix 3; de Groot et al., 2010; Van der Ploeg and de Groot, 2010; and Van der Ploeg et al., 2010; de Groot et al., 2012).

Actual values for a given site or given policy challenge or decision will have to be assessed in its specific context, and the values in the table should be taken as indicative values; not extrapolated to any specific water or wetland. There are techniques available, such as value transfer, which can help where there are sufficient similarities between the study site and

values from literature, but they need to be used with care. This approach (and the caveats surrounding it) is explained further in TEEB (2010).

**Table 2.1 Monetary values of services provided by wetlands** (Int.\$/ha/year – 2007 values) <sup>67</sup>

Category of wetlands	Service category	No. of estimates	min value (Int.\$/ha/y)	max value (Int.\$/ha/y)
<b>Coral reefs</b>	provisioning services	33	6	20,892
	regulating services	17	8	33,640
	habitat services	8	0	56,137
	cultural services	43	0	1,084,809
	<b>Total</b>	<b>101</b>	<b>14</b>	<b>1,195,478</b>
<b>Coastal systems</b> (habitat complexes e.g. shallow seas, rocky shores & estuaries)	provisioning services	19	1	7,549
	regulating services	4	170	30,451
	habitat services	2	77	164
	cultural services	7	0	41,416
	<b>Total</b>	<b>32</b>	<b>248</b>	<b>79,580</b>
<b>Mangroves &amp; tidal marshes</b>	provisioning services	35	44	8,289
	regulating services	26	1,914	135,361
	habitat services	38	27	68,795
	cultural services	13	10	2,904
	<b>Total</b>	<b>112</b>	<b>1,995</b>	<b>215,349</b>
<b>Inland wetlands</b> (floodplains, swamps/marshes and peatlands)	provisioning services	34	2	9,709
	regulating services	30	321	23,018
	habitat services	9	10	3,471
	cultural services	13	648	8,399
	<b>Total</b>	<b>86</b>	<b>981</b>	<b>44,597</b>
<b>Rivers and lakes</b>	provisioning services	5	1,169	5,776
	regulating services	2	305	4,978
	habitat services	0	0	0
	cultural services	5	305	2,733
	<b>Total</b>	<b>12</b>	<b>1,779</b>	<b>13,487</b>

*Source: TEEB (2010); de Groot et al. (2010); See also Brander et al. (2006, 2011), Ghermandi et al. (2011) and TEEB (2010) for other overviews of valuation studies and associated meta-analyses.*

As regards regulating ecosystem services, peatlands and mangroves act as essential carbon storage areas (Wilson et al., 2012; Siikamäki et al., 2012 – see section 3.5 and Box 5.1) and are important for coastal protection against storms and erosion. Some wetland areas can play important roles in flood mitigation and thereby provide an important regulating ecosystem services, since approximately 2 billion people live in high flood risk zones (MA, 2005b). Not all wetlands offer flood mitigation benefits. The flood mitigation potential depends on the geographic situation, the interaction of the wetland area with other flood defences the potential flood waters, and what the alternative land uses could have been (Posthumus et al., 2010; Rouquette et al., 2011). This role will be increasingly important in

the light of increasing sea levels, storms and other extreme events that may arise from climatic change.

Furthermore, wetlands are often characterised by beautiful landscapes and rich biodiversity, thereby providing important aesthetic, educational and recreational ecosystem services that contribute to human wellbeing, cultural identity and economy. Wetlands may hold important spiritual values for some cultures. Many people across the world have cultural value links with water and wetlands which may be overlooked when changes occur to these habitats. While these are not monetary values, it is essential to recognise that such values are important for local communities.

It is also important to note that the ecosystem services that wetlands provide are not always synergistic with each other. Maximising ecosystem services for water supply or flood defence could imply trade-offs, for example, with biodiversity or cultural values. In such cases it is important to be clear of priorities for wetland management and, therefore, which trade-offs are acceptable and which are not (see section 4.2).

Finally, it should be noted that determining the value of water and wetland ecosystem services is different from the concept of the price paid by consumers for water supply. Water prices are determined by factors such as infrastructure and treatment costs, which may be subsidised and take into account other factors. This is different from the value of the ecosystem which provides water supply as a service.

Box 2.3 provides some examples of ecosystem services provided by wetlands and Box 2.4 a country perspective.

### **Box 2.3 Examples of ecosystem services delivered by wetlands**

#### Carbon sequestration from peatlands

Even though peatlands only cover 3% of the global land area, they contain approximately 30% of all the carbon on land, equivalent to 75% of all atmospheric carbon and twice the carbon stock in the global forest biomass. They represent the most important carbon storage on land and the second most important one on Earth, next to the oceans. The carbon in peat has accumulated over thousands of years thanks to permanent waterlogging, restricting aerobic decay. The peatland equilibrium between production and decay is, however, delicate and can easily be disturbed by human activities. Drainage for agriculture or forestry turns peatlands from a carbon sink to a carbon source. CO<sub>2</sub> emissions from peatland drainage, fires and exploitation are approximately 3 billion tonnes per year, which equates to more than 10% of the global fossil fuel emissions. For this reason, restoration and conservation of peatlands represent a key strategy for climate change mitigation (along with protection of other peatland ecosystem services).

*Source: Parish et al. (2008); FAO (2012b)*

#### Denitrification from estuarine environments

Nitrogen plays a key role in determining the presence of the different species in most coastal areas and is often a limiting factor for primary production. The excess influx of nutrients like nitrogen and phosphorus (mainly caused by run-off inorganic fertilisers, manure and detergents) results in eutrophication. This consists of an increase of primary producers such as algae, which then rapidly die off. Their subsequent aerobic decay drastically reduces the oxygen available for other species, in some cases even blocking sunlight under the

water surface and producing harmful toxins.

Piehlert and Smyth (2011) demonstrated that salt marshes and temperate shallow-water estuarine ecosystems (such as submerged aquatic vegetation and oyster reefs), present significant rates of natural denitrification (bacterial nitrogen removal by reduction of the nitrates to gaseous N<sub>2</sub>), which helps mitigate the problem. The nitrogen removal function of these habitats provides an important contribution to the estuarine ecosystem function.

*Source: Piehler and Smyth (2011)*

#### Seafood and other ecosystem services from coral reefs

Coral reefs are one of the ecosystems with the highest level of biodiversity, and, even though they cover only 0.2% of the world's oceans, they contain about 25% of marine species. They provide habitat to a wide range of fish and invertebrate species, sustaining the livelihood of millions of people (more than 275 million people reside within 30 km of reefs and less than 20km from the coast). It is estimated that a well-managed reef in the Indian and Pacific Oceans can provide between 5 and 15 tons of seafood per square kilometre per year. In addition, coral reefs provide a wide range of ecosystem services: they represent a major tourist attraction, protect shores and islands from surges and storms, and provide habitat for many reef-dwelling species that can potentially be used for pharmaceuticals.

*Sources: Cesar et al. (2003); World Meteorological Organization (2010); UNEP-WCMC (2001); WRI (2012)*

#### **Box 2.4 Value of floodplains for nutrient retention and carbon sequestration: in Germany**

In Germany, only 30% of the original floodplains along major rivers and streams are active, meaning that they are still connected to the river and become flooded during flood events (Brunotte et al., 2009). The other 70% are inactive floodplains behind dykes with built infrastructure, such as housing and industry, valued at approximately €267 billion. While the value of such built assets in the active floodplains is only €35 billion, the value of their natural assets in the form of nutrient retention and carbon sequestration can be considerably higher (Scholz et al., in press).

The overall potential of active floodplains in Germany for nitrogen retention is approximately 42,000 tons per year and for phosphorous retention approximately 1,200 tons per year. Compared to rivers, retention capacities of floodplains are on average two times higher for nitrogen and ten times higher for phosphorous, with retention being greatest during flood events. Annually, the calculated marginal cost for nitrogen retention in the active floodplains reaches about €252 million and for phosphorous €72 million.

The calculated carbon stocks of soils in the active floodplains amount to a total of 549 million CO<sub>2</sub> equivalents and in the inactive floodplains of 774 million CO<sub>2</sub> equivalents. Although peatlands cover only 7% of the floodplains, they contain 70% of the carbon stock. In particular, the inactive floodplains intense land use is causing peatland degradation resulting in emissions of 2.53 million t CO<sub>2</sub>-equivalents per year, corresponding to the CO<sub>2</sub>-emissions from 1,265,750 cars annually. More than two thirds of these emissions (1.8 million t CO<sub>2</sub>-equivalents per year) originate from inactive floodplains behind dykes. The cost of these carbon emissions ranges between €35 million per year (based on a market price for carbon of €13.82/t CO<sub>2</sub>) up to €177 million per year (based on the damage cost of carbon of €70/ t CO<sub>2</sub>).

The restoration of inactive floodplains, e.g. through the realignment of dykes, is a possible option for reducing carbon emissions and enhancing nutrient retention to improve water quality. This can be in particular an option in rural areas where the value of built infrastructure behind dykes is often low. This would also reduce

the maintenance costs of dykes.

Source: Bronotte et al. (2009) and Scholz et al. (in press)

## Natural infrastructure can deliver ecosystem services more cost effectively than built infrastructure

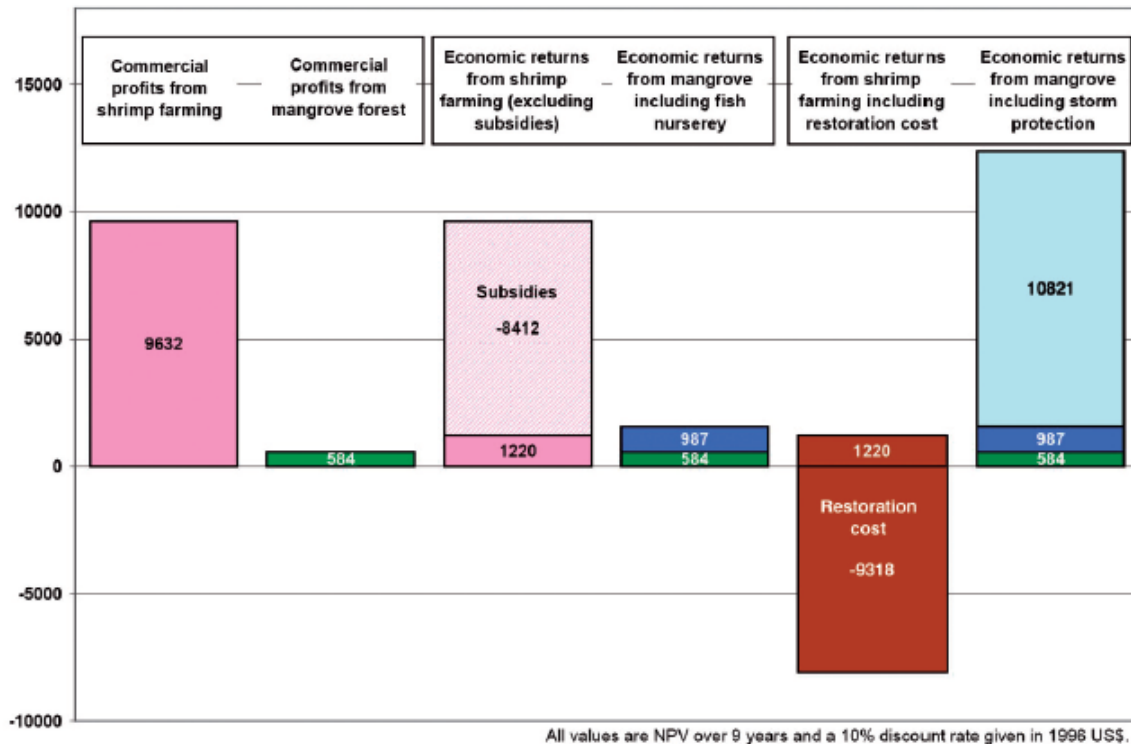
Public and private sectors of the economy and society directly benefit from the ecosystem services provided by water and wetlands, including; individuals, communities and cities, the agriculture, forestry, energy and health sectors, and many others. At the national and regional scales, the sustainable management of water and wetland-related ecosystem services can thus provide multiple benefits, contributing to national security, human well-being, health and livelihood.

Wetlands work as natural infrastructure and networks of natural ecosystems that deliver a range of important ecosystem services described in section 2.1 above (Krchnak et al., 2011). In some cases they substitute built infrastructure and in other case complement it, with ecological and man-made infrastructures interlinked.

Wise use of wetlands, including the conservation and restoration of hydrological functions, is essential in maintaining an infrastructure that can help meet a wide range of policy objectives. Natural ecosystems can provide ecosystem services at a lower price than hard engineered approaches (see Box 2.5 for some examples).

For example, the benefits of mangroves in Southern Thailand were estimated at about US\$10,821/ha for coastal protection against storms, US\$987/ha for fish nurseries and US\$584/ha for collected wood and non-timber forest products (Barbier, 2007)<sup>8</sup>. According to this estimate, most of the economic benefits associated to mangrove conservation were due to the role of the mangrove wetlands as a natural infrastructure against storm protection. In contrast, the benefits of commercial shrimp farming were estimated at US\$ 9,632/ha with government subsidies contributing the equivalent of US\$ 8412/ha (Figure 2.3). Hence shrimp production without subsidies creates benefits of only US\$ 1120/ ha which is dwarfed by the monetary value of the ecosystem services provided by mangrove conservation (see also Hanley and Barbier 2009). While the benefits of mangroves are provided continuously, shrimp production is declining after five years and shrimp farms are abandoned when turning unproductive. The costs of restoring mangroves are with US\$ 9318/ha beyond the private profits from shrimp and have to be borne by the public.

**Figure 2.3 The benefits (in US\$/ha/year) for mangrove and shrimp farms in southern Thailand before and after subsidies are taken into account**



Sources: : Barbier et al, 2007 and Hanley and Barbier 2009

In developed countries, water security has been improved largely through building often expensive infrastructures such as dams, storage tanks, pipes and aqueducts. Global investments in water infrastructure are in the order of trillions of US dollars (Vörösmarty et al., 2010). Although they have delivered improved water security, they can also be responsible for major impacts to other provisioning ecosystem services (like freshwater and agricultural products) and other supporting, regulating and cultural ecosystem services. In addition, climate change is alternating the design parameters upon which this infrastructure was originally planned (e.g., flood frequency and extent predictions). The reliance on such infrastructure, and difficulties in modifying it, in some cases result in increased risks for some areas or inordinate expenses in redesign and reconstruction based on the same built infrastructure approach.

Vulnerability to water insecurity is particularly high in many developing countries, which cannot afford high investments in alternative technological solutions. Ensuring water availability and quality remains a key challenge in these countries, and water-related disasters like floods and droughts cause major impacts on health and the economy. In addition, desertification, land degradation and droughts in drylands reduce food security and are a major cause of famine. There is increasing recognition that a wise response by developing countries is to utilise the benefits that wetlands offer in terms of managing water, including, when necessary, in combination with well-planned built infrastructure.

Furthermore, water and wetlands are crucial for sustaining many man-made infrastructures; for example in the cases of irrigation systems, municipal water supply, electricity generation and sewage run-off/sanitation. Not only does hydropower depend on water availability, but also thermoelectric power plants (fossil fuelled and nuclear) are strongly dependent on water availability for cooling (van Vliet et al., 2012). Reduction in flows due to over-

abstraction, for example, can present risks to the power sector. Similarly, the natural protection against natural hazards (e.g. floods) provided by wetlands can, in many cases, avoid significant damages to built infrastructure (e.g. roads, houses, factories).

Ignoring the ecosystem services provided by natural infrastructures and degrading them by constructing man-made ones can often cause major impacts on the welfare and livelihoods of local communities. For example, the Diama dam, in Senegal, was built in 1985 to store water for irrigation and stop dry season influx of saline water into the lower delta. The dam led to hyper-salinisation, expansion of area covered by invasive weeds, a reduction of daily income per fisher to less than US\$3 per day, a decrease in the number of women able to gather grasses for weaving to less than 20 women, and the disappearance of cattle grazing in the delta. When the seasonal flooding of the delta was restored by changing the timing of the flood releases of the dam, the income per fisher increased to over US\$20 per day, more than 600 women were able to gather weaving materials from the delta, and livestock grazing was again possible (more than 150,000 cattle days per year) (Krcnak et al., 2011; Hamerlynck and Duvail, 2008). Thus changing the performance of the built infrastructure allowed for re-building of the natural infrastructure.

### **Box 2.5 Examples of wetland ecosystem services as a more cost-efficient solution than technological alternatives**

#### The Scheldt estuary, Belgium and the Netherlands

A cost-benefit analysis on infrastructural works planned for the Scheldt estuary, flowing from Belgium into the Netherlands, showed that a combination of dikes and flood plains could offer more benefits than major measures - such as a storm surge barrier. The planned work included deepening the fairway to the harbour of Antwerp and complementary measures to protect the land from storm floods coming from the North Sea. The cost-benefit analysis took into account the ecosystem services using a contingent valuation approach<sup>9</sup> for the recreational value of new floodplains. Based on these results, the Dutch and Flemish governments approved an integrated management plan consisting of restoration of approximately 2,500 ha of intertidal and 3,000 ha of non-tidal areas, reinforcement of dikes, and dredging to improve the fairway to Antwerp.

*Sources: De Nocker et al. (2004); Meire et al. (2005); Broekx et al. (2011)*

#### Fynbos Biome, Western Cape, South Africa

The economic benefits of wetlands in the Fynbos Biome of the Western Cape, South Africa, were estimated using a replacement approach, which calculated the water treatment capacity of wetlands. The economic benefit was calculated on the basis of the cost of performing the same service, i.e. removal of nitrogen, with man-made water treatment plants. The study calculated the average value of the wetlands' water treatment service as US\$ 12,385/ha per year, which is a high enough value to compete with alternative land uses.

*Source: Turpie (2010)*

#### The Catskill watershed, New York, USA

The Catskill / Delaware watershed provides about 90% of the water used by the New York City citizens. In 1997, a study showed that building a new water treatment plant would cost between

US\$6 and US\$8 billion, whereas ensuring a good water quality through a set of measures to reduce pollution in the watershed would only cost US\$1.5 billion. Based on this, the city administration opted for a programme which remunerated farmers for sustainable farming activities that reduce aquifer contamination and used 10 and 15-year contracts for retaining land from production and sustainable forest management practices. In 2009, the programme implemented 427 Best Management Practices, at a total investment of nearly US \$3.4 million. In addition, the programme included 167 Nutrient Management Plans and over 375 Whole Farm Plans, as well as 21 farmer education programmes (recording high attendance). A Nutrient Management programme was established allowing farmers to gain credits through heightened stewardship of manure resources that they could then utilise to reimburse nutrient management related expenses. A variety of different on-site projects were also implemented to improve water quality in the watershed.

*Sources: Salzman (2005); McCauley (2006); Landell-Mills and Porras (2002); Wunder et al. (2009), Watershed Agricultural Council (2010)*

### 2.3 Status and trends of water and wetlands<sup>10</sup>

**What has been lost? Trends in wetland area.** People have been progressively draining, in-filling and converting both coastal and inland wetlands for many centuries, for example since at least Roman times in Europe and since the 17<sup>th</sup> century in North America. This destruction and degradation continues. Major drivers of loss and degradation have been (and continue to be) conversion to first extensive and then intensive agriculture (croplands), changes in water use and availability, and increasing urbanisation and infrastructure development and, on the coast, also port and industrial developments and aquaculture.

Overall, estimates suggest that since 1900 the world has lost around 50% of its wetlands (UNWWAP, 2003), with 60% loss in Europe (55-67% losses in different countries; EEA 2010) and 54% loss since the 18<sup>th</sup> century in the USA (exceeding 90% loss in some states; Dahl 1990) and further 5% losses of both inland and coastal wetlands more recently (Dahl 2006). Highest rates of loss in these countries were in the 1950-1980 period, with losses continuing but more slowly since then. For example, in Europe whilst a further 2.7% of inland vegetated wetlands were lost between 1990 and 2006, open waters increased by 4.4% and coastal wetland area remained stable (EEA 2010).

Whilst wetland losses have generally slowed in North America and Europe, this is not the case everywhere else. In China, natural inland wetlands decreased in area by 33% between 1978 and 2008, whilst artificial inland wetlands increased by 122% over the same period, and 31% of coastal wetlands were lost in the same period (Niu et al. 2012). Overall losses of coastal wetlands in east Asia over the 50 years to 2005 have been high: 51% in China, 40% in the Republic of Korea and >70% in Singapore (MacKinnon *et al.* 2012). In addition to the large total areas of coastal wetlands land-claimed in east Asia, chiefly for urban, infrastructure and port and industrial developments, annual rates of loss have also been particularly high, at up to 6 times more rapid than rates of loss reported from elsewhere. In addition, further major coastal land-claims are on-going or have been approved in this region, totalling at least a further 6,000 km<sup>2</sup> (MacKinnon *et al.* 2012).

Trends in areas of different wetland types reflect these general patterns. **Coastally**, 20% (3.6 million hectares) of **mangroves** were reported lost between 1980 and 2005, with 80% losses



over this period in some countries (FAO, 2007); whilst reported rates of mangrove loss in most regions have slowed since 2000 the loss rate in Asia (the region with the largest mangrove area) accelerated. Similarly 20% of **seagrass beds** are estimated as having being lost between 1930 and 2003 (Butchart et al. 2010), and 85% of **oyster reefs** have been lost (Beck et al. 2011). At least 38% of UK estuaries had been lost by the 1990s (Davidson *et al.* 1991). Wetland area lost from 14 of the world's major **deltas** (mostly coastal) was over 52% between the 1980s and early 2000s (Coleman et al 2008). Loss of coastal vegetated wetlands (**saltmarshes**) in the USA was only 1.5% between mid-1970s and mid-1980s and a further 0.7% from 1998-2004 (Dahl & Johnson 1991; Dahl 2006), but for part of the Mississippi delta there was an earlier greater loss, of about 50% from 1956-2004, with most rapid rates of loss in the 1970s (Bernier et al. 2006). In south-east UK, almost 90% of saltmarsh has been lost through land-claims and rising sea-levels (Hughes & Paramor 2004).

**Inland open water** area (of both natural and artificial wetlands) decreased overall by 6% in the 15 years from 1993-2007, but within this trend is a larger decrease (9.5%) up to 2000, followed by a 3% increase in area during the 2000s (Prigent et al. 2012), likely at least in part a consequence of recent increases in dam and water storage construction (Acreman 2012). Similarly in Europe there was a 4.4% increase in open water areas from 1990-2006, largely through the creation of artificial waterbodies by new dams (EEA 2010).

Trends in **inland vegetated wetlands** are less well documented, but examples include a 5.0% loss of European marshes and bogs between 1990-2006 (EEA 2010), and a loss of 2.5% on inland wetlands in the USA between mid-1970s and mid-1980s (Dahl & Johnson 1991) and further losses of vegetated inland wetlands up to 2004 (Dahl 2006) – although these losses since the 1990s were counterbalanced by a 12% increase in restored and created ponds over the same period. In Morocco 25% of inland wetland area was lost in 20 years in the late 20<sup>th</sup> century, with losses of some types of wetland being up to 98% (Green *et al.* 2002).

**What has been lost? Trends in wetland-dependent species.** Unsurprisingly, trends in the status of wetland-dependent species follow the overall patterns of continuing wetland habitat loss. The Living Planet Index (LPI) for **freshwater species and populations** has declined by 37% in 38 years from 1970-2008 – a larger decline than for any other biome - and for tropical regions there has been an even greater (70%) decline, in contrast to an increase of 35% in the freshwater temperate index (WWF 2012). The marine LPI (which includes many coastal species) has also declined (by 22%) over the same period. Regionally, the decline in the overall LPI has been greatest in the Indo-Pacific biogeographic realm (64%).

For **waterbirds** (Wetlands International 2010), whilst the global status of biogeographic populations has improved slightly since from 1976-2005, more populations remain in decline (38%) than are increasing (20%). As for the LPI, the global trend masks major differences in status across regional, flyways and taxa: whilst populations in Europe and North America have relative good, and improving, status since the mid-1970s, those depending on South America and Africa, and long-distance migrants worldwide have a much poorer and declining status, and the status of all types of waterbird population in the Asia-Pacific region has been, and continues to be, particularly bad. Whilst the status of some waterbird taxa has improved, that of others is deteriorating rapidly: the status of shorebirds

(sandpipers, plovers and their allies) decreased by 33% over the 20 years to 2005 (Butchart et al. 2010), with populations using the East Asia-Australasia flyway with especially poor and rapidly declining status.

**What remains? Global wetland area.** The global extent of coastal and inland wetlands is estimated to be in excess of 12.8 million km<sup>2</sup>, but this recognised as a considerable underestimate. Estimates for global area of inland (freshwater) wetlands vary considerably (from 5.3 – 9.5 million km<sup>2</sup>), but are also considered underestimates (Finlayson *et al.* 1999). Much of the total area is **inland wetlands**: for example, 5.7 million km<sup>2</sup> of natural freshwater wetlands (including 3.85-4 million km<sup>2</sup> of peatlands); and 1.3 million km<sup>2</sup> of rice paddy (see Spiers 1999). Open water wetlands (both natural and human-made) cover a seasonal maximum of 5.66 million km<sup>2</sup> (Prigent *et al.* 2012). Areas of **coastal wetlands** are smaller, and include 0.5 million km<sup>2</sup> of major estuaries (MA 2005c); 0.566 million km<sup>2</sup> of major deltas (Coleman *et al.* 2008); 0.138-0.147 million km<sup>2</sup> of mangroves (FAO 2007; Giri *et al.* 2011); 0.177 million km<sup>2</sup> of seagrass beds (Green & Short 2003); and 0.392 million km<sup>2</sup> of saltmarshes and up to 0.6 million km<sup>2</sup> of coral reefs (cited in Crooks *et al.* 2011).

**What is the state of the remaining wetlands?** Wetlands continue to face severe pressures, despite many benefits they provide to people and many conservation/restoration successes from recent efforts at local to national to global scales. Although there is no comprehensive assessment of the state of the world's remaining wetlands, many are recognised as having deteriorated in status and to be currently degraded. In 2012, 127 governments reporting to the Ramsar Convention indicated that the overall status of their wetlands had deteriorated in recent years in 28% of countries but improved in only 19% (Ramsar Convention 2012). Other examples include that coral reef condition (live hard coral cover) deteriorated by 38% between 1980 and 2004, with most occurring in the 1980-1990 decade (Butchart et al. 2010). Eutrophication of inland and particularly coastal wetlands, leading to algal blooms and hypoxia (low oxygen levels) is increasing in some areas, for example the Baltic Sea (Conley et al. 2011). Major changes in water management, including through damming and increasing abstraction upstream has led to impacts on downstream wetlands in many river basins, through reductions or changes in water availability (e.g. Carpenter et al. 2011). Long-term and accelerating reduction of regulating services has occurred in Yangtse basin wetlands, linked to agricultural intensification (Dearing et al. 2012). Designation of wetlands as protected areas, nationally or internationally, does not mean that they necessarily remain in a healthy state: for example, in China the area of national wetland reserves has decreased over the past 30 years, and over three-quarters of reserves are reported as in poor condition (Zheng et al. 2012). Likewise, while 30% of Ramsar Parties report that the condition of their Ramsar Sites has improved in recent years, 17% report deteriorating status.

**What are the costs of inaction?** Many water resource developments that have been undertaken to increase access to water have not given adequate consideration to harmful trade-offs with other services provided by wetlands, and many such conversions of wetlands have favoured provisioning services (notably food production) at the expense of losing or reducing delivery of regulating and supporting services from both those locations, and elsewhere downstream in river basins (MA, 2005b). Given the often high values, and the diversity, of ecosystem services provided by intact wetlands (section 2.2), and that a large proportion of these values are from water-related regulating services such as regulation of

water flows, moderation of extreme events and water purification, the widespread and major losses of all types of inland and coastal wetlands must inevitably have already led to a progressively increasing major loss of wetland ecosystem service value delivery to people. Permitting the remaining wetlands be converted or letting them degrade means further loss of their value to people.

Such costs of inaction (or actions to convert wetlands) can be very high. For example, coastal wetlands in the USA are estimated to currently provide USD 23.2 billion.yr<sup>-1</sup> in storm protection services alone. But large areas of such wetlands have already been lost, and further loss is continuing. A loss of one hectare of such wetland is estimated to correspond to an average increase in storm damage from specific storms of USD 33,000 (Constanza et al. 2008). The costs of just one recent summer flooding event in the UK, in 2007, are estimated at £3.2 billion (USD 5.2 billion) (Environment Agency 2010), with damage and costs occurring largely in areas of former river floodplain converted through urban, industrial and infrastructure developments.

When wetlands have been allowed to be lost or degraded, there is a second category of the cost of such inaction: the cost of restoration (see sections 2.4 and 5.3 for further exploration of the costs and benefits of restoring different wetland types). Overall, whilst costs of restoration can be high, and require long-term management investment, the resulting economic benefits to people can outweigh such costs (see e.g. Alexander & McInnes 2012). But in general even with active restoration interventions, once they have been disturbed wetlands either recover slowly (over decades or centuries) or move towards alternate states that differ from their original (pre-disturbance) state (Moreno-Mateos et al. 2012; Mossman et al. 2012). So, few if any wetland restorations fully return the value of their former ecosystem services. Continuing to allow wetland loss and degradation to occur, even with restoration efforts, will result in further progressive overall loss of wetland service values: the benefits of avoiding such future loss and degradation are high.

## **2.4 Restoring degraded wetlands delivers economic benefits**

Just as loss and degradation of wetlands leads to loss of the economic benefits of ecosystem services, restoration of wetlands can restore some of those services and hence deliver economic benefits.

Removing the stressors or pressures on the ecological character of existing wetlands is the best practice for preventing further loss and degradation. When this is not feasible or when degradation has already occurred, wetland restoration must be considered as a potential response option. The commitments and obligations under the Ramsar Convention clearly mandate wise use and the avoidance of wetland loss and degradation as the first and highest priority. The Convention has also provided national governments and others with a framework on how to avoid, mitigate and compensate for wetland loss and degradation, which includes identification of the opportunities for wetland restoration<sup>11</sup>.

Restoration is not a substitute for protecting and ensuring the wise use of wetlands, i.e., the potential to restore a wetland is not a justification or suitable trade-off for the continued degradation of wetlands. In addition, wetland restoration can be much more costly than the costs of managing and maintaining a naturally-functioning wetland (see also sections 5.2 &

5.3). Furthermore, while restoration can play an important role in enhancing wetland benefits, experience shows that a “restored” wetland rarely provides the full range and magnitude of services delivered by a wetland that has not been degraded (Moreno-Mateos et al., 2012).

In the past, some wetland restoration efforts have failed due to, among other things, narrow objectives which focus on one benefit or a partial suite of benefits. The inability to recognize or appreciate the potential for achieving multiple benefits across sectors has, in some cases, precluded cost-effective, participatory approaches to wetland restoration that may be more successful in recovering benefits and delivering more sustainable outcomes for people and the environment.

Decision makers should take immediate and appropriate measures to recognize the full suite of environmental, cultural and socio-economic benefits from wetland restoration. In the tropics for instance, mangroves and peat swamp forests play a critical role in carbon storage and climate regulation. The failure to recognize these multiple benefits often greatly undermines the rationale for wetland restoration and compromises future well-being<sup>12</sup>.

Box 2.6 shows some examples of benefits provided by wetland restoration. Other examples are included in Box 5.1.

#### **Box 2.6 Examples of benefits related to restoration of wetlands**

##### Waza floodplain, Cameroon

Loth (2004) calculated that engineering works to reinstate the flooding regime in the Waza floodplain (8,000km<sup>2</sup>), which was damaged in the 1970's by the construction of a large irrigated rice scheme, would cost approximately US\$11 million. The same study calculated that the economic effects of flood loss were almost US\$50 million over the 20 years since the scheme was constructed, including direct economic losses of more than US\$2 million/year through reduced dry season grazing, fishing, natural resource harvesting and surface water supplies. The costs of restoring the flood regime would be covered by the benefits in less than five years and would bring around US\$2.3 million additional income per year to the region. This figure includes the opportunity cost of the loss of millet and sorghum production and of gum arabic harvesting opportunities.

*Source: Loth (2004)*

##### Manalana wetland, South Africa

In 2006 the 'Working for Water' (WfW) public works programme invested €86,000 to restore the Manalana wetland (near Bushbuckridge, Mpumalanga). It was estimated that the total economic benefits provided by the rehabilitated wetland was €182,000 in Net Present Value terms; that the value of livelihood benefits derived from the degraded wetland was just 34% of what could be achieved after investment in ecosystem rehabilitation; and that the provisioning services now provided by the rehabilitated wetlands have an economic value of €297/household per year. In addition, the Manalana wetland acted as a safety net for poor households during periods of economic difficulties such as high unemployment.

*Source: Pollard et al. (2008)*

##### Hail Haor wetlands, Bangladesh

The Management of Aquatic ecosystems through Community Husbandry (MACH) project, initiated by the Bangladesh government and the United States Agency for International Development (USAID), aimed to

address the problems related with the drainage of wetlands for agricultural production. MACH estimated the economic benefits of the Hail Haor wetlands to be almost US\$8 million per year using GIS-based land-use mapping and interviews with the local community. The economic benefits of fishery, non-fish aquatic products, use of aquatic vegetation, pasture, dry season rice, transportation and recreation were included. Thanks to the protection strategy implemented by the project, fish catch improved by 80% in Hail Haor. Moreover, ecotourism in the area increased as a result of the rising number of resident bird species allowed by the ban on fishing and aquatic plant harvesting in the protected area.

*Source: Thompson and Balasinorwala (2010)*

#### Restoration of wetlands for local livelihoods and health, Central Asia

Intensification and expansion of irrigation activities in Central Asia led to shrinking of the Aral Sea and degradation of the Amu Darya delta in Uzbekistan, leaving only 10 percent of the original wetlands. The Interstate Committee on the Aral Sea, in consultation with the World Bank, requested the development of a coherent strategy for the restoration of the Amu Darya delta. A Strategic Environmental Assessment (SEA) approach was used to structure the decision making process. Valuation of the ecosystem services was instrumental in changing the course of development from technocratic and unsustainable interventions, towards the restoration of natural processes that were better capable of creating added value to inhabitants under the dynamic conditions of a water-stressed delta. The process created a strong coalition of local stakeholders and authorities, resulting in the necessary pressure to convince the national government and the donor community to invest in a pilot project- the restoration of the Sudoche wetlands. The project resulted in an increase in productivity of the region:

- Incomes of both poorest and richest households have increased;
- The number of cattle has increased;
- Production of hay for own use and selling on regional market has increased;
- Cutting of reeds and selling of reed-fiber mats (boards) has increased;
- Fish consumption has increased up to 15 kg a week per family;
- Population of muskrats increased.

The best indicator of success is the return of young people to the villages in the region.

*Source: Slootweg (2010a); Slootweg et al. (2008)*

## 3 IMPROVING MEASUREMENT AND ASSESSMENT FOR BETTER GOVERNANCE

### KEY MESSAGES

- *Information on the location and extent of water and wetland resources should underpin land and water management decisions.*
- *An appreciation of the hydrological functions of wetlands is essential to understanding their water related benefits to society and the economy.*
- *Understanding the reasons for wetland ecosystems degradation is crucial for identifying opportunities where a focus on ecosystem services can be of help for better managing water resources and wetlands.*
- *The management of water and wetlands can benefit from improved understanding of the ecosystem functions and the flow of ecosystem services. These in turn can be improved through better hydrological, biophysical and socio-economic data (e.g. indicators, mapping and accounting) that meet the needs of stakeholders and decision makers.*
- *Monetary valuation can significantly help demonstrate the importance of wetlands to society and the economy and thereby help argue for their protection, wise use and restoration. However, a single methodology cannot reflect all values embedded in water-related ecosystem services and wetlands. It is important to combine different approaches including bio-physical indicators, monetary valuation and participatory methods.*

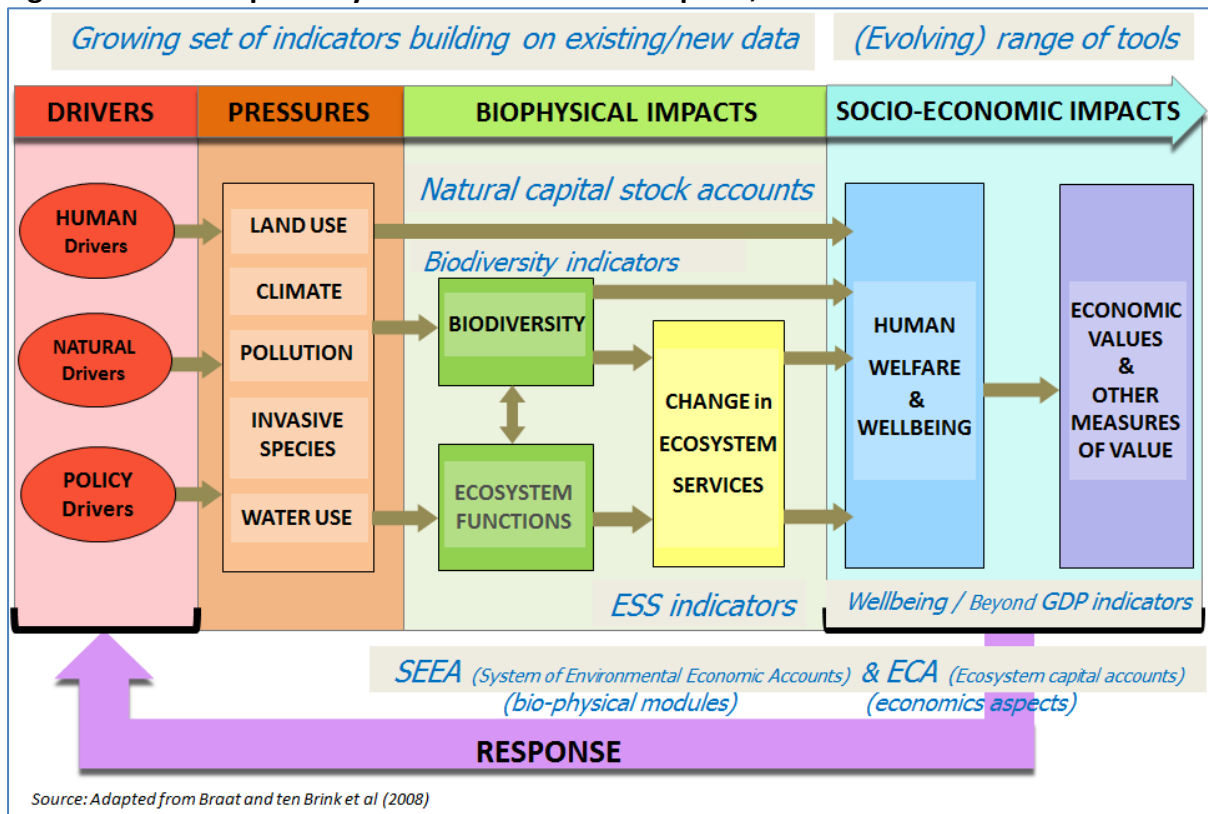
### 3.1 Introduction

The increasing appreciation of ecological processes, functions and services, as well as of the interaction between nature and the economy, leads to improved governance of water and wetlands.

Figure 3.1 below presents a simplified illustration of the interconnections between the ecosystem functions (e.g. hydrological functions) and service flows (e.g. clean water provision); the drivers and implied pressures affecting the state, functions and flows; and the benefits that people, society and the economy gain from nature and the tools to value these benefits - whether adopting economic or other metrics. The figure also shows the role of indicators and different measurement/assessment approaches in contributing to the evidence base and good governance. There is a growing wealth of evidence in the form of biodiversity and ecosystem indicators with some building on existing data and data collection processes and others reflecting on new commitments and tools. Environmental accounts are also becoming an increasingly important part of the landscape through natural

capital stock accounts (e.g. water, forestry, carbon) and commitments to the integrated environmental economic accounts (SEEA/WAVES, see section 3.6).

**Figure 3.1 The pathway from drivers to impacts; information needs and tools**



The Convention on Biological Diversity’s (CBD) Strategic Plan for Biodiversity 2011-2020<sup>13</sup> includes commitments to raise awareness of the value of biodiversity and to integrate them into plans, strategies, and accounts (Aichi Biodiversity Targets 1 and 2). Parties to the CBD are currently revising their National Biodiversity Strategies and Actions Plans to take on board physical assessments of nature and flow of ecosystem services. Collection, systematisation, and interpretation of environmental, economic, and social information are crucial to this process.

### The values of nature: a combination of measures to develop the full picture

Historically, there has been a lack of understanding of the multiple values of water and wetlands. The values of these ecosystems have seldom been adequately acknowledged or taken into account in the policy making and private decision making processes. This has been a contributing factor to the continuous loss and degradation of water-related ecosystems and wetlands that we are experiencing. Improving awareness on the importance and values of nature is crucial for better governance as a way to support conservation, wise use and restoration of wetlands, while helping achieve development objectives.

A focus on ecosystem services in the management of water and wetlands can help identify opportunities for 1) better harnessing and maintaining the multiple benefits that ecosystem services related to water and wetlands provide; 2) developing more cost effective strategies

than conventional technical solutions can offer; 3) avoiding costs related to the loss of biodiversity and ecosystem services.

In order to unlock these potentials, it is necessary to recognize who benefits by how much from which ecosystem services and how this might improve with positive restoration and management activities - or risk being negatively affected by any ecosystem degradation.

Different approaches and tools can help assess the benefits that flow from water and wetlands by providing different and complementary information, including **qualitative**, **quantitative**, **spatial** and **monetary** approaches. Given their relevance to demonstrating value, each of the elements is presented below.

- 1) **Qualitative analysis** is based on non-numerical information, which describes values and benefits that are not easily translatable into quantitative information (e.g. landscape beauty, impacts on security and wellbeing, cultural and spiritual values). For instance, determining which wetlands have particular cultural values to which communities is in itself an important means of communicating value.
- 2) **Quantitative data** is used to represent the state of, and the changes in, the ecosystems and in the ecosystem services they provide using numerical units of measurement (e.g. groundwater availability in a watershed in cubic metres, nitrogen and phosphorus found in a water body in micrograms per litre and changes to this through water purification functions of wetlands, carbon stored in peatlands in tonnes per hectare and sequestered annually in tonnes per hectare per year; and number of people who benefit from access to clean water from wetlands). The value of ecosystems can be demonstrated using physical stock and flow indicators as well as social indicators (e.g. proportion of households benefitting from access to clean water).
- 3) **Geospatial mapping** allows the quantitative data to be linked with geographical information (e.g. which community benefits from clean water provision from a given wetland). It can also be the basis of modelling the outcomes of alternative land and water management decisions on specific wetland sites, and their ecosystem services. This can be integrated into local accounting and decision making tools (e.g. InVest, see section 3.4).
- 4) **Monetary valuation** can build on biophysical information on the services provided by ecosystems to derive values (e.g. carbon storage in wetland sea grasses in tCO<sub>2</sub>/ha can be converted to stock and sequestration values by multiplying it by the carbon price in the international markets). It can be of help to inform a specific decision, management tool or policy instrument, e.g. the strategies of using wetlands for carbon sequestration, ecosystem based adaptation to climate change, flood mitigation or the establishment of a water fund (see section 3.5).

Assessments of ecosystem services that build on these approaches and aim at informing ecosystem management and decision making could also usefully include a stakeholder process for targeting ecosystem services that are of high priority for the different stakeholder categories and hence contribute to the development of solutions. Participation can be important for both a provision of evidence (and hence quality of the analysis) and for the buy-in and acceptance of the decision (e.g. land use change, permit, investment, or payment for ecosystem service). This can help take into account qualitative indicators of importance and stakeholder preferences, thus complementing the quantitative and monetary indicators.



The sections below explore in more detail the issues, practices and some key developments of different parts of the links as noted in Figure 3.1 and different steps related to assessing and demonstrating the value of water and wetlands. Section 3.2 focuses on biodiversity and ecosystem service indicators. Section 3.3 focuses on the information needs for an improved wetland and water management. Section 3.4 presents some examples of geospatial mapping. Section 3.5 discusses advantages and limits of monetary valuation to argue for wetland conservation and restoration. Section 3.6 explores environmental accounting. Finally, section 3.7 presents some practical way forwards by presenting six practical steps assessing values to help develop the evidence base to inform governance of environmental challenges. See also MA (2005a), TEEB (2010), TEEB (2011), TEEB (2012b) on the state of ecosystems, the flow of ecosystem services, their indicators, measurement and assessment.

### 3.2 Indicators

Information on biodiversity and biophysical processes of ecosystems is fundamental for assessing their state and capacity to deliver certain ecosystem services. It is also important to explore possible ecological thresholds, where ecosystem functions can be irreversibly lost, with often significant (and non-linear) impacts on ecosystem service flows and values. Good water and wetland management requires information on the extent and quality of water and wetlands (i.e. the stock of natural capital), on the flow of ecosystem services they provide and on how these are changing.

The level and type of evidence may be very different when considering the national level (e.g. national water or carbon accounts) and the local level, where data needs should be specifically tailored to the local problem and context (e.g. decisions on permit granting to drain a wetland, or designing a payment for ecosystem service scheme for water purification and provision or flood control).

Indicators play an important role in informing public policies regarding water and wetlands. They report on the overall status, trends of ecosystems and their values, thereby helping to identify the most urgent environmental problems to address, while also helping to set up the policy priorities. In addition, they are key to target setting, policy, and instrument design and evaluation, as they can be used to assess to what extent a certain policy is contributing to the achievement of a desired policy objective. It is important, therefore, to identify and use indicators that capture the different dimensions of values of water and wetlands and are useful in practical decision making.

One area of new momentum at the international level is that on bio-physical and ecosystem service indicators (ten Brink et al., 2011; TEEB, 2010). They are powerful tools to help demonstrate and communicate the values of nature. Table 3.1 presents some examples of ecosystem service indicators. Which indicators should be the focus of policy attention depends on the policy or decision objective and on particular ecosystem being looked at. This in turn reflects national priorities and challenges.

**Table 3.1 Examples of ecosystem service indicators – useful as quantitative measures of value of nature**

Ecosystem service	Ecosystem Service Indicator
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<b>Provisioning Services</b>	
<b>Food:</b> Sustainably produced/harvested crops, fruit, wild berries, fungi, nuts, livestock, semi-domestic animals, game, fish and other aquatic resources etc.	Crop production from sustainable [organic] sources in tonnes and/or hectares Livestock from sustainable [organic] sources in tonnes and/or hectares Fish production from sustainable [organic] sources in tonnes live weight (e.g., proportion of fish stocks caught within safe biological limits)
<b>Water quantity</b>	Total freshwater resources in million m <sup>3</sup>
<b>Raw materials:</b> Sustainably produced/harvested wool, skins, leather, plant fibre (cotton, straw etc.), timber, cork etc; sustainably produced/harvested firewood, biomass etc.	Timber for construction (million m <sup>3</sup> from natural and/or sustainable managed forests)
<b>Regulating services</b>	
<b>Climate/climate change regulation:</b> Carbon sequestration, maintaining and controlling temperature and precipitation	Total amount of carbon sequestered / stored = sequestration / storage capacity per hectare x total area (Gt CO <sub>2</sub> )
<b>Moderation of extreme events:</b> Flood control, drought mitigation	Trends in number of damaging natural disasters Probability of incident
<b>Water regulation:</b> Regulating surface water runoff, aquifer recharge etc.	Infiltration capacity/rate of an ecosystem (e.g. amount of water/ surface area) - volume through unit area/per time Soil water storage capacity in mm/m Floodplain water storage capacity in mm/m
<b>Water purification &amp; waste management:</b> Decomposition/capture of nutrients and contaminants, prevention of eutrophication of water bodies etc.	Removal of nutrients by wetlands (tonnes or percentage) Water quality in aquatic ecosystems (sediment, turbidity, phosphorous, nutrients etc.)
<b>Erosion control:</b> Maintenance of nutrients and soil cover and preventing negative effects of erosion (e.g. impoverishing of soil, increased sedimentation of water bodies)	Soil erosion rate by land use type
<b>Cultural &amp; social services</b>	
<b>Landscape &amp; amenity values:</b> Amenity of the ecosystem, cultural diversity and identity, spiritual values, cultural heritage values etc.	Changes in the number of residents and real estate values
<b>Ecotourism &amp; recreation:</b> Hiking, camping, nature walks, jogging, skiing, canoeing, rafting, recreational fishing, diving, animal watching etc.	Number of visitors to protected sites per year Amount of nature tourism
<b>Cultural values and inspirational services, e.g. education, art and research</b>	Total number of educational excursions at a site Number of TV programmes, studies, books etc. featuring sites and the surrounding area

Sources: building on, inter alia, MA (2005a); Kettunen et al. (2009); Balmford et al. (2008); TEEB (2010)

Indicators can be designed for a variety of policy objectives. For example, Box 3.1 shows information on a set of indicators being considered by the Subsidiary Body on Scientific,

Technical and Technological Advice (SBSTTA) to measure, inter alia, the state of water-related ecosystems and the ecosystem services they provide in the context of the implementation of the Strategic Plan for Biodiversity 2011 and its Aichi Biodiversity Targets.

This work also shows that many indicators are potentially available, including through environmental agencies and statistical bodies, beyond the traditional environment/biodiversity interests. This is particularly the case for those used for monitoring progress towards sustainable development targets.

### **Box 3.1 Water-related indicators from CBD SBSTTA**

#### 1. Clean water

- 1.1: Proportion of population using an improved drinking water source (in use)
- 1.2: Proportion of population using an improved sanitation facility (in use)
- 1.3: Water quality (in use)
- 1.4: Wastewater treatment (in use)
- 1.5: (a) Proportion of cities obtaining water supplies from protected areas; and/or (b) Proportion of protected areas established and managed primarily to protect water supplies (to be derived)
- 1.6: Area of wetland used in water treatment (including both natural and constructed) needing development)
- 1.7: Access to improved drinking water based on change in water quality (under development through FAO LADA/UNCCD)

#### 2. Water availability/water security

- 2.1: Water scarcity (or presented as "Proportion of total water resources used") (in use)
- 2.2: Water use intensity by economic activity (in use)
- 2.3: Human and economic losses due to water-related natural disasters (in use)
- 2.4: Percentage of population living in water hazard prone areas (needs development)
- 2.5: Land affected by desertification (in use)
- 2.6: Water footprint (needs some development)
- 2.7: Soil moisture (likely available soon from new remote sensing data)
- 2.8: Climate moisture index (CMI) (Aridity index) (in use)
- 2.9: Extent of terrestrial carbon storage vulnerable to water insecurity (can be derived from water scarcity and carbon storage metrics)
- 2.10: Trends in number of water-related conflicts and number/magnitude of inter-state conflicts (needs some development)

### 3. Sediment transfer

3.1: Sediment transfer (partly available, needs to be further derived)

### 4. Provisioning services related:

4.1: Actual hydropower installed capacity/potential capacity (in use)

4.2: Area water-logged by irrigation (in use)

4.3: Area salinized by irrigation (in use)

4.4: Crop water productivity (in use)

### 5. Disease regulation:

5.1: Population affected by water-related diseases (in use)

5.2: Parasite loadings (needs further work)

### 6. Indicators of enabling conditions (water-related):

6.1: Incorporation of water-related ecosystem services into national planning processes (can be derived from existing sources)

6.2: Progress in implementation of Integrated Water Resources Management (IWRM) (in use)

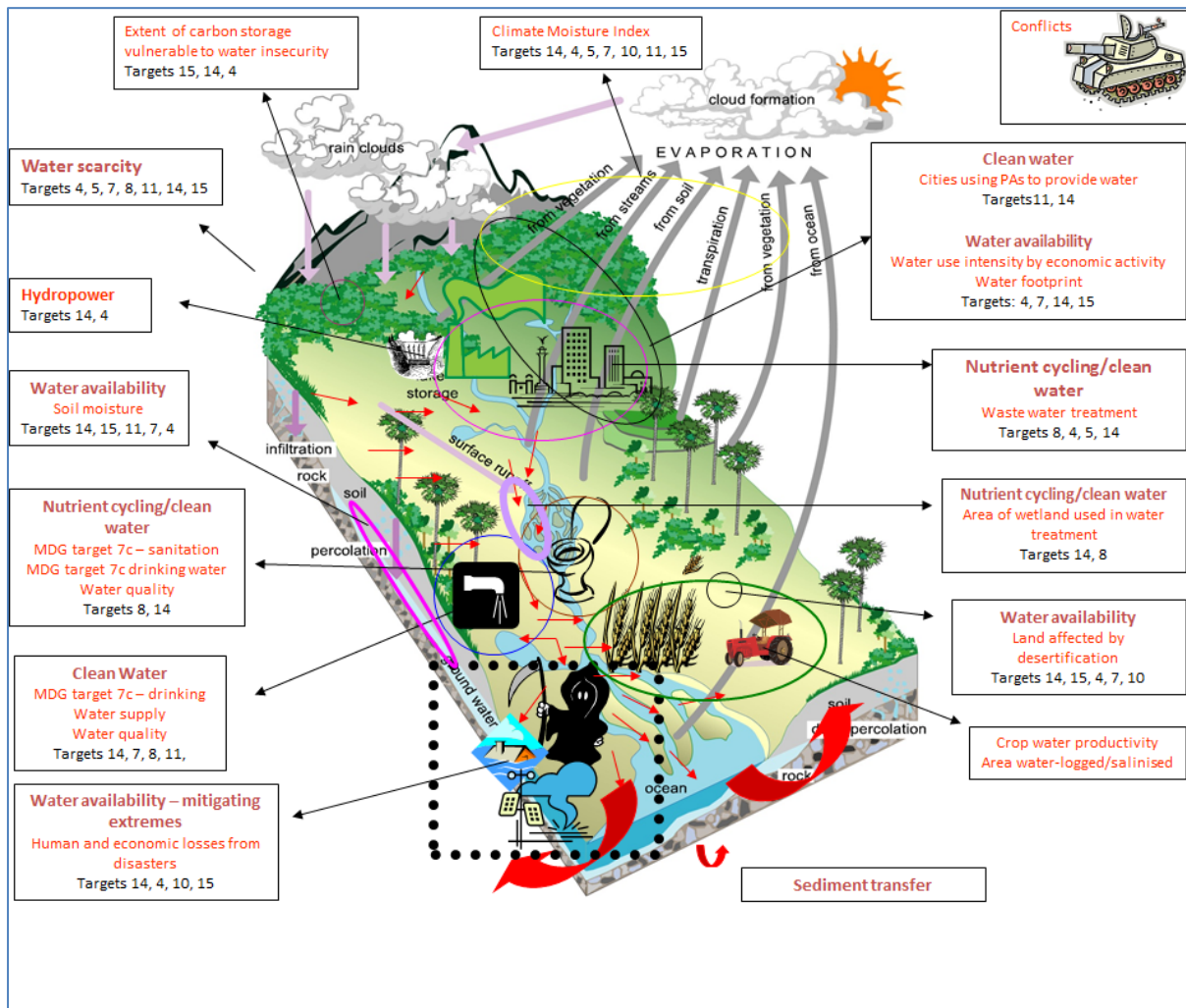
6.3: Women represented in water management (under development, included in response to the tenth meeting of the Conference of the Parties request to capture gender)

*Source: SCBD (2011)*

Indicators within the Millennium Development Goals (MDG) and the Rio+20 successor Sustainable Development Goals (SDG) include several related to water – notably target 7c under Goal 7 (Environmental sustainability), which is to halve by 2015 the proportion of the population without sustainable access to safe drinking water and basic sanitation. Wetland ecosystems will be critically important in contributing to achieving these targets. Ecosystem services from wetlands are also means of achieving other key MDGs. These include Goals 1 on poverty and hunger and Goals 3 to 5 on equality and health, given, inter alia, the importance of ecosystem services especially to the rural poor (TEEB, 2011) (see also discussion in Chapter 5).

Figure 3.2 presents a more complete picture of the range of targets from the MDG commitments and the Strategic Plan on Biodiversity 2011 to 2020. This figure builds on and extends the earlier figure on the water cycle (Figure 2.1) that focused on the indicators.

**Figure 3.2 The water cycle, key services and indicators and associated targets** (Strategic Plan for Biodiversity 2011 to 2020 and MGDs)



**The water cycle: hydrological pathways and ecosystem services.** In the above figure, ecosystem services are shown in blue, Aichi Biodiversity Targets in black and in red are shown some relevant indicators in use by other processes including for agencies monitoring human development targets and sector agencies (e.g. the FAO). (Technical explanation of this figure is provided in UNEP/CBD/SBSTTA/15/INF/10 together with sources of data). Source: redrawn from MRC (2003)

### 3.3 Geospatial mapping

Geospatial mapping is a powerful instrument to demonstrate where the source of value comes from (i.e. the location and the extent of water and wetlands resources), who the beneficiaries are, and what the interconnections between the two are. Demonstrating spatially which communities benefit from water supply, purification, flood control or food from a given wetland can be a powerful tool to communicate the value of a wetland in the local socio-economic context. Mapping can also significantly help the design and evaluation of environmental policies.

Many research efforts are being carried out to combine information on ecosystem services and geographical information. As an example, Naidoo et al. (2008) mapped four proxies for assessing the ecosystem services provided by ecosystems worldwide, i.e. carbon storage and sequestration, grassland production for livestock and fresh water provision. Another example is the BIOMES project at the Joint Research Centre of the European Commission

(JRC) (Maes et al., 2011), which aims to provide a spatially explicit assessment of European ecosystem services. Research mapping of the interrelationships between ecosystems, population centres and man-made infrastructures, such as the one realised by Vörösmarty et al. (2010), is very helpful for understanding the links and the interdependencies between them. There are also many research efforts that apply geospatial tools to the analysis of specific wetlands, see for example Nagabhatla et al. (2008) in Sri Lanka and Gumma et al. (2009) in Ghana.

Within the Natural Capital Project<sup>14</sup>, the tool InVEST (Integrated Valuation of Environmental Services and Trade-offs) was developed for the spatial assessment of ecosystem services. In particular, hydrological services including sediment and water retention, water yield and water purification have been assessed for informing land use decisions in the Yangtze River basin in China. In Boaxing County, China, this tool helped establish development zones while protecting areas with high ecosystem service value for erosion control and flood protection by setting aside key conservation areas (Yukuan et al., 2010). The same instrument has also been used to help inform the establishment of a Water Fund in Colombia (see Box 5.3 and Annex I), the development of an Integrated Coastal Zone Management Plan in Belize<sup>15</sup>, and to locate the best areas for conservation activities and define the best management practices for forestry and plantations in Indonesia<sup>10</sup>. In each case, the existence and value of water-related ecosystem services has been an important aspect of the evidence base driving change.

There is also a wide range of complementary research projects which aim to improve the availability and quality of information on wetlands at the global level. Box 3.2 presents two such examples that should help improve the evidence base on the water, wetlands and ecosystem service nexus.

### **Box 3.2 Towards improved availability and quality of information on wetlands and water**

#### **Developing a Global Wetland Observation System (GWOS)**

Data and information on the location, areas and state of wetlands and their ecosystem services is patchy, and information is scattered widely through published and unpublished sources and datasets. The Ramsar Convention has recognized the urgent need to improve access to, and analysis of, wetland data and information, and has placed a top priority in its future scientific and technical work (COP11 Resolution XI.17, 2012) for establishing a “Global Wetland Observation System” (GWOS), for the benefit of the Convention and for all others concerned with the wise use of wetlands. The GWOS is being scoped and developed as an open partnership, linked with GEO-BON and others, between those involved with collecting and analysing wetland-related data, and those needing improved their access to such information for wetland assessment and reporting purposes. It is expected that its functionality will include access to published papers and reports, spatial data-layers relevant to wetlands, tools for spatial analysis of wetland status and trends, and an archive function to help maintain access to time-limited project datasets. The GWOS will provide a source for not only the periodic of State of the World’s Wetlands and their Services (SoWWS) reporting to the Ramsar Convention, but also for a Watershed Health Index tool similar to the recently published Ocean Health Index, and for the Convention on Biological Diversity (CBD) and the upcoming Intergovernmental Science-policy Platform on

<sup>10</sup> TEEBcase by Thomas Barano, Emily McKenzie, Nirmal Bhagabati, Marc Conte, Driss Ennaanay, Oki Hadian, Nasser Olwero, Heather Tallis, Stacie Wolny, Ginny Ng (2010) Integrating Ecosystem Services into Spatial Planning in Sumatra, Indonesia, available at: TEEBweb.org.

Biodiversity and Ecosystem Services (IPBES), amongst others.

### **Piloting a regional GWOS approach: the Mediterranean Wetlands Observatory (MWO) and Globwetlands-II project**

The Mediterranean Wetlands Observatory (MWO), is a Mediterranean Wetlands Initiative (MedWet)/ Station Biologique de la Tour du Valat initiative to monitor and assess Mediterranean wetlands. It demonstrates how a regional GWOS partnership approach for sharing and serving up wetland information for decision-makers can be successfully developed. In 2012 the MWO issued its first technical report and synthesis for decision-makers, providing an assessment of past and present status of Mediterranean wetlands, and their future issues and pressures, the “Mediterranean Wetland Outlook 2012” available on: <http://www.medwetlands-obs.org/>

The European Space Agency’s “Globwetlands-II” project, working in partnership with Ramsar’s Scientific & Technical Review Panel, Medwet, the MWO, Wetlands International and a number of Ramsar/Medwet national focal points, has been designed to both support the work of the MWO and to develop better use of remote sensing techniques for the monitoring and management of wetlands, through the creation of harmonised geo-information maps and indicators. It consists of a remote sensing toolbox for satellite image processing and a GIS toolbox for indicator calculation. As well as supporting in-country capacity-development for using satellite imagery, it is also assessing trends in Mediterranean wetlands and their surrounding areas since the 1970s, focusing on the southern and eastern Mediterranean coasts. The techniques are now being planned for application in the northern Mediterranean, and have the potential for transfer to other parts of the world. More information on: <http://www.globwetland.org>.

### **The Global Wetlands initiative**

The International Water Management Institute’s (IWMI) “Global Wetlands initiative” will provide a multi-purpose and multiple-scale inventory with core data elements which will be built through a combination of continental and regional initiatives with regional and national delivery of the outcomes in order to ensure greater relevance and effective dissemination of wetland related information. The initiative aims to provide a multiple-scale and purpose-driven global wetland mapping and inventory data resource through continental and regional projects that can support further wetland assessment and management. IWMI is one of the five International Organisation Partners (IOPs) of the Ramsar Convention. More information on: <http://www.iwmi.cgiar.org/wetlands/GlobalWetlandInventoryMapping.asp>

## **3.4 Monetary valuation**

Monetary valuation can translate part of the information obtained through qualitative and quantitative indicators into monetary figures. For example, the wastewater purification service provided by healthy wetlands can be valued in monetary terms through the equivalent cost of a wastewater treatment plant that would provide a similar service. Additionally, the revenues generated from tourism can give an indication of the importance of the cultural ecosystem services provided by many wetlands. Some ecosystem services have a direct economic value that can be readily monetised, such as the local economic value of fish catches.

Monetary valuation can give an indication of the society’s preferences that is easily understandable and communicable. It can help make explicit preferences that are normally hidden and not reflected in market prices (e.g. the preference for clean water).

In many cases, provisioning ecosystem services (such as food or timber) are more visible and are favoured in the policy-making process because they have a market price, but there are many other ecosystem services that are less visible and often overlooked or

underrepresented in the policy-making processes. The calculation of the economic value of traditionally less well covered provisioning services (e.g. the value of some genetic materials or of water provision from wetland ) and non-provisioning ecosystem services (e.g. water purification, waste water treatment, and erosion control) contribute to the arguments for conservation, wise use and restoration.

For example, an evaluation study carried out in 2009 by the International Union for Conservation of Nature (IUCN) together with the Environment and Agricultural Research Centre and the Economic and Social Policy Analysis Centre estimated that the annual economic benefits derived from agriculture in the Sourou Valley, Burkina Faso, were only 3% of the total ecosystem services (valued at US\$21.2 million), despite the fact that in the mid-1990s the government had launched a master plan for agricultural development in the region. Timber products instead accounted for 37%, non-timber forest products for 21%, pastures for 18%, and both fishery and transportation on water for 10% (Somda and Nianogo, 2010). As another example, a recent study demonstrated that most potential carbon emissions due to mangrove loss could be avoided at a cost between \$4 and \$10 per ton of CO<sub>2</sub>, which is a lower price than the current price of carbon allowances in international markets (Siikamäki et al., 2012).

Valuing ecosystem services is an important means to bringing to fore the role of institutions. As manifestations of values, institutions influence preferences, choices, and actions of various stakeholders linked to wetlands. Valuation provides a tool for self-reflection, alerting us to the consequences of our choices and behaviour on various dimensions of natural and human capital (Zavestoski, 2004). It therefore is an important institution in itself to engendering change in the way societies respond to the crises of continued wetland loss and degradation.

The outcomes of any valuation process depends on what the various stakeholders value, whose values count, who benefits, and the manner in which social and ecological systems interlinkages are accounted for. Values and the process of valuation reflect socially and culturally constructed realities linked to worldviews, mind-sets and belief systems shaped by social interactions ,as well as political and power relations operating within a realm of local, regional and global interdependencies (Wilk and Cliggett, 2006; Hornborg et al., 2007).

Thus the choice of valuation methods also involves choosing the socio-cultural context which emerges from the understanding of what values are, or should be, and how they should be elicited. Valuation methods imply certain models of humans, nature and their interactions and they define whether values are revealed, discovered or constructed (Vatn and Bromley, 1994). Seen in this perspective, valuation methods function as “value-articulating” institutions by defining a set of rules concerning valuation processes (Jacobs, 1997).

Different methods can be used for monetary valuation and each one has its own advantages and limitations. They provide different kinds of information and differ in the degree of required resources and stakeholder involvement. The three most used categories of monetary valuation are the following:



1) The ones based on markets: for example using market prices to value services not in the market (e.g. non-marketed fish, timber, other forest products, water); estimating value via the avoided cost of prevented environmental damage; using the costs of substitutes, mitigation or restoration options as indicators of value;

2) The ones based on revealed preferences: for example, using the Travel Cost method to estimate the value of a protected area through the amount of time and money people spend to visit it; using the Hedonic Pricing method, using changes in property prices due to changes in the surrounding environment as an indicator of landscape value;

3) The ones based on stated preferences: for example using Contingent Valuation approach, which is based on asking people's willingness to pay for improved environmental protection (e.g. improved water quality) or to accept compensation for a reduction in the environmental quality.

Box 3.3 shows some examples of monetary valuation of ecosystem services provided by wetlands, complementing those in chapter 2.

### **Box 3.3 Examples of monetary values of ecosystem services delivered by wetlands**

#### Water supply

The Te Papanui Conservation Park (Lammermoor Range) provides the Otago region, New Zealand, with ecosystem services valued at around US\$96 million (which is the avoided cost of outsourcing the water that is currently provided for free by Te Papanui). The most important ecosystem service is the water supplied for the city of Dunedin (calculated at around US\$65 million of net present value in 2005) for electricity (around US\$22 million), and for irrigation water (around US\$ 8.5 million).

*Sources: New Zealand Department of Conservation (2006); BPL (Butcher Partners Limited) (2006)*

#### Flood control

The 7,000 ha Muthurajawella Marsh near Colombo, Sri Lanka provides flood attenuation ecosystem services that have been valued at over US\$5 million/year. This value was calculated by estimating the costs needed to construct a drainage system and pumping station that would provide the same flood control function, by extrapolating costs of construction of such system in a nearby area.

*Source: Schuyt and Brander (2004)*

#### Storm protection and erosion control

The storm protection and erosion control services performed by the 1,800 ha of mangroves in the Ream National Park, Cambodia, were valued at US\$300,000/year. Moreover, the mangroves provide habitat, nursery and breeding grounds for fish, as well as firewood, medicinal plants and construction materials. All these subsistence goods were valued at almost US\$600,000 per year.

*Source: Emerton et al. (2002)*

#### Multiple benefits

The ecosystem services provided by the Mississippi River Delta, USA, were estimated at between US\$12 and US\$47 billion/year. They included storm protection, water supply, climate stability, food, furs, habitats, and waste treatment in addition to the major cost savings achieved through ecosystem restoration<sup>16</sup>. More than

90% of these ecosystem services are provided by wetlands. However, the Mississippi River Delta is being degraded at a worrying pace, and it was estimated that it has lost over 1.2 million acres of land in the last 80 years. A recent report demonstrated that the restoration of the Delta would bring considerable economic benefits and it would represent a profitable national investment.

*Source: Batker et al. (2010)*

Given the growing level of interest in the monetary valuation and commitments to understanding the values of nature, it is important to have a realistic insight on the scope and limitations of different valuation tools (see TEEB, 2010, for a discussion). Generally, a range of methodologies will be needed to help assess the range of values embedded in water and wetland-related ecosystem services. Biophysical and monetary methodologies should be combined in order to ensure that a full picture of the benefits is presented.

It has been noted that ethical values, cultural needs, human rights, sacredness, and ancestral rights are of fundamental importance and not amenable to economic analysis (Martinez-Alier et al., 1997). Furthermore, there are concerns regarding the use of monetary valuation and a perception that monetary valuation could lead to a “commoditisation of nature” (McCauley, 2006). It has also been argued that monetary valuation is anthropocentric in nature and ignores the ecosystems that do not provide direct benefits to people and the economy.

It is important to recognise these concerns. However, to ignore the economic value (including monetary value) of nature is to reduce the ability to make robust arguments that have a chance of informing decisions for the protection of important ecosystems. The use of monetary valuation in many cases enhances the social visibility of the benefits brought about by environmental protection and restoration. By doing so, it can act as a counterweight to the pressures causing environmental degradation, which are driven by economic activities where market prices do not take into account negative impacts on health and the environment (sometimes termed “externalities”<sup>17</sup>). In these cases, economic assessments can help address this imbalance by demonstrating the importance of protecting and restoring our natural heritage to policy-makers, managers, and the general public. (TEEB, 2010; TEEB 2011). Some examples are provided in Box 3.4.

There is a growing momentum and commitment to understanding the values of nature at a national level (Strategic Plan for Biodiversity 2011-2020) and at a company level. Companies can take into account the ecosystem services via the use of corporate ecosystem valuation tools and ecosystem service benchmarks, which allow to evaluate investment risks and opportunities associated with biodiversity and ecosystem service (BES) (see [www.wbcsd.org/web/evi.htm](http://www.wbcsd.org/web/evi.htm), Grigg et al., 2011; KPMG and NVI, 2011).

#### **Box 3.4 Ecosystem service values influencing decision making**

##### Water purification

The ecosystem services provided by the Nakivubo Swamp (catchment area >40km<sup>2</sup>) to the Greater City of Kampala, Uganda, in terms of water purification was estimated at US\$2 million/year (which would be the cost of the infrastructure required to provide a similar service). The cost of managing the wetland in order to

simultaneously optimise its waste treatment potential and maintain its ecological integrity is about US\$235,000 per year. This study led to the reversal of previous plans to drain and reclaim the wetland, and consequently significant conservation benefits. It also entailed conservation risks (risk that the pressure from waste water will affect biodiversity, and in turn other ecosystem functions and services).

*Sources: Emerton and Bos (2004); UNDP-UNEP Poverty-Environment Facility (2008)*

#### Multiple Ecosystem Services

The contribution of coral reefs and mangroves to Belize's economy were estimated for 2007 at between US\$150 million and US\$196 million for tourism (12-15% of GDP), between US\$14 million and US\$16 million for fisheries, and between US\$231 million and US\$347 million for protection from erosion and wave-induced damage. The water-related ecosystem services were estimated to be the largest. These results were used by local NGOs to advocate for tougher fishing regulations, mangrove protection, and also to calculate compensation for damages caused by a container ship grounding on the barrier reef in January 2009.

*Sources: Cooper et al. (2008); Humes, A. (2010); Supreme Court of Belize (2010)*

### **3.5 Environmental accounting**

Many policy decisions aim to maximise policy objectives such as economic growth or employment generation and therefore are directly influenced by and evaluated against the data provided by national accounts such as Gross Domestic Production (GDP), economic growth rate, and government deficit. Natural capital is often ignored, among other reasons, because it is not included in national accounting, as defined by the System of National Accounts (SNA)<sup>18</sup>.

Hence measuring natural capital, the ecosystem services that it provides, and the changes in its state is essential for nature to be taken into account in the decision-making processes. Availability of information is also essential for good management of natural capital, including policy design and evaluation of the results. Natural capital and environmental-economic accounts can play a key role in systematically collecting information on the links between the economy and the environment. They might also serve as a basis for better-informed decision making related to ecosystems and biodiversity.

One of the approaches to complementing economic accounts with environmental statistics is represented by National Accounts Matrix including Environmental Accounts (NAMEA). NAMEA associates information on the environmental impact (in physical units) to standard economic accounts. It is organised in a matrix based on the input-output methodology developed by economist Leontief. The environmental data collected in NAMEA are pressure indicators, and include two environmental sets of data: one for environmental problems (i.e. the greenhouse effect) and another for pollutants. The environmental problems and pollutants to be included depend on the political priorities of each country.

Water NAMEA is currently in use in many countries. It provides valuable information for water management (e.g. water use per added value of each sector) including not only direct use, but also all water use along the production chain.

Another complementary approach is represented by the System of Environmental-Economic Accounts (SEEA). Launched in 1993 by the United Nations and the World Banks, it provides

an internationally agreed methodology for environmental accounting. The SEEA framework has a similar structure and definitions as the SNA, and therefore can be used together with economic statistics and indicators. A revision of the SEEA is currently being prepared by the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA). The new SEEA will include:

- 1) The core environmental resource accounts, which measure in physical terms the energy, water and material flows that cross the boundary between the economy and the environment and circulate within the economy (Volume 1, published in 2012);
- 2) The experimental ecosystem accounts, which aim to measure the state of ecosystems, their capacity to provide ecosystem services and the economic costs of avoiding or repairing environmental damages (Volume 2, due in 2013);
- 3) Extensions and applications of the accounts, i.e. various monitoring and analytical approaches that could be adopted using SEEA data in order to describe ways in which SEEA can be used to inform policy analyses (Volume 3, expected after Volume 2 is completed).

In addition, several international initiatives and commitments on environmental accounting have been put in place in recent years (see Box 3.5).

### **Box 3.5 International commitments on environmental accounting**

#### **WAVES: Global Partnership for Ecosystem Valuation and Wealth Accounting**

The World Bank's (WAVES) partnership, launched in 2010 at the CBD COP10 in Nagoya, Japan, calls for countries to implement the SEEA where there are already agreed methodologies, as well as to contribute to the development of innovative accounting methodologies to take into account the natural capital (e.g. ecosystem capital accounts). Countries engaged in the partnership include Australia, Canada, Japan, Norway, France, the UK, Botswana, Colombia, Costa Rica, Madagascar, and the Philippines. The partnership and commitments to accounts have received a positive boost from the Rio+20 commitments. The recent Gaborone Declaration by 10 African Nations (Gaborone Declaration, 2012) also called for support for green accounting and created momentum for the accounts related commitments at Rio+20.

#### **Rio+20 commitments**

At the Rio+20 Conference in June 2012, fifty-seven countries and the European Commission supported a communiqué that called on governments, the UN system, international financial institutions and other international organizations to strengthen the implementation of natural capital accounting around the world and factor the value of natural assets like clean air, clean water, forests and other ecosystems into countries' systems of national accounting. 86 private companies also joined forces behind the move and committed to collaborating globally to integrate natural capital considerations into their decision-making processes. In addition, governments have recognized the need for broader measures of progress to complement GDP in order to better inform policy decisions, and have requested the UN Statistical Commission to launch a programme of work in this area (UNCSD, 2012).

#### **Legislative requirements for accounts: a European example**

In the European Union, the Regulation on National Environmental Economic Accounts has been adopted, which requires the 27 member countries to regularly report on various resources and emissions related to water, air, land and also on environmental taxes. Such harmonised reporting methods will ensure a clearer picture of the interlinkages between the economy and the environment. It will also give a clearer indication of the flow of resources through the Member States' economies. Additional modules can be proposed every three years. The inclusion of ecosystem related accounting and SEEA in particular is one area of potential

inclusion under discussion.

Water is a priority area for the implementation of SEEA. For this reason, a SEEA subsystem, called SEEA-Water<sup>19</sup>, was developed by the United Nations Statistical Commission (UNSC), together with the London Group on Environmental Accounting<sup>20</sup> to provide a conceptual framework to organise hydrological and economic information on water in a standardised and consistent way. SEEA-Water measures the water stocks and abstraction for production purposes, household consumption (including reuse), as well as the pollution that is released into the environment. It also includes costs related to collection, purification, distribution and treatment and the price paid by final consumers (see Box 3.6).

Many countries have developed, or are in the process of developing, water accounting, e.g. France, Spain, the Netherlands, Mauritius, Mexico, Moldova, Canada, and Australia (European Environmental Agency, 2010, Eurostat, 2002, UNESCO-WWAP and UNSD, 2011).

#### **Box 3.6 Information contained in the SEEA-Water**

- (a) Stocks and flows of water resources within the environment;
- (b) Pressures imposed on the environment by the economy in terms of water abstraction and emissions added to wastewater and released into the environment or removed from wastewater;
- (c) The supply of water and its use as an input in the production process and by households;
- (d) The reuse of water within the economy;
- (e) The costs of collection, purification, distribution and treatment of water, as well as the service charges paid by its users;
- (f) The financing of these costs, that is, who is to pay for the water supply and sanitation services;
- (g) The payment of permits for access to abstract water or to use it as a sink for the discharge of wastewater;
- (h) The hydraulic stock in place, as well as investments in hydraulic infrastructure made during the accounting period.

*Source: United Nations (2012)*

In addition, experimental ecosystem accounts are currently being developed to expand the scope of environmental accounting. A standardised methodological approach for experimental ecosystem accounts will be proposed in SEEA Volume 2. In addition, the European Environmental Agency is developing Simplified Ecosystem Capital Accounts (SECA), as the European contribution to the discussion on SEEA Volume 2 (EEA, 2011). The main difference between environmental accounting (SEEA Volume 1) and ecosystem accounts (SEEA Volume 2) is that, while the former measures the flows of resources between nature and the economy, the latter aims to also take into account the resources that do not directly enter the market and the ecosystem services they provide, including regulation, support/habitat and cultural ecosystem services.

As regards water accounting, ecosystem accounts aim to measure the available water without degrading the environment, and the changes in its use. As a way to do so, the European SECA aims to calculate the Total Ecosystem Accessible Fresh Water (TEAW) as the total available rainfall after water is withdrawn plus the return of water to the environment (i.e. wastewater, losses in transport, irrigation). In addition, SECA should estimate water quality by multiplying TEAW by a water stress coefficient. The result will give an indication of the water that is usable without compromising the functioning of the related ecosystems, which is called Net Ecosystem Accessible Freshwater Surplus (NEAWS).

Another accounting approach that is used for water is the Water Footprint, which gives an indication of the water consumption associated with products or countries<sup>11</sup>. The methodology distinguishes between blue water (water abstracted from surface or groundwater), green water (precipitation water that is stored in the soil as soil moisture or stays on top of the soil or vegetation) and grey water (polluted water). Water Footprint gives an indication of the water embedded in a product or consumed by a country (including the embedded water in products). However, it should be kept in mind that it cannot give information on the environmental impact, as it sums up water intakes all along the production chain of a product or across a nation and thereby cannot take into account local water availability and quality.

### 3.6 Gaps and needs

Decision-making benefits from an improved evidence base. In practice, this will require specific data collection exercises for local decisions to reflect local conditions and the specific nature of the decision (e.g. restoration of degraded wetland). Beyond the site and decision specific information needs, there are also some gaps in knowledge that merit addressing (see Box 3.7). It is important to ensure that the values of water and wetlands are fairly and fully represented in the decisions (e.g. permit decisions, policy choices, investment decisions, instrument choice - see Annex II). Section 3.7 also presents a way forward for assessing the values of nature for specific local decisions.

#### Box 3.7 Gaps and needs

Some issues that might need determining, depending on the context and the policy requirements include:

- A clear statement of the water-related problems in place at the appropriate scale and the translation of these problems into ecosystem service based terminology;
- The objectives for social and economic development (e.g. health protection) and how the ecosystem services contribute, or could contribute, to these;
- Information on the distributional aspects of ecosystem services; who benefits and who loses, and also how the ecosystem services are distributed across time and space.
- The extent of the current stock of wetland resources and its role in water supply (flow of services) at

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<sup>11</sup> See the report "Water footprint of nations" (2004) from UNESCO-IGE.

the scale in question and relevant biophysical data to ensure insights on ecosystem functions that might not be visible from stock and flow indicators alone;

- The extent of previous wetlands, or existing degraded wetlands, which might be restored in order to provide ecosystem services to manage the problem in question;
- An overview of the full range of relevant ecosystem services that water and wetlands provide, and a more detailed analysis of ecosystem services that are of highest relevance to stakeholders (and their economic values if and where this is appropriate). Such a tiered approach in information can help ensure both that a sufficiently complete picture of ecosystem services is created, while directing sufficient resources and capacity to the ecosystem services of particular relevance for the decision at hand;
- Determining the economic value of ecosystem services, when possible, to inform decision making, economic instruments and policies;
- How the water and wetlands and the ecosystem services they provide are changing and how they can be managed to address both biodiversity objectives and development objectives given the range of ecosystem service flows.

Finally, it is important to be aware of the inherent complexity of the processes, interactions, and uncertainties of environmental indicators and valuation exercises. It is often intrinsically impossible to encompass the full breadth of environmental consequences entailed by changes in the stock and flow of ecosystem services, since some of them are not yet fully understood in all their ramifications and potential mutual interactions. This requires that any assessment is transparent as to what it covers, what it does not cover, and the level of robustness of the results - including implication of the limits of coverage (TEEB, 2010, 2011). In any case, the results of any environmental assessment and valuation should always be treated with caution and complemented by different tools and perspectives.

Even though progress still needs to be made towards water and ecosystem accounting, there is already much information available that can inform policy actions aimed at the conservation, wise use, and restoration of water-related ecosystems and wetlands and the ecosystem services that they provide. In some cases, limited information will be a sufficient evidence base to inform policy action, but in others this will not be enough - particularly in the long term. In the future, a better body of information on ecosystem services with high relevance to the environmental challenges being considered and the concerned stakeholder groups involved is crucial in order to build indicators needed for evidence-based policy-making.

### **3.7 A practical step wise approach to assessing the values**

Bringing together all information on the values of water and wetlands into a coherent decision making framework, which is focused on the key management objectives and integrates stakeholder inputs, can be a complex challenge. TEEB has sought to help decision makers through the development of a stepwise approach to navigate through the available options for integrating ecosystem services in local and regional management. Box 3.8 explains the approach and Box 3.9 provides a worked through example of the Kala Oya river

basin in Sri Lanka. Annex 1 presents further examples; Tubbataha Reef National Park, Philippines and the PES scheme for improving water provisioning in Moyobamba, Peru.

### Box 3.8 The six-steps approach

The TEEB six-step approach was developed (see TEEB 2012b) for providing some basic guidance on how to identify ecosystem service opportunities in ecosystem management:

**Step 1:** Specify and agree on the problem with stakeholders

**Step 2:** Identify which ecosystem services are most relevant (to the decision to be made and covering the key stakeholders)

**Step 3:** Identify the information needs and select appropriate methods, as the study design determines what kind of information you get

**Step 4:** Assess expected changes in availability and distribution of ecosystem services

**Step 5:** Identify and appraise policy options based on the analysis of expected changes in ecosystem services

**Step 6:** Assess social and environmental impacts of policy options, as changes in ecosystem services affect people differently

The order of the steps as outlined is flexible and can be adapted to the specific circumstances of the investigated site. More detailed information on the TEEB stepwise approach can be found in the report TEEB for Local and Regional Policy Makers (TEEB, 2010a, Box 10.1, p.177) and in the book TEEB in Local and Regional Policy and Management (TEEB, 2012b, Box 11.1, p.286).

### Box 3.9 Kala Oya river basin in Sri Lanka

The Kala Oya river basin in Sri Lanka has a traditional irrigation system with human-made wetlands for water storage (known as water tanks). Increasing water demand and unsustainable land use have led to reduced water inflow and an increased sediment load.

**Step 1:** Two challenges were identified by the regional authority, IUCN and residents: (i) competing water demands between traditional users, hydro power and modern agriculture; and (ii) the need for improved tank management.

**Step 2:** It became clear that, apart from the water tanks' benefit for rice cultivation, the wetland provided other important ecosystem services – fish stocks, lotus flowers, fodder and drinking water.

**Step 3:** What information was needed? First, assessing the value of the tank's provisioning services would offer insights about people's dependence on them. It was decided to use participatory appraisal methods, market prices and labour costs. Secondly, three regulating/ habitat services were selected for a qualitative trend analysis (using literature and expert judgment): water recharge, soil retention and habitat services.

Resource	% of households	Value per Household (US\$/hh/yr)	Value per Unit Area* (US\$/ha/yr)
Paddy cultivation	13%	177	161
Vegetable cultivation	7%	86	39
Banana cultivation	3%	1150	209
Coconut cultivation	13%	238	216
Domestic water	93%	226	1,469
Livestock water	13%	369	335
Commercial water	2%	132	12
Fishery	16%	309	351
Lotus flowers	10%	106	72
Lotus roots	7%	235	107
<b>Total</b>			<b>2,972</b>

\* Total inundated area



**Step 4:** So far, rice production had been considered the principal benefit. Later, results showed that rice accounted on average for about US\$ 160 per hectare per year - but other provisioning services, including water supply, accounted for an average value of about US\$ 2,800. This was important for future water allocation negotiations.

**Step 5:** To improve tank management, four scenarios were examined (see table below) and probable future costs and benefits were jointly considered with qualitative information on the regulating/habitat services. Scenario 4 (i.e. removing silt and rehabilitating the tanks water storage capacity) was the best option with regard to all criteria.

**Step 6:** The scenario of rehabilitating the tanks water storage capacity was also the most expensive option, requiring labor for silt removal. As intact tanks secure water supply for 93% of households, these costs were accepted locally.

Cost-Benefit Assessment of Alternative Tank Management Scenarios					
Scenario	Net Present Value in US\$ '000			Indirect use trends (Index)	Natural Capital in 30 years
	Cost	Incremental tank benefits	Quantifiable net benefit		
S1: Do nothing	0	0	0	-7	↓ ↓
S2: Raise spill	0.4	24.2	23.8	-4	↓
S3: Raise spill and rehabilitate tank reservation	35.8	64.6	28.8	6	↑
S4: Remove silt and rehabilitate tank reservation	62.8	120.7	57.9	7	↑ ↑

Source: Emerton (2004), Vidanage et al. (2005) and associated TEEB case in TEEB 2010a

## 4 INTEGRATING THE VALUE OF WATER AND WETLANDS INTO DECISION-MAKING

### KEY MESSAGES

- *Integrated management approaches such as Integrated Water Resource Management (IWRM), Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP), if properly applied, allow decision makers to simultaneously discuss and achieve multiple objectives (e.g. ensuring water, food and energy security, mitigating and adapting to climate change, alleviating poverty) and to deal with the synergies and trade-offs among them.*
- *In order to better manage and protect water ecosystem services and wetlands, a range of different instruments and management approaches should be combined. These include improving site management, regulation and land use planning, property rights, improving or creating markets by information, pricing and incentives, and direct investments.*
- *Market-based instruments like taxes, fees, subsidies and their reform, tradable permit schemes, banking and Payment for Ecosystem Services (PES) programmes can play an important role in that they can encourage the efficient use of resources, foster environmental protection, and involve a variety of social actors. These are however not a panacea, and should be seen as a complement to environmental regulation in the context of good governance.*

### 4.1 Introduction

Understanding the value of water and wetland ecosystem services is only the first step. To use this understanding to help protect these services requires its integration into appropriate types of decision making. A wide range of decision making contexts and tools directly or indirectly affect water and wetlands. Spatial planning approaches have been adopted in many cases, such as Integrated Water Resource Management (IWRM), Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP). Environmental regulation in various forms provides another route for protecting water and wetlands. Businesses and consumers are highly sensitive to the prices they pay for goods and services, but these may not take account of the loss of value from degrading water and wetland ecosystem services. A range of market-based instruments can be used to address this imbalance.

This section explores the different types of tools and instruments used in decision-making by explaining how the value of water and wetland ecosystem services can be better integrated into the design of these governance and market approaches, thus providing a stronger basis for the protection of water and wetlands and the services they provide.

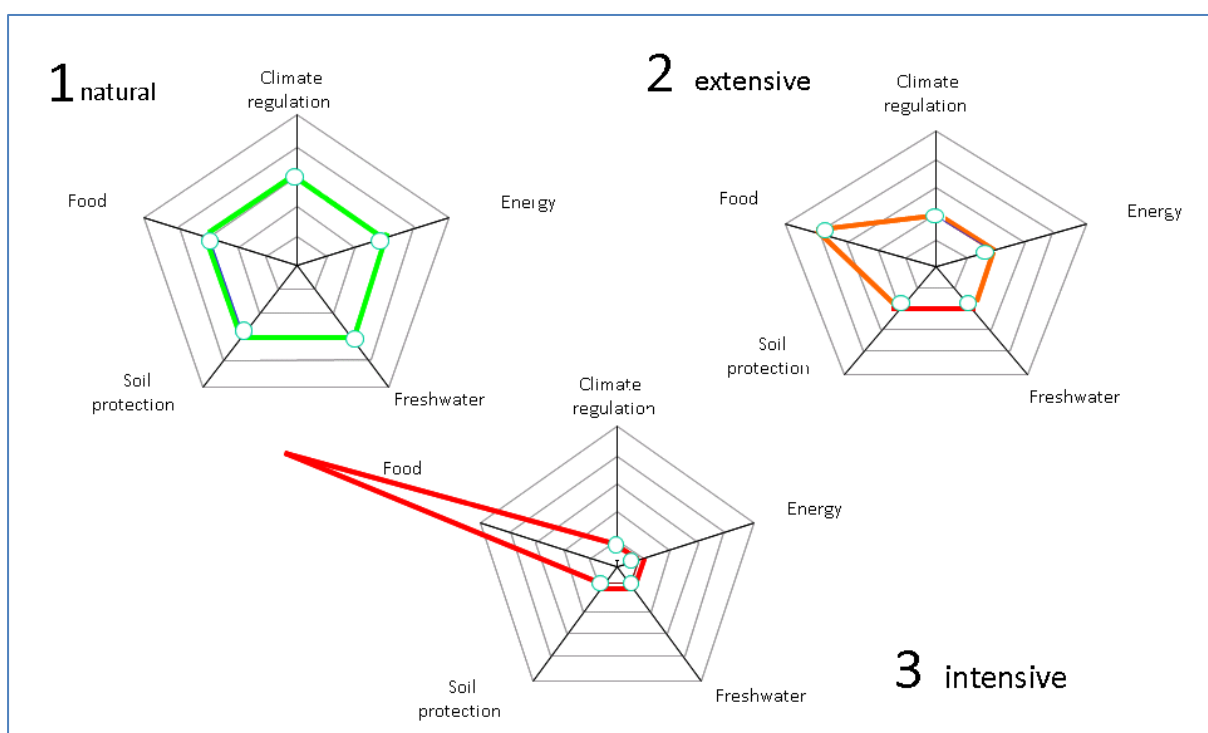
### 4.2 Wetlands and integrated water resources management

Water and wetland management has historically focused on individual management objectives mainly aimed at maximising provisioning ecosystem services (e.g. agricultural production, fisheries). This approach has led in many cases to an impoverishment in ecosystems' capabilities of delivering regulating, supporting and cultural ecosystem services. However, it is being increasingly recognised that wetlands should be managed to meet a wide range of interacting environmental, social and economic objectives (see for example Maltby and Acreman, 2011; Rouquette et al., 2011; Morris et al., 2009; Moreno-Mateos and Comin, 2010). Such 'multi-objective' management results in greater

biodiversity and provision of a wider range of ecosystem services, including fishery preservation, improved water quality, flood control, carbon sequestration and recreation.

Figure 4.1 presents a schematic to illustrate the trade-offs across ecosystem services from different land use choices – showing the ecosystem services flows for a natural ecosystem, extensive agriculture and intensive agriculture practice. With the increase in agricultural output, it is not atypical that the land produces less of other ecosystem services. In some cases intensive agriculture can be a social optimum, but in others it maximises private benefit at a cost to the wider society. Understanding the trade-offs entailed in land-use choices can help in good governance; this understanding needs to factor in the other inputs to production to achieve the chosen ecosystem services (in this case food provision) and to get a truer picture of the overall benefits of particular land-use choices.

**Figure 4.1 Different land-use choices and trade-offs across ecosystem services**



Source: ten Brink (2008)

The design of multi-objective water and wetland policies needs to build synergies between different levels of policy making (i.e. international, national, local) and different categories of stakeholders (e.g. individual land and water users, communities, policy-makers, local and regional managers, companies, NGOs) who may be interested in different kinds of ecosystem services. Furthermore, it is important to combine different instruments and management approaches; including improved site management, regulation and spatial planning, property rights and market-based instruments (MBIs).

In order to facilitate this task, approaches such as Integrated Water Resource Management (IWRM), Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP) have been developed in recent years as innovative approaches to water and coastal management. They are focussed on the landscape scale (e.g. river basin, coastal zone, marine region), are multidisciplinary in nature, and pursue the involvement of different categories of stakeholders (GWP and NBO, 2009). Other spatial planning approaches, such as urban planning, are important for landscape scale assessment of ecosystem services and management decisions.

These approaches allow decision makers to simultaneously discuss and formulate multiple objectives (e.g. ensuring water, food and energy security, mitigating and adapting to climate change, alleviating poverty) and to identify synergies among them (e.g. between regulating, supporting and cultural ecosystem services). They are also important for mainstreaming protection/restoration objectives into water, food, energy, climate and development policies. In mainstreaming the use of values for ecosystem services in wise use management decisions, it is important to take into account the concept of environmental limits, i.e. the limits of change which are acceptable.

In addition, these approaches facilitate the process of dealing with the trade-offs between policies aimed at improving different ecosystem services (e.g. provisioning ecosystem services versus regulating/supporting ecosystem services). For example, wetlands' shallow depths, large surface areas and high shoreline complexities have a positive impact on biodiversity and provide high nitrogen retention, whereas small, deep wetlands are characterised by higher phosphorus retention (Hansson et al., 2005). Similarly in lowland rural floodplains, management trade-offs can be found between biodiversity protection and agriculture, since shallow water tables and frequent flooding favour biodiversity but are worse for agricultural production due to the reduced flood storage capacity and the increased flood risk (Rouquette et al., 2011). Conversely, it is also important to recognise synergies between policies and objectives - such as the role of wetlands in recharging soil water tables which can supply water to agricultural users. Box 4.1 provides three examples of integrated water management.

#### **Box 4.1 Examples of good integrated water management**

##### The Pangani River Basin, Tanzania

The Pangani River Basin, Tanzania, provides livelihoods to over three million people, mainly from agriculture and fisheries. Water is extremely scarce in the area and not all aspirations for the basin regarding agricultural and energy production can be met. The IUCN Water and Nature Initiative (WANI) started a project in the area on Integrated Water Management, which included 1) participatory governance, 2) increased institutional capacity at basin level, 3) increased knowledge about water resources, 4) empowerment of water users, and 5) conflict resolution and platforms for stakeholder dialogue. Environmental flow assessment and economic analysis of ecosystem services were used in order to explore strategies for improving the river basin management.

*Sources: IUCN (2011)*

##### The Komadugu Yobe Basin, Upstream of Lake Chad, Nigeria

In the Komadugu Yobe Basin (area of 148.999 km<sup>2</sup>, 95% in Nigeria) unsustainable water management practices changed the seasonal river flow and caused widespread environmental degradation. Moreover, there was fragmented regulation, conflicting responsibilities among institutions, lack of coordination for hydro-agricultural developments, and inequitable access to water resources in addition to growing tensions and risk of conflicts among water users. In response to these problems, the IUCN Water and Nature Initiative (WANI) and national partners launched an IWRM project which included 1) the establishment of new institutions for implementing IWRM at the basin and national level, such as the State IWRM Committees; 2) the development and adoption of a water basin charter; 3) the development of a Catchment Management Plan to resolve water problems, which promoted data collection activities and a water audit; and 4) Livelihood pilot projects (field interventions to improve river flow by removing weeds and silt blockages). Finally, financial management and awareness raising activities were also implemented.

*Sources: Barchiesi et al. (2011)*

##### Catchment planning in South Africa

In Mhlathuze municipality, an area identified as a biodiversity hotspot, a classic case of 'development' versus 'conservation' dilemma led to conflict in the rapidly industrializing municipality in favour of development, in large part due to poverty and lack of local opportunities. The municipality undertook a strategic catchment assessment. The study highlighted the 'free' ecosystem services provided by the area (nutrient cycling, waste management, water supply, water regulation, and flood and drought management). The annual value of these ecosystem services was estimated at R1.7 billion (nearly US\$200 million). Politicians reacted positively once they realized the economic value of these ecosystem services.

The municipality embarked upon a negotiating process to identify (1) sensitive ecosystems that should be conserved, (2) linkages between ecosystems, and (3) zones that could be developed without impacting the area's ability to provide ecosystem services. More importantly, (4) it identified management actions that would ensure not only the survival of key biodiversity assets, but also sustainable development opportunities using biodiversity resources.

*Sources: TEEB (2012b) and Van der Wateren et al. (2004)*

### 4.3 Improving site management<sup>21</sup>

On-site, integrated management is crucial for the restoration and protection of water and wetland related ecosystem services. However, to do this requires site managers to understand the values of the ecosystem services provided by water and wetlands by working with local communities. For example, decentralised flood protection measures (i.e. a set of small technical interventions distributed throughout an entire drainage area such as; retention basins, small dams, artificial lakes, restoration of meanders and vegetation near river channels, afforestation of flood plains, and better soil management) can significantly reduce the occurrence and intensity of floods (Reinhardt et al., 2011). The damage potential of storms for coastal areas, river floods and landslides can be considerably reduced through a combination of careful land use planning and ecosystem maintenance or restoration to enhance buffering capacity (Maltby and Acreman, 2011).

Box 4.2 provides an example of good on-site management practices.

#### **Box 4.2 Example of good on-site management**

##### The Essex Marshes, UK

Salt marshes give an important contribution to water quality by removing pollutants and absorbing carbon dioxide. They also protect boat moorings and marinas and reduce the need for costly artificial sea defences. In the past 25 years, the Essex coast experienced the loss of approximately 50% of its original 30,000 hectares of salt marshes, and 1% is still being lost each year as a result of increased sea levels and coastal squeeze. Essex Wildlife Trust created a major coastal re-alignment project in 2002, with the objective of restoring salt marshes. The project will provide approximately £500,000 in benefits over the next twenty years through savings or new incomes on issues such as sea wall maintenance, water quality, flood defence, created ecotourism opportunities and waste water management.

*Sources: Natura 2000 web page, <http://www.natura.org>*

### 4.4 Regulation and land use planning

In order to translate an assessment of the value of water and wetland ecosystem services into improved decision making, there has to be an effective governance framework in place. Effective and efficient regulation of activities that impact water and wetlands is, therefore, necessary to halt losses, stimulate restoration, and maintain the integrity of ecosystems and the ecosystem services

they provide to people. This not only includes the basic legal and institutional frameworks for regulatory action, but also a situation where there is respect for the rule of law (i.e. laws are implemented). Corruption can be a major impediment which cannot be overcome simply by improving the evidence base for water ecosystem services through better valuation of the benefits nature provides. This is particularly true for water where built infrastructure involves large capital and operational investment and high opportunities for corruption.

There are three main types of environmental regulatory approaches (TEEB, 2011):

1. Regulation of water discharges that sets standards for emissions, ambient quality and technical practice (e.g. best available techniques), performance (e.g. water quality objectives) or management (e.g. agricultural activities) practices;
2. Regulation of products, which sets restrictions on product use (e.g. activities damaging endangered species) or production standards (e.g. certification, best practice codes);
3. Spatial planning, which regulates land uses and establishes protected areas (e.g. spatial planning frameworks such as IWRM, ICZM and MSP).

Examples of regulation and spatial planning to improve water and wetland management include the control of pollution from waste water treatment plants to protect the quality of surface water for other users, the designation of areas protecting drinking water sources from nitrate contamination, and the design of non-conversion zones in order to safeguard mangroves that provide important benefits or the establishment of protected areas. Further examples can be found earlier in this report (e.g. Box 4.2). Effective regulation and careful spatial planning help control some critical pressures on wetlands, including water availability and quality, which in turn make the ecosystems less vulnerable to external challenges such as climate change, floods and storms.

#### **4.5 Property rights and improving the distribution of costs and benefits**

Institutional arrangements, such as property rights, mediate the linkages between wetland ecosystem services and human societies. These are often based on customary and traditional management practices linked to wetlands, building on their multiple resources and use characteristics.

These rights set up the rules that delimit the range of activities granted to individuals (or groups) over specific (or range of) ecosystem services (and in several cases geographical areas), including, but not limited to; defining access (right to enter a defined physical area and enjoy non-subtractive benefits), withdrawal (right to obtain resource units or products of resource systems), management (right to regulate internal use patterns and transform resource by making improvements), exclusion (right to determine who will have an access right, and how that right may be transferred), and alienation (right to sell or lease exclusion, management or withdrawal rights) (Schlager and Ostrom, 1992).

The complexity of property rights has an influence on the way costs and benefits of ecosystem services are distributed and shared across societies and thereby have an important influence on the way priorities on ecosystem services are generated, managed and trade-offs negotiated.

Furthermore, lack of clearly defined property rights and the degree of fit with ecosystem structure and processes that underpin ecosystem services can accentuate wetland degradation and loss through conflicts, non-cooperative behaviour, and inefficient management.

Including social fairness as an objective of ecosystem management, along with ecological sustainability and economic efficiency, is a key step towards improved sharing of costs and benefits related to policy decisions linked with water and wetlands.

Mapping stakeholders and institutions with ecosystem services and eliciting stakeholder differentiated benefit and cost sharing provides the analytical framework for assessing social fairness dimensions, particularly ecosystem services trade-offs.

Regulations and fiscal measures, such as polluter pays principle and full cost recovery, can make the economic cost of damage to biodiversity and ecosystem services visible to, and felt by, those responsible – thus changing the incentives that influence their actions. Tools such as Payments for Ecosystem Services (see next section) provide mechanisms for incentivizing resource stewardship by rewarding the providers of these services.

Clarifying rights, in particular collective rights to common property, enables building broad-based stakeholder engagement in wetland management and sustained provision of ecosystem services.

Box 4.3 provides an example on the influence of property right on the ecosystem services provided by wetlands.

#### **Box 4.3 Chilika Fisheries, India**

Chilika, a Ramsar Site located on the eastern coast of Odisha State, supports high biodiversity and harbours several endangered and endemic species. The diverse and dynamic assemblage of fish, invertebrate and crustacean species provide the basis for a rich fishery which supports over 0.2 million local fishers and currently generates over 9% of the state's foreign revenue from marine products. With 70% of the fish stock dependent on recruitment of juveniles from the sea, the spawning migration cues created due to the spatio-temporal salinity gradient play a critical role in maintaining fish productivity.

##### *Traditional system of access and benefit sharing*

For generations, Chilika fishers evolved a management system based on a system of resource partitioning wherein access to each fisher group was determined based on the species they specialized in catching. In the late 1950's these were formalized in the form of Primary Fishermen Cooperative Societies (PFCS) as grass-root fishery institutions.

##### *Change in the ecosystem causes change in distribution of benefits*

From 1984-85, prawn culture was introduced to Chilika as a part of a supplementary income programme for low income families. Subsequently, increasing international demand, devaluation of the Indian Rupee, and trade liberalization increased the export potential of Chilika shrimp and prawn. This triggered a massive influx of individuals from farming communities into culture fishery ultimately leading to occupational displacement and loss of fishing grounds of traditional fishers in addition to conflicts with the immigrants. Fisheries' policies for Chilika also gradually tilted in favour of prawn culture. In 1991, lease policy classified Chilika fisheries into "capture and culture" sources as well as provided scope for sub-leasing the fishery sources to non-fishers and fish merchants. Further in 2001, the diverse fishing grounds were classified into prawn and non-prawn sources, invoking severe protest from the traditional fishers.

Meanwhile, Chilika underwent rapid degradation owing to increased sediment loads from the catchments and reduced connectivity with the sea. Fisheries declined substantively from over 8,000 MT reported in 1985/86 to 1,700 MT in 1998-99. The associated decline in ecosystem components and processes led to inclusion of Chilika in the Ramsar Convention's Montreaux Record (a list of Wetlands of International Importance where changes in ecological character have occurred, are occurring, or are likely to occur).

#### *Change in power relations due to introduction of new practices*

Rapid increase in illegal prawn enclosures (*gheries*) played a huge role in changing the power relationships within fishing operations. The *gheries* were mainly operated by the non-fishers who had the ability to invest higher capital resulting in greater power and influence to oversee the operations. These in turn became sources of capital for the traditional fishers, gradually replacing the role of PFCS as capital providers. While the apex institutions were unable to provide any financial assistance to the PFCS for procurement of fisheries equipment or for working capital requirements, the non-fishers used this as an opportunity to create a credit trap for the fishers. The fishers gradually fell into debt and the cooperative fishing gradually became moribund. Aquaculture was finally declared illegal in the wetlands on environmental grounds following the orders of Supreme Court.

#### *Introduction of counter measures in order to protect traditional practices*

The Government of Odisha established The Chilika Development Authority (CDA) in 1992 to undertake programmes and effect policy changes for restoration of the ecosystem and affect livelihood outcomes. A key component of the response strategy was a major hydrological intervention in 2000 by opening a new mouth to the Bay of Bengal thereby restoring the lagoon-sea connectivity. Participatory programmes were implemented for conserving catchments, sustainable fisheries development, capacity building at multiple levels, ecotourism development, and community awareness generation. Restoration of hydrological regimes, in particular salinity gradient, led to a remarkable recovery of ecosystem. Within four years there was a near seven fold increase in fish landings, fourfold increase in average productivity, and 56 new species of fish and shell fish recorded. Annual censuses of Irrawaddy Dolphins reported an increase from 89 to 158 individuals from 2003 – 2010, an increase in habitat use, improved breeding, dispersal, and a decline in mortality rates. This led to resurgence of wetland tourism which had dwindled due to degradation. Chilika was delisted from the Montreaux Record in 2001 and the intervention was recognized with the Ramsar Wetland Conservation Award and Evian Special Prize for 'wetland conservation and management initiatives' (Ramsar, 2008).

#### *Ecosystem restoration increases provision of ecosystem services*

The 680% increase in fish landing valued at US\$ 18.3 million (at 2008 prices) was a considerable gain to the local economy. However, socio-economic surveys done pre and post restoration revealed that the status of Chilika fishers remained dismal. The per capita incomes increased by only 34% while 85% of the fishers continued to be indebted and the amount of debt per household tended to increase by a similar figure. Their access to basic amenities continued to be much below the state averages.

Further research on distribution aspects of the fisheries value chain highlighted the role of coercive chains of credit linked to the power structure of the local economy. Trading of Chilika fisheries takes place through a chain of local, national and international markets. Exports to international markets (primarily of prawns) contributes 22% of the total value. On an average, 38% of the addition to value of the catch takes place beyond the landing centres, in which the fishers do not participate or receive a share. The proportionate share of value increases as the trade chain concentrates towards the higher end. As per the present structure, more than 90% of the total catch of 33,300 fishers is channelized through 500 middlemen and 800 local traders. Due to very limited presence of formal credit institutions and weak asset base, the fishermen are forced to take loans and advances from the middlemen at a higher rate of interest along with a precondition to sell the entire catch at prices determined by the latter which are 10 – 12% lower than the market. At the same time, the purchase from the fishers is through a biased weights and measures system which leads to further reduction in catch value by 15 – 18%. Through this process the fishers lose nearly 30 – 32% of the catch value and end up paying a return in excess of 80-100% per annum on the loan amount (as compared to institutional rates of less than 10%). Spreading this over a comparatively larger population means a comparatively smaller increase in incomes, and thereby inability to beat the vicious credit trap. Merely enhancing ecosystem services without addressing the distributional aspects would continue to create incentives for coercive market structures.

#### *Additional policies and regulations are needed for securing access and benefit for traditional land users*

CDA is responding to the existing inefficiencies in fisheries through design and implementation of a Fisheries Resource Management Plan centred on a co-management strategy with active participation of fishers. An apex



central society for Chilika fishery has been established to rejuvenate PFCSs by providing financial, infrastructural and institutional support management for their catches to enhance financial stability and working efficiency. Credit is being made available to these groups on viable terms, along with extensive capacity building and infrastructural support. Interventions such as provision of ice boxes are assisting the fishers to maintain fish fresh for longer and negotiate a better price. A regulatory regime for fisheries is also being introduced and will set exemplary punishment and disincentives for any form of fishing detrimental to the ecosystem. Finally, the bases of community managed fisheries are being established in Chilika.

*Source: Kuma et al., 2011*

#### **4.6 Using market-based instruments to protect water and wetland ecosystem services**

The behaviour of companies, nations and citizens is strongly influenced by the prices they pay for goods and services. However, the prices of goods and services often do not take account of the economic losses caused by the degradation of water and wetland ecosystems and, therefore, the loss of value from degraded ecosystem services. A range of different market-based instruments (MBIs) can play an important role in integrating the costs associated with such loss of value into decision making and consequently influencing the behaviour of citizens and companies. Examples include taxes and charges, phasing out or reforming environmentally harmful subsidies, quantity based instruments, liability rules, and Payment for Ecosystem Services (TEEB, 2011). Examples of how each of these is used in the context of protecting water and wetland ecosystem services are described below.

##### **Taxes, fees, subsidies and charges**

Taxes, fees, subsidies and charges discourage environmentally harmful activities by increasing their costs compared to other more environmentally friendly alternatives (see Box 4.4 for an example). In theory, environmental taxes are more efficient than regulation because they make agents with lower abatement costs pollute (and pay) less than those with higher costs. In fact, the former will find it more convenient to reduce their environmental impact than to pay the tax, whereas the latter will prefer to continue polluting and paying the tax. As a result, costs to society as a whole are lower. Besides, tax policies encourage economic agents to continuously try to reduce their environmental impact, instead of binding them to a certain standard (Pearce and Turner, 1990). In addition, environmental taxes provide a source of funding that may be used to support environmental-friendly practices.

Furthermore, taxes and charges make the environmental issues an element of a company's profit and loss account and hence increase the likelihood that the finance director and board will become aware of the environmental concern. Even where the price effect is small, there may be an important signalling and awareness effect. Finally, MBIs are also information raising instrument, which can help provide information on the market and develop the evidence base for future initiatives.

##### **Box 4.4 Fees for water pollution discharges in Colombia**

The Ministry of the Environment's Decree 901 (1997) defined a fee on the total suspended solids concentration and on biochemical oxygen demand (the amount of oxygen required to biologically decompose organic matter – used as an indicator of pollution in water bodies) in water. The Ministry calculates the amount of pollutants allowed in each water body, based on the restoration costs. The regional environmental

authorities are responsible for calculating the tax to be paid in each water basin in order to reach the objective set by the Ministry. They are also responsible for levying the tax, based on the reports of polluting companies on the amounts released to water bodies. Every six months the regional environmental authorities monitor the pollution in the water bodies and consequently adjust the tax in order to reach the desired reduction target.

*Source: Kraemer et al. (2003)*

The phasing out of Environmentally Harmful Subsidies (EHS) can also significantly contribute to improving efficient resource use and therefore water quality and quantity, as it no longer rewards and incentivises activities that degrade water and wetland based ecosystem services (see Box 4.5 for an example, and also Lehmann et al., 2011).

#### **Box 4.5 The low price of irrigation water in Spain and Italy**

In Spain and Italy the dry climate means that water is needed for irrigation of many crops, but water resources are scarce in many areas. This is exacerbated by the low water prices for agriculture, which are well below costs and encourage an excessive usage. Both in Italy and Spain the costs related to the construction of infrastructures for irrigation are mostly covered by national and European funds (i.e. by taxpayers), and are not recovered in prices, as neither are the environmental externalities. In addition, in Italy, the water tariff is mostly based on the irrigated area and not on the volumetric usage; therefore farmers are not encouraged to economise their water usage. The irrigation subsidy often encourages the choice of water-intensive crops (often for export) in areas characterised by water scarcity. The total subsidies to irrigated agriculture in the most important Spanish river basins are calculated at about €911 million per year by Calatrava and Garrido (2010). The same authors estimate the recovery rate of capital cost at between 30% and 50%, and the recovery rate for operation and maintenance cost at between 90 and 99%. According to OECD (2010) data, the total cost recovery rate in Italy ranges between 20 and 30% in the South and between 50% and 80% in the North. Similar problems occur in other parts of the world where water prices are low.

*Sources: Massarutto (2003); Calatrava and Garrido (2010); Arcadis et al. (2012); OECD (2010)*

### **Quantity-based instruments**

Quantity-based instruments, such as tradable permit schemes, set a limit on the use of a resource, allocate the use right certificates to the users by auctions or free of charge, and create an artificial market for trading the rights (see Box 4.6 for some examples). There are a number of experiences on the use of water rights trading to enhance the efficiency of water use to protect water bodies and also on the use of water banks. Trading in water rights is also not limited to quantitative use of water, but can also be applied to trading in rights to discharge pollutants.

Water banks are innovative instruments that have been implemented in California, Australia, Chile, Mexico, China, and Spain, among others. They are generally used to deal with droughts in order to use in urban areas part of the water normally employed in agriculture and to compensate the farmers for the economic loss that this implicates. Water banks work as follows: the intermediary, usually a governmental body, purchases the right to use water from owners willing to sell it. Afterwards, it sells the water rights on the market, thereby establishing the rules and the administrative framework. This mechanism automatically assigns water to the users that maximize its profitability, thereby promoting the efficiency of the system.

In the wetland banking, an activity which has detrimental effects on wetlands is counterbalanced by a purchase of wetland credits, which are issued for activities that restore, enhance, create or preserve other wetland areas. Wetland banking can be a means to obtain funds from the private sector targeted at wetland restoration.. Wetland banking is being used in the US, for instance.

#### **Box 4.6 Examples of tradable permit schemes**

##### The salinity credits in the catchment area of Bet Bet, Victoria, Australia

In 2003, the Australian government funded eleven pilot projects to develop market instruments to improve water quality. One was an innovative salinity credit system established in the catchment area of Bet Bet, Victoria (9,600 ha). The salinity of the river in this area that is caused by the reduction in aquifer recharge caused by a reduction in permanent vegetation with deep roots. Salinization threatens agriculture in the area, reducing productivity, damages the infrastructure and has a negative impact on the river ecosystems. The Bet Bet tradable salinity credits were assigned based on an auction, where farmers could offer their commitment to undertake actions to reduce salinity in exchange for a certain payment. The farmers who won the auction could fulfil the obligations and were paid for either reducing salinity in their field or by buying salinity credits from other farmers who had achieved higher reduction than those established in the contract that resulted from the auction.

*Source: Connor et al. (2008)*

##### Water use rights, China

In Zhangye City, Ganzhou District, Gansu Province a water rights tradable permits scheme was launched in 2002. Water use right certificates were distributed to county irrigation districts and subsequently to townships, villages and households. In Minle County, each district distributed certificates to households based on the land area and a water resource deployment scheme, which was checked, ratified and strictly enforced. High-efficiency users were given preference for distribution of use rights and per capita use was determined based on proximity to water resources. The water used for agriculture significantly decreased as a result of the scheme. This enables a more efficient use of water and forms an important tool in the protection of water bodies.

*Source: Forest Trend (2009)*

##### Water quality rights trading in the United States

Trading for water pollution discharges is well established in the United States. The US EPA issued a National Water Quality Trading Policy in January 2003. Such trading is a voluntary option for operators enabling them to meet their permit limits in a more cost effective way. The EPA argues that trading could provide both significant economic and environmental benefits. For example, full implementation of trading has been estimated to be able to save \$1 billion in waste water treatment costs in the Chesapeake Bay alone. To support trading, the EPA has produced a range of support tools, including a handbook and IT support systems for companies and advice to regulators on how to integrate trading with traditional permitting approaches.

*Source: EPA (2009)*

### **Liability-based instruments**

Liability-based instruments assign responsibility for preventing and remediating environmental impacts to those who cause them. Liability rules create an economic incentive to developers/users to incorporate the risk of a potential hazard and the value of remediation into their decisions. They

establish that those who damage the environment beyond a defined limit must pay for restoration or to compensate the loss of ecosystem services, and thereby they provide economic incentives to reduce risk and stimulate technical improvement. An example is the liability regime established in the European Union, which specifically includes damage both to water objectives and biodiversity objectives within the scope of the regime. The law requires, for example, that if a company discharges pollutants causing damage which threatens the legal objectives of EU water policy, it is required to pay for the restoration of various water bodies in the EU. This provides a strong incentive to avoid such damage, thus helping to preserve the ecosystem services from that water body. Similar legislation is in place in a number of other countries across the world.

Box 4.7 shows some examples of liability and compensation.

#### **Box 4.7 Practical examples of liability and compensation**

##### *Oil spills: compensation and legislative response*

The *Exxon Valdez* oil spill (1989), affected 200km of Alaskan coastline, The legal proceedings included a compensation claim for both use and non-use values. Exxon settled its lawsuit with the US Government for US\$1 billion and agreed to spend around US\$2 billion on clean-up; it later settled a class action lawsuit for additional amounts. The disaster also led to the US Oil Pollution Act 1990.

The *Erika* oil spill in 1999 of 10 million litres of oil caused the death of up to 100,000 birds near the French Atlantic coast. Within the EU, this led to the 'Erika I package' (legislation for double-hulled ships and Liability Directive) (Europa, 2007).

The 2010 Deepwater Horizon oil spill in the Gulf of Mexico: The oil company responsible (BP) created a US\$20 billion escrow compensation fund; ceiling increased in July when BP set aside a pre-tax charge of US\$32.2 billion to cover liabilities (BP, 2010).

##### *Damage to coral reefs*

Israel: In the Israeli Red Sea, where coral reefs provide important recreational services, the damage of a 20m<sup>2</sup> area of coral reef would signify a charge of approximately US\$120,000 to the party responsible for the damage (Wielgus et al., 2003; Wielgus, 2004).

#### **Payment for Ecosystem Services**

Payment for Ecosystem Services (PES) can be a useful instrument to finance conservation of water-related ecosystems and wetlands and to involve new stakeholders (e.g. private companies). PES programmes allow for the translation of the ecosystem services that ecosystems provide for free into financial incentives for conservation, targeted at the local actors who own or manage the natural resources. They can be funded by the ecosystem service users or by foundations, NGOs or government agencies, when the ecosystem service user is the society as a whole or a very broad category of stakeholders. REDD+ is an example of an international programme to fund the protection of ecosystem services. PES programmes bring economic benefits to both ecosystem service users (who are subject to a lower cost than that associated with the degradation of the natural resources and the reduction/cessation of the ecosystem services they provide) and ecosystem services providers (who receive compensation for their conservation/restoration activities), besides benefitting the ecosystems and the associated natural resources (Costanza et al., 1997; Wunder, 2005; Fisher et al., 2009; TEEB, 2011, Chapter 5).

The amount of payment in a PES programme can be established through monetary valuation of the remunerated ecosystem services, negotiation among the involved stakeholders, or reverse auctions<sup>22</sup>. In most cases, the price is determined through a negotiation process based on the opportunity costs<sup>23</sup>. The reason for that is that monetary valuation is generally a lengthy and expensive process and reverse auctions involve high transaction costs and uncertainties. The development of PES schemes has been most widely used for the protection of water-based ecosystem services. There is, therefore, significant experience on this type of instrument that may be more widely appropriate for the protection of the water related ecosystem services .

Box 4.8 provides some examples of PES schemes on water-related ecosystems and wetlands (see also the Peru case in Annex I). These examples show the importance of taking a wider catchment-based approach to understanding how water based ecosystem services are threatened in order to develop a PES scheme to target these pressures and so protect the services provided.

#### **Box 4.8 Examples of Payment for Ecosystem Services in watersheds and wetlands**

##### The PES programme in Costa Rica

In Costa Rica, PES helps to protect water related ecosystem services, but also others. The PES scheme remunerates four kinds of forest-related ecosystem services: 1) the storage of CO<sub>2</sub> in forest biomass, 2) the supply of water for human consumption, agriculture and energy production, 3) the conservation of biodiversity, 4) the landscape beauty. The majority of funding comes from fuel taxes, although various international institutions help finance the project. To receive payment, forest owners must submit a plan and carry out sustainable forest management practices of forest conservation, such as firewalls or reforestation plans.

*Sources: Pagiola (2008)*

##### The Payment for Hydrological Environmental Services programme, Mexico

The Programme was established to finance the hydrological ecosystem services provided by forests, and in particular, the protection of watersheds and aquifer recharge. The programme is financed through part of the federal taxes on water, and remunerates forest owners for maintaining the forest cover in areas where forests have a high impact on the water ecosystem services and are subject to high risk of deforestation.

*Sources: Muñoz-Piña et al. (2008)*

##### Pimampiro PES programme, Ecuador

A PES programme is being carried out in Ecuador to protect the water catchment area of the Pimampiro municipality. The programme was designed to protect the water quality and quantity of the river basin Palaurco through the conservation of native forests. The beneficiaries of the payment are 19 farms. The funding is derived from a surcharge of 20% in the water prices paid by the 1,350 families with water metering, plus some funds of the Pimampiro municipality and the interests of a fund made available by the FAO and the Inter-American Foundation.

*Source: Wunder and Alban (2008)*

##### The Vittel PES programme, France

At the end of the 1980's, Vittel, a French mineral water company, initiated a PES programme to preserve the quality of its bottled water, which was threatened by the presence of nitrates and pesticides associated with the intensification of agricultural and livestock rising practices upstream. After approximately ten year of negotiations between the company and the farmers, a package of incentives available to farmers in the area

was established, including: 18 and 30 year-contracts to ensure continuity; the abolition of the debt associated with the purchase of land by farmers; an average of €200 per hectare per year for five years to cover the costs related to the transition to the new, more sustainable agricultural model; a lump sum of up to € 150,000 per farm to meet the initial costs; free work hours to produce organic fertilizer; technical assistance and free introduction to new social and professional networks. The PES was a success: all 27 farms in the area but one adhered and chose 30-year contracts, allowing the protection of 92% of the water catchment area.

*Source: Perrot-Maître (2006)*

#### The SCaMP programme in the UK

United Utilities (UU) Group PLC is the UK's largest water business and provides water and wastewater services to approximately 7 million people in the north west of England. It also owns 57,000 ha of land, much of which is in protected areas. In 2005, UU launched a PES scheme called Sustainable Catchment Management Programme (SCaMP), with the objective of improving the water quality. Between 2005 and 2010, the SCaMP programme covered an area of 20,000 ha and invested £10.6 million in a set of environmental measures to restore drained, burnt and overgrazed moorland and degraded blanket bog, as well as increasing diversity of hay meadow/rush pastures and woodlands. In order to facilitate the engagement of the farmers who leased land within the project area, UU encouraged them to entry in the Higher Level Stewardship (HLS) agri-environment scheme and, since the HLS only covers half of the capital investment costs, to provide part or all of the upfront costs (e.g. building, fencing, gripping). UU also implemented a SCaMPII project in its remaining land (30,000ha), which includes 53 projects and an investment of £11.6 million between 2010 and 2015. The measures included in this second project are similar to the ones of SCaMP and are mainly focussed on water quality improvement.

While aimed at improving water quality, the projects led to important co-benefits, such as improving biodiversity, increasing rates of carbon sequestration, securing greater water retention and maintaining the tenant farmers income. As a result of the catchment management measures, significant improvements were observed in protected areas; 273 ha new native broadleaved woodland was created; 23 ha of degraded upland hay meadow was brought into favourable management; 10 ha of upland heath was restored, and 9.3 km of new native species hedgerows were established. Other positive outcomes were the reduction in sediment reaching the streams due to the re-establishment of vegetation, and the re-colonisation of common cotton grasses and crowberry due to the removal of grazing stocks.

*Sources: Anderson and Ross (2011) and McGrath and Smith (2006)*

#### **4.7 Scope and limits of Market Based Instruments**

Making constructive use of markets by improving the information available to consumers and putting in place MBIs can play an important role in the improvement of water-related ecosystems and wetlands, influence policy-making and favour the involvement of a wide range of stakeholders.

However, the use of market-based instruments (MBIs) is a complement to environmental regulation, and they are only adequate in some specific contexts. For example, water rights trading can only work where illegal water abstraction is prevented by effective regulation.

MBIs allow more flexibility to private actors, who can choose between polluting and paying a tax, buy a tradable right or be subject to liability. Therefore, it may not be advisable to use them to protect high-value water and wetland ecosystems or to achieve site-specific protection goals. In addition, incentive-based approaches are often designed using a trial-and-error procedure, which allows the tax or the amount of tradable permits to be gradually adjusted to reach the desired objective. For this reason, MBIs should not be used where failures can lead to severe and irreversible environmental impacts (Bayon, 2004).

In general, MBIs are effective when the cause of environmental degradation is mainly economic (e.g. the lack of internalisation of environmental externalities), such as is the case for over-abstraction of water for agricultural irrigation or many cases of damage from over-fishing in coastal areas. If the chief obstacles to protecting ecosystem services are other factors of social, institutional, technical, logistic nature (e.g. the lack of knowledge of water ecosystem services or infrastructures such as dams) it is then preferable to use regulations or other environmental policy instruments such as spatial planning or awareness-raising. Also, it should be borne in mind that the ecosystem services concept and the related valuation methods are anthropocentric in nature and do not capture all values provided by ecosystems but only those which benefit humans.

MBIs have also other drawbacks (TEEB, 2011). In general, introducing environmental taxes or charges often generates political opposition and is generally less accepted than setting technical requirements through environmental standards (hence a reward scheme tends to be more acceptable than a punitive charging or taxation scheme). Furthermore, MBIs can be questioned under an ethical point of view, as in some way they give the “right to pollute” to those who can afford to pay. They, therefore, need to be constructed in a way that provides genuine incentives to deliver protection of water and wetland ecosystem services.

In some cases, monetary valuation and MBIs can even undermine the use of other kinds of languages and values (e.g. those related to ethics, culture, human rights), and evidence has been found on the fact that under some circumstances a monetary incentive can “crowd-out” moral, intrinsic motivations for environmental protection (Martinez-Alier, 2002; Kosoy and Corbera, 2010; Clements et al., 2010). For a discussion on the scope and limits of monetary valuation see also Section 3.3 and TEEB (2010).

To conclude, decision makers require arguments to support the protection of water and wetlands. In some cases, a simple argument based on a general recognised importance of water may be sufficient. In other cases, different valuation tools may be needed. Here we have focused on the approaches based on monetary valuation, but other approaches may be relevant in different circumstances. MBIs is one of the possible means to enable the values of water and wetland ecosystem services to be recognised, and should complement other alternative approaches, such as planning and regulation. In any case, it is important to note that if the values of water and wetland ecosystem services are not conveyed in terms understandable and acceptable to those who make decisions, there is a serious risk that these services will be degraded or lost.

## 5 TRANSFORMING OUR MANAGEMENT APPROACH TO WATER AND WETLANDS

### KEY MESSAGES

- *Management of water and wetlands should focus on the full suite of benefits and not on only a single issue - whether biodiversity or a single ecosystem service. Furthermore, favouring the link between local communities to wetlands can give an important contribution to conservation and restoration by ensuring local acceptance of, and engagement with, change.*
- *We need to avoid further loss of wetlands in order to ensure that the wide range of ecosystem services continues to be delivered - whether food and clean water to local communities or carbon storage for global benefits.*
- *We also need to maintain and enhance the connectivity of water and wetland ecosystems, recognising that ecosystem services of highly connected systems is greater than those that have become fragmented*
- *Many wetlands that have already been degraded could merit restoration as the increase in the value of ecosystem service can outweigh the restoration costs. The actual level of benefit is site-specific.*
- *Improving the state of water and wetlands can have a positive effect on poverty alleviation by ensuring food, water and energy security. By addressing several policy objectives, it creates a more robust foundation for management action to protect and enhance water and wetland ecosystem services. It can help with meeting the MDGs and also the Rio+20 endorsements that access to water is a human right and a core element, not only of local and regional development, but also of international development cooperation.*
- *The engagement of traditional knowledge and practices can lead to effective restoration and wise use of wetlands.*
- *It is important to carefully manage the transition process towards an improved protection of water-related ecosystem services and wetlands, by understanding the winner and losers and, if appropriate, compensating those whose interests are more severely affected.*
- *Awareness-raising and education are also crucial for the transition. They can help water and wetland protection and improvement since both increase acceptance and participation. This is critical for transition management and stakeholder buy in.*
- *The above steps will help put water at the heart of the transition to a sustainable economy and recognise the critical role of wetlands and water related ecosystems in the water cycle. There will be a need for action at all levels and across stakeholders if the opportunities of working with nature are to be realised and the risks of losses appreciated and acted upon.*

### 5.1 Introduction

As discussed in Chapter 4, many different management instruments can be used to protect and improve the state of water and wetlands. Some instruments are already widely used (e.g. regulation and spatial planning), whereas others are receiving increasingly attention as efficient ways of promoting wetland conservation through the involvement of new stakeholder categories (notably, the Market Based Instruments).

These instruments are crucial to building a new management approach aimed at enhancing conservation and restoration of wetlands. This new approach should look for synergies with projects aimed at enhancing livelihoods and alleviating poverty, such as for example sustainable tourism, and should take into account traditional practices and local knowledge. A good transition management



(e.g. favouring the creation of employment opportunities for those who may lose their job because of conservation/restoration policies) will be key to gaining a wider acceptance and participation of different stakeholder groups.

Awareness-raising and education on the value of wetlands will play a crucial role in the conservation and restoration of wetlands. In fact, there are still negative cultural beliefs related to wetlands, which see them as useless and dangerous wastelands and fail to see the numerous benefits they provide to humanity.

This last chapter will look in turn at different key elements which can constitute a change in our management approach to wetlands and water-related ecosystems.

## **5.2 Avoiding loss and conversion**

As explained in Section 2.3, many water-related ecosystems and wetlands are at risk, and further losses will often require measures associated with high costs to replace at least part of the ecosystem service lost, when it is possible (TEEB, 2011; TEEB, 2012b). In fact, in some cases restoration can be very expensive, indeed beyond budgets and affordability.

Costs, restoration potential and timescale are very ecosystem and site specific, but Table 5.1 gives some figures on the restoration costs for different kinds of ecosystems (more details can be found in TEEB, 2011, Chapter 9, Annex 1). Restoration of coral reefs is the most expensive example among the ones covered by Table 5.1 (up to 11,000,000 €/ha in a restoration project in South-east Asia), and it is followed by restoration of coastal systems, mangroves and estuaries (325,000 €/ha in the Bolsa Chica estuary, California). Other restoration activities may be much cheaper, e.g. a restoration of freshwater wetlands in Denmark through hydrological manipulation (8,375€/ha) and a project involving mangrove replantation in Thailand (between 8,800 and 9,300 €/ha).

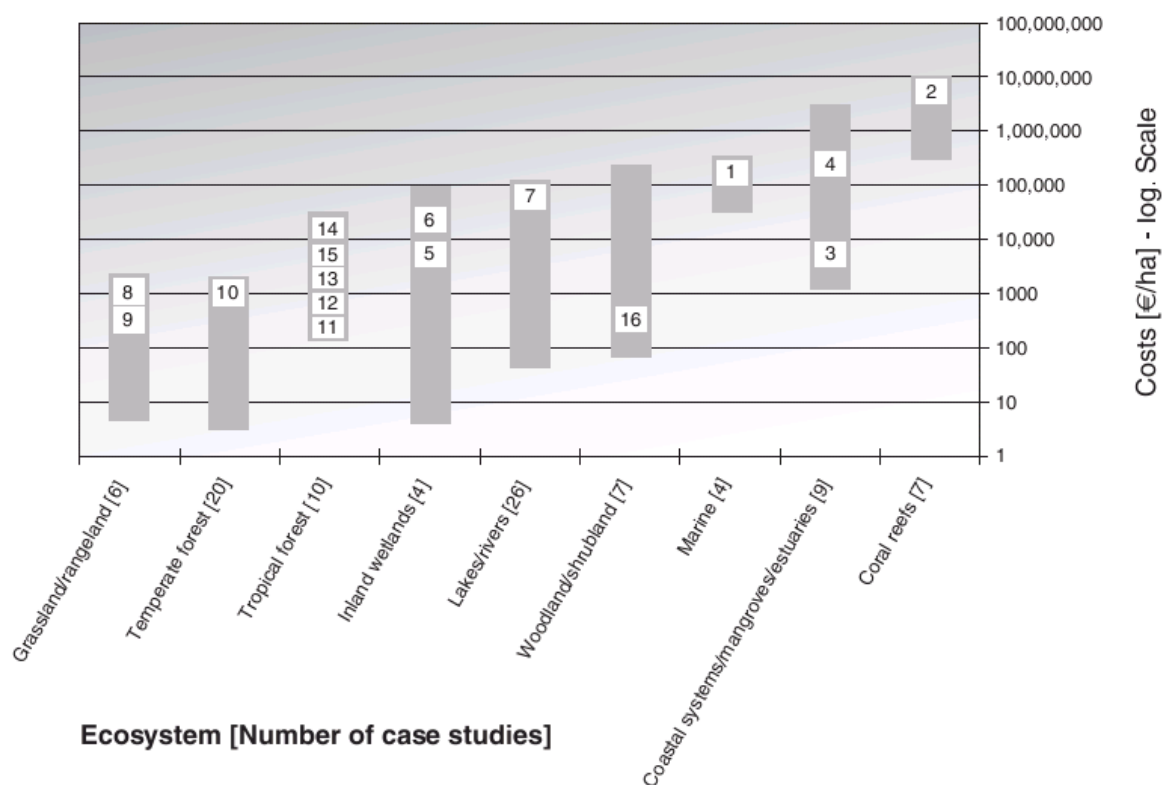
Also, restoration can take a long time. Mudflats can be restored quickly (1 to 10 years) and saltmarshes and reed beds can be restored within 10 years in certain circumstances, but 100 in others. Grey dunes and dune slacks that offer coastal protection and offer water purification benefits are estimated between 100 and 500 years, and blanket, raised bogs that are important for carbon sequestration can take millennia to restore (Barnam and Morris, 2007). In other cases, the loss of ecosystem services can be irreversible.

Prioritisation of activities is necessary to ensure efficiency and effectiveness of conservation and management policies. This can be done through integrated assessment and management, as well as spatial planning (see Chapter 4).

## **5.3 Restoration**

There remains an important economic argument (inter alia) for subsequently restoring or rehabilitating the degraded ecosystems where a precautionary approach is not adopted or successful and degradation has occurred. In fact, their restoration and the associated improvement in ecosystem service flows can often provide new or improved benefits to people. These benefits include climate change mitigation and adaptation, protection from extreme events, water, energy and food security and livelihood for local communities. Restoration also helps achieve biodiversity targets for highly depleted ecosystem types and threatened species.

**Figure 5.1 Summary of restoration cost estimates**



*Note:* Bars represent the range of observed costs in a set of 96 studies reviewed for this study. The numbers refer to specific studies identified and listed below as illustrative examples of the studies in which cost data have been reported in sufficient detail to allow analysis and comparison. For further details, see Annex 1.

*Sources:* Aronson et al (2010) and additional studies: (1) Eelgrass restoration in harbour (Leschen et al, 2007); (2) Restoration of coral reefs in South-east Asia (Fox et al, 2005); (3) Restoration of mangroves, Port Everglades, US (Lewis Environmental Services, 2007); (4) Restoration of the Bolsa Chica Estuary, California, US (Francher, 2008); (5) Restoration of freshwater wetlands in Denmark (Hoffmann and Baattrup-Pedersen, 2007); (6) Control of phosphorus loads in stormwater treatment wetlands (Juston and DeBusk, 2006); (7) Restoration of the Skjem River, Denmark (Skovognatur, 2007); (8) Re-establishment of eucalyptus plantation, Australia (Dorough and Moxham, 2005); (9) Restoring land for bumblebees, UK (Pywell et al, 2006); (10) Restoration in Coastal British Columbia Riparian Forest, Canada (GRN, 2007); (11) Masoala Corridors Restoration, Masoala National Park, Madagascar (Holloway et al, 2009); (12) Restoration of Rainforest Corridors, Madagascar (Holloway and Tingle, 2009); (13) Polylepis forest restoration, tropical Andes, Peru (Jameson and Ramsey, 2007); (14) Restoration of old-fields, NSW, Australia (Neilan et al, 2006); (15) Restoration of Atlantic Forest, Brazil (Instituto Terra, 2007); (16) Working for Water, South Africa (Turpie et al, 2008).

*Source:* TEEB (2011, Chapter 9)

Restoration can be very expensive, but many experiences across the globe suggest that restoration and rehabilitation of degraded ecosystems can bring considerable benefits to people and often provide ecosystem services at a lower cost than alternative man-made infrastructures (see Box 2.5).

Depending on the extent of the degradation suffered by wetlands, restoration can be achieved through “passive restoration” (strategies to allow ecosystems to regenerate themselves by eliminating key threatening processes) or, when spontaneous self-regeneration is not possible, active interventions (TEEB, 2011, Chapter 9). Examples of active interventions are tree planting and rewetting drained peatlands and coastal wetlands by reducing water losses (e.g. through blocking drains and reducing groundwater extraction). In many cases, restoring a site will not lead to the same level of biodiversity and ecosystem service flows, because the ecosystem degradation has entailed that one or more thresholds of irreversibility (e.g. species extinction) has been passed. In these cases, rehabilitation can be carried out, in order to restore/rehabilitate at least some

ecosystem processes and allow the provision of certain ecosystem services.

Restoration often, in cases where severe degradation has already taken place, provides a suite of economically and socially essential ecosystem services, such as water treatment and soil stabilisation. Restoration therefore also contributes massively towards avoided loss or at least it slows the process of loss down. Restoration has the added advantage that it is much easier to demonstrate and showcase and educate people by comparing a baseline service delivery before restoration and after.

Box 5.1 provides some examples of wetlands restoration and the benefits they provided to people.

#### **Box 5.1 Examples of wetland restoration projects and their benefits**

##### Peatland restoration in Mecklenburg-Western Pomerania, Germany

In Germany over 930,000 ha of peatlands were drained to allow for agricultural production. In the Mecklenburg-Western Pomerania state (in north-Eastern Germany), 97% of the 300,000 ha of peatland was drained. As a consequence the carbon stored in the peat was degraded leading to carbon emissions. In the last two decades, cattle raising decreased in this area, reducing the need for grazing areas and fodder production, reducing the agricultural opportunity costs. In addition, an increased need for water storage was foreseen in view of the future effects of climate change in the area. For these reasons and for the high costs of maintaining drainage infrastructure and equipment, the Ministry of Agriculture, the Environment and Consumer protection of the Mecklenburg-Western Pomerania (MLUV MV) state prepared in 2000 a peatland restoration strategy, which was mainly financed by the state and the EU.

Between 2000 and 2008 an area of 29,764 ha (equivalent to about 10% of the area of drained peatlands in MLUV MV), has been restored. This means that emissions of about 300,000 tCO<sub>2</sub>-equivalents every year are avoided (with an average of 10.4 tCO<sub>2</sub>-equivalents per hectare) (Schäfer, 2009). When assuming a marginal cost of damage caused by carbon emissions of 70€ per tCO<sub>2</sub> (Federal Environment Agency, 2007), the effort to restore peatlands avoids damage from carbon emissions of up to 21.7 million € every year, on average 728 € per hectare of restored peatlands.

Based on this the idea of the so-called “MoorFutures” were born ([www.moorfutures.de](http://www.moorfutures.de)): companies and individuals can invest in peatland restoration for offsetting their carbon emissions. Already restored peatlands have also shown to generate additional benefits for biodiversity, providing habitat for native animal and plant species. For example sea-eagles and ospreys can be observed all year round, while hundreds of migrating cranes use the sites as a stopover on their north-south migration. This increases also the attractiveness of the region as a destination for nature tourism.

Furthermore, restored peatlands also allow generating income through extensive grazing, production of reed or sphagnum mosses (to be used respectively as substrate in horticulture and as building material/biofuels) and the growth of alder forests (whose timber can be used to produce high quality furniture). These so-called “paludicultures” allow for the production of commodities while maintaining the multiple functions and services of peatlands. This can further reduce opportunity costs making peatland restoration a potential win-win option for climate change mitigation, land use and biodiversity conservation.

*Sources: Förster (2010); MLUV MV (2009); Schäfer (2009)*

##### Peatland restoration in Bellacorick, Ireland

The industrial cutaway peatland at Bellacorick was restored in 2009, by blocking drains, creating peat ridges to contain the water and landscape the peatland surface. The project led to a higher water table level and the extensive recolonisation of the former bare peat substrate by vascular and moss vegetation. The restoration project allowed re-establishing the carbon sink function of natural peatlands. It was estimated that the benefits in terms of carbon restoration were worth on average €1,506 per ha for the avoided carbon loss (75

tCO<sub>2</sub> eq per ha; adopting a carbon price of €20t CO<sub>2</sub>-eq) and €118 per hectare per year for the average net carbon sequestration (5.9 tCO<sub>2</sub> eq per ha per year).

*Source: Wilson et al. (2012)*

#### River Napa's restoration, USA

The Napa Valley has suffered major repetitive losses due to frequent flooding in populated areas with the last major flood occurring in 1986, forcing the evacuation of 5000 residents, causing the loss of three lives, and damage of US\$100 million (1986 dollars). The present value of damageable property within the floodplain is well over US\$ 1 billion. In order to avoid and mitigate floods in the Napa River Basin, a US\$ 400 million project was initiated in 2000, with the objective of increasing the capacity of the wetlands adjacent to the river to handle flood waters, while maintaining and restoring its original shape and alignment. Local stakeholders including residents, researchers, business owners, representatives from the state and civil society, came up with a new plan called the "Living River Guidelines." Existing floodwalls and levees were replaced with terraced marshes, wider wetlands barriers, and restored riparian zones. Also, the river was restored closer to its original shape, allowing it to meander as much as possible. Over 700 acres around the Napa city were converted to marshes, wetlands and mudflats. 50% of project costs were financed locally through a 1% yearly sales tax increase for 20 years, and the other 50% by federal sources, grants and loans from the state. The project reduced the risk of floods, increased the property value and tourism, and improved the water quality and wildlife habitats. Extensive private investment in property development totalling US \$400 million has been sparked since the approval of the flood project. Flood insurance rates will either be lowered or eliminated when the regulatory flood maps are changed through the Federal Emergency Management Agency (FEMA). Roughly 3,000 properties will have their flood insurance rates lowered at the end of the project.

*Source: Almack (2010)*

#### Mangrove restoration in Senegal

45.000 ha of mangroves in the estuaries of Casamance and Sine Saloum, out of 185,000ha, have been lost since the 1970s due to droughts, reduced freshwater flows caused by upstream agricultural activities, deforestation for obtaining firewood and timber for construction activities, and infrastructures like dams and roads. Mangrove degradation caused a sharp reduction in fish stock and also an increase in water salinity, which in turn hinders the growth of paddy rice.

In 2008, a Senegalese NGO named Oceanium replanted 163 ha of mangroves. In the following years, it obtained financial support from the company Danone, which allowed it to cover with mangroves 1,700 ha in 2009 and 4.900 ha both in 2010 and in 2011. The project led to an increase in fishery resources and wood. It was also registered under the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC).

*Source: <http://www.livelihoods.eu/livelihoods-fund.html>*

## **5.4 Traditional practices and local knowledge**

Traditional practices and local knowledge can play an important role in the wise use of wetlands, and need to be taken into account in wetland management. Recognising and strengthening the link of local communities to wetlands can contribute to conservation by involving a wide range of stakeholders. Also, local and traditional knowledge should be considered key in managing wetland ecosystem services. In many cases, traditionally evolved techniques of ecosystem management are better tailored to local conditions than general management approaches. Moreover, involvement of local communities is a key factor for successful policy change and its acceptance.

The integration of traditional water and related resource management practices can often increase the cost-effectiveness of restoration projects by, for example, reducing the need for outside

expertise, tools and technologies or increasing community involvement due to the accrual of valuable co-benefits.

Box 5.2 shows one of the 33 examples presented in a recently published book on the relationship between culture and wetland protection in Japan (Tsujii and Sasagawa, 2012) and one of the case studies analysed in a report on the cultural values in the Mediterranean (Papayannis and Pritchard, 2011).

#### **Box 5.2 Examples of the relation between traditional knowledge and wetland protection**

##### Pond dredging and clean-up, Sakata, Niigata City, Japan

*Katabushin* is a traditional form of lagoon management, which consists of dredging the lagoon to remove debris, which is then used to fertilise surrounding rice paddies, together with reed cutting and rubbish collection on the banks. The Sakata lake ecosystems were degraded since the 1960s, and threatened with succession and eutrophication after the *Katabushin* practice was ceased. *Katabushin* was revived in 2002, after interviewing elders who remembered the state of the lake before degradation. The Sakata conservation group organises every year a *Katabushin* event, which attracts between 200 and 300 participants and is crucial for the conservation and restoration of Sakata. The event plays a key role in preserving Sakata's culture by allowing participants to sample lotus and water chestnut dishes. Also, lessons on dry lotus blossom arrangement are organised during the event.

*Source: Tsujii and Sasagawa (2012)*

##### Prespa Lakes, Greece, Albania and the FYR of Macedonia

Micro and Macro Prespa Lakes are among the oldest lakes in Europe. They are very rich in biodiversity and host many endemic species. In the past, many traditional activities were linked to the conservation of wet meadows. Until the 1980s, cattle grazing maintained the diverse and short vegetation of the wet meadows, allowing the presence of rare bird species such as pelicans and the then rare cormorants. Reeds were used as a building and insulation material, as a resource for making household objects and as animal feed. Buffalo grazing controlled the spread of the reed beds and allowed the presence of wet meadows. Wet meadows play an important role in the ecosystems of the lake (they are used as spawning grounds by some fish species and as feeding and nesting areas for water birds, and support a large number of invertebrate, amphibians, reptiles and mammals). A programme is now being carried out by the Society for the Protection of Prespa (SPP) for the integrated management of water resources in the two Prespa lakes, which will aim to reconnect with traditional practices; one of the main activities of the program is the re-introduction of the traditional management of reed beds through grazing by buffaloes.

*Source: Papayannis and Pritchard (2011)*

## **5.5 Sustainable tourism**

Sustainable tourism can contribute to transition management, since it is a way of supporting local livelihoods and local cultures, while generating incentives for the conservation and management of natural resources. In addition, sustainable tourism in wetlands can help providing means for conservation and improvement of ecosystem services. In many cases, it also facilitates the acceptance and enforcement of environmental regulation by local population and businesses and can be combined with communication and education activities, targeted both to local communities and tourists. Not only, According to the UNWTO definition, sustainable tourism should “make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity” (Ramsar and UNWTO, 2012). Key elements of sustainable tourism are appropriate planning,

regulating and monitoring of tourist activities, as well as the involvement of local communities e.g. through training activities and credit schemes to set up small tourism businesses.

It is important to be aware of the fact that tourism in wetlands depends on the water-related ecosystem services delivered by healthy wetlands (e.g. freshwater, flood protection), and also on other ecosystem services (e.g. beautiful landscapes), and therefore constitutes an additional motivation for restoration and conservation

Box 5.3 presents some examples of sustainable tourism management that brings benefits to local communities.

### **Box 5.3 Examples of sustainable tourism**

#### Tubbataha Reefs Natural Marine Park, Philippines

The Tubbataha Reefs Natural Marine Park was created in 1988 for banning fisheries, as destructive fishing was increasingly threatening the function of the reef as a nursery ground for the Sulu Sea. Intact reefs are also attractive for dive tourists providing an important source of income. However, the ban alone was insufficient to solve the problem. Interests were divided between those pushing for a fishing ban within the park and the fishers claiming their rights to extract resources in the park. Externally imposed park rules were not respected.

In 1999 a workshop was held involving all interest groups – preservationists as well as fishers. Fishers were not convinced of the benefits of a no-take zone and information on this could not be provided in the short term. However, a willingness-to-pay study among tourists visiting the area opened up options for better balancing the costs and benefits of conservation between the stakeholders in a way that all stakeholders were willing to accept the no-take policy, even without proofs of the medium-term benefits to fisheries. Tourists are asked to pay a conservation fee, which is used for managing the protected area, compensate fishermen and fund livelihood initiatives in communities in the region. Also, there are regulations controlling scuba diving to protect the reefs from potential damage from tourism. As a result the no-take zone was respected and fish biomass increased both within the park and outside park boundaries (spillover effect) benefiting local fisheries.

After a decade of difficulties, this marine protected area was swiftly and successfully implemented. Critical for this was the well-facilitated involvement of all stakeholders, the identification of significant income potential from visitors, and a short term re-distribution of funds which could provide sufficient incentive for local fishermen to accept the no-take zone, so that the future benefits of this measure could become tangible.

#### Ibera marshes, Argentina

In the Ibera Marshes in Argentina, conservation-based tourism activities have revived the economy of Colonia Carlos Pellegrini, near the Ramsar Site “Lagunas y Esteros del Iberá”, creating new jobs and allowing local inhabitants stay employed in the town rather than migrate to cities to look for work. Around 90% of the population now work in the tourism sector. In order to favour local employment, the site managers provide local rangers and guides with training on working with guiding tourists. In addition, local communities receive support to establish municipal nature trails.

#### Lake Ichkeul, Tunisia

Two droughts in 1992 and 2002 and the large volume of water abstraction for agriculture led to a decline in Lake Ichkeul’s ecosystems (e.g. 75% reduction of waterbirds) and to a consequent reduction in the interest of tourists in the lake. Water management practices allowed the restoration of the lake, resulting in the doubling of the number of tourists since 2005. The promotion of the lake as a tourist destination helped raise awareness on the value of the lake ecosystems and the importance of the wise use of wetland. It also generated new sources of income for the Park management and conservation and allowed establishment of basic training and credit schemes to increase the involvement of local communities in tourism activities.

### Lake Nakuru, Kenya

Lake Nakuru receives every year around 149,500 international and 95,500 domestic visitors, who are charged an entrance fee of US\$ 80 and US\$ 11 respectively. The income from the entrance fees and concession fees from the lodges contribute to paying for the costs of park management. Overall, around 70% of Kenya's international tourism is targeted to the country wildlife, and therefore biodiversity conservation is not only an environmental objective but it is also crucial for the country's economy. Awareness on the importance of nature is promoted with large-scale environmental education programme, involving about 100,000 school students each year and with inexpensive wildlife viewing tours that the National Park runs for residents.

*Source: Ramsar and UNWTO (2012)*

### Maldives: Tourism more valuable than fisheries

The Atoll Ecosystem Conservation project, implemented by the Maldivian Ministry of Housing, Transport and Environment, supported by the GEF and UNDP, carried out a study to calculate the monetary value of coastal and marine diversity, and focussed on the two main economic sectors: fishery and tourism. The direct benefits from the two sectors were evaluated using the market price method. The tourism sector employs 64,000 people or 58% of the workforce. Taking into account both direct and indirect production, consumption and earnings, the current upstream contribution of tourism to GDP is estimated to be US\$ 764 million (Rf 9,741 million) or 67% of GDP. Official records show that the fisheries sector contributes Rf 855 million, or 8.5% of GDP (Emerton et al. 2009). There are also direct benefits from biodiversity: already in 1993 it was estimated that a single Grey Reef Shark is worth US\$ 3,300 a year to the Maldivian tourism industry, compared with the one-off value of US\$32 that a fisherman would get from the same shark (Anderson and Ahmed 1993). As a consequence, the Government of the Maldives banned the fishing of sharks in 2010.

Sources: Phan and Meerer (2009), Emerton et al. (2009), Anderson and Ahmed (1993)

## **5.6 Synergies between wetland restoration/conservation and poverty alleviation**

Improving and restoring wetlands can be a cost-effective way of meeting a range of policy, business, and private objectives. This includes not only water security, but also food and energy security, since water plays a key role in agriculture and energy production (see Chapter 2). Moreover, wetlands have a central role in climate change adaptation and their sustainable management in many cases is able to improve their resilience to climate change by mitigating its effects, which are delivered through hydrological change (e.g. increased storms, droughts and floods), thereby protecting human well-being and the economy. Finally, well-preserved wetlands contribute to social cohesion and economic stability by ensuring livelihood for local communities and also preserving cultural identity. For all these reasons, ensuring healthy and well-preserved wetlands is crucial to alleviate poverty and meet the UN Millennium Development Goals for 2015 (WWAP, 2012). They are also expected to be instrumental in contributing to meeting the Sustainable Development Goals that will be set by 2015.

The importance of water for sustainable development, and the key role played by ecosystems in maintaining water quantity and quality were recognised at the Rio+20 Conference held in June 2012 (see paragraphs 119 to 124 of the outcome document "The Future We Want"<sup>24</sup>; also see Box 2.1). During the Rio+20 conference, the need for developing integrated water resource management and water efficiency plans was stressed, as well as the commitment to ensure safe drinking water and sanitation to an increasing portion of world population.

Reallocating investments to protect water ecosystem services, natural water infrastructures, including wetlands, will be crucial in fulfilling these objectives. For example, water sanitation can be improved through wetland restoration. Access to clean freshwater can be ensured by healthy

wetlands like rivers and lakes. Investments in water and wetland management will provide long-term economic benefits, reduce overall costs, and may be cheaper than the alternative technological solutions (see Box 2.5 for some examples). Also, restored wetlands can provide livelihood for local communities (e.g. by supporting viable fish populations or attracting tourists). Box 5.4 shows some examples of poverty alleviation associated to wetland restoration projects.

#### **Box 5.4 Synergies between ecosystem restoration and poverty alleviation**

##### The Volta River Basin, Ghana and Burkina Faso

The Volta River Basin's area (400,000 km<sup>2</sup>) includes six countries, but 85% is located in Burkina Faso and Ghana. During the last decades, extensive exploitation of natural resources in the area, due to population increase and poverty, led to water scarcity, land degradation and siltation of river channels. In order to simultaneously address both environmental and poverty issues in the basin, the IUCN Water and Nature Initiative (WANI), launched the project "Improving Water Governance in the Volta River Basin", in partnership with national partners. The project consisted of 1) the establishment of participatory and multi-scale (local, national, transboundary and regional) governance frameworks for joint management of water resources; 2) livelihood pilot projects in order to demonstrate the positive effects in terms of poverty alleviation of integrated water resource management (rehabilitation of a small dam, digging of 3 wells, plantation of 27,000 tree seedlings and 6,500 fruit seedlings, provision of 19 water pumps and more than 40 sheep or goats); 3) collection of data to inform decision-making, including socio-economic surveys and a water audit. The project included awareness raising activities and financial, management and technical training targeted to local population.

*Sources: Welling et al. (2012)*

### **5.7 Transition management**

Some types of wetlands have a negative image in the eye of the general public. For example, swamps, marshes and bogs are often seen as insalubrious places, which favour the spread of illnesses like malaria. Furthermore, protection and restoration of wetlands can not only bring (direct or indirect) economic benefits to many people, but they can simultaneously negatively impact other stakeholders (e.g. restoring coastal mangroves for storm protection can impact the livelihood of shrimp farmers). In fact, as mentioned before (see section 4.2), in many cases a trade-off is found between the conservation or improvement of supporting and regulating ecosystem services (e.g. flood protection, sediment transport and water purification) and the delivery of provisioning ecosystem services (e.g. agricultural products and timber). The resulting loss in employment opportunities may cause opposition of local population against sustainable wetland management.

For this reason, a careful management of the transition process towards an improved protection of water-related ecosystem services and wetlands is crucial, not only from an ethical point of view but also for the wide acceptance of the needed reforms. Disseminating knowledge on the benefits that wetlands provide to local communities can help counterbalance the negative vision on wetlands some stakeholders may have. In addition, it helps build a balanced view on the trade-offs involved with wetland management, thereby increasing acceptance and participation in the required transition policies and actions. Ensuring an equitable sharing of the benefits may imply compensating those whose benefits are eroded as a consequence of the enhancement of other ecosystem services.



For a successful transition management, it is important that the process of changing decision making and the proposed instruments and strategies are addressing the needs of all relevant stakeholders, while also integrating the opportunities and challenges that are characteristic for the given ecosystems.

In the case of the Tubbataha Reefs Natural Marine Park (see Box 5.3 and Annex 1) simply establishing a no-take zone did not solve the problem of reef degradation as fishermen continued entering the area applying unsustainable fishing methods. Only when a compensation payment to fishermen generated through a fee on dive tourism was introduced, fishermen could agree on respecting the no-take zone. As a result, fish populations within the park regenerated leading to a “spillover effect” to the areas outside the park which in turn increased the catch of fishermen beyond what they caught earlier without the no-take zone. The compensation payment allowed fishermen to receive immediate benefits from a no-take zone and helped to overcome the time lag in the recovery of the reef ecosystem.

The example of Kala Oya in Sri Lanka (Box 3.9) illustrates how the re-introduction of traditional practices for water management can help local communities to realise multiple benefits from ecosystem services provided by the traditional man-made water tank system and inform restoration strategies. In a stakeholder process costs and benefits of different management options for water tanks with regards to ecosystem services were assessed. It was found that rice cultivation is only one benefit besides many others including water provisioning for domestic use and livestock, fisheries and harvest of lotus flowers. Although manual removal of silt was the most labour and therefore cost intensive option for rehabilitating the tank system, local communities opted for this strategy as they could apply it themselves having better control over their resource supply.

In the case of the restoration of the Napa River (see Box 5.1), not only the extreme flood events mobilised decision makers to restore the river bed but local stakeholders including residents, researchers, business owners, and representatives from the state and civil society, came up with a new plan called the “Living River Guidelines.” They were important change agents for proposing strategies that created multiple benefits for the local community including reduced potential flood damages, improved water quality and habitats, and creating higher recreational values. Eventually also insurance rates are expected to decline due to lower flood risks.

Box 5.5 provides some further case examples for a successful transition management.

#### **Box 5.5 Example of transition management initiatives**

##### Water Funds in Latin-American

The Northern Andes region faces three critical problems: 1) natural ecosystems, mainly páramo and mountain forests – the key hydrologic regulators of the region – are threatened by conversion to crop and ranch land; 2) ranchers and farmers depend on the land for their livelihoods making it unjust, inequitable, and unsustainable to stop their land usage; and 3) growing population and demand for water. Coupled with unpredictable impacts of climate change, there is a threat to the long term availability of natural resources in the region.

Preventing access to the natural ecosystems would unjustly harm the farmers’ livelihoods. However, allowing continued conversion increases the likelihood of ecosystem degradation and threatens access to water services, such as clean drinking water for these same people, as well as downstream users and beneficiaries such as cities, water utilities, agricultural and beverage industries.

Water funds aim at solving this conflict by establishing long-term trust funds that involve a public-private partnership of water users who determine how to invest financial resources in activities for maintaining or

enhancing water services in priority areas.

The Nature Conservancy (TNC) developed a step-by-step methodology for how to create a water fund. The general components include:

- 1) Assess the ecosystem service mechanism: identify the ecosystems and people that are water service “suppliers” and those that are “users” using already existing data available whenever possible;
- 2) Develop sustainable financial mechanisms with transparent management. Finance can come from public agencies (e.g. water utilities, hydropower companies), private companies (e.g. beverage companies, agriculture associations), citizens (e.g. in cities paying fees, taxes, for water use), grants and private foundations, bilateral and multilateral donor agencies and cooperators and the financial returns generated from the trust fund.
- 3) Establish a multi-stakeholder institutional mechanism including public and private partnerships. The multi-institutional governing body which includes representatives of all stakeholders makes decisions about how to spend money in the watershed prioritizes investment based on feasibility studies and the advice from a technical committee.
- 4) Implement concrete actions to generate services and conservation benefits, e. g. securing protection of natural ecosystems; and implementing best management practices on productive systems to provide ecosystem services.
- 5) Establish an accountability system to ensure delivery of services and protection of natural ecosystems including indicators that allow measuring the impact of the action on the ecosystems, the services they provide and on the livelihoods of people.

While clearly replicable in Colombia and Ecuador, where most of the 13 current water funds are either operational or under development, there are challenges to replicating them globally. Creating a water fund requires time, leadership, particular biophysical and social conditions, and a “fit” with national and regional laws. Developing feasibility studies, identifying good regions for the water fund approach, engaging stakeholders, selling the model, and establishing relationships involve large upfront costs. Effective replication in new regions requires people to undertake these tasks and charismatic leadership to engage new stakeholders.

*Source: Calvache et al. (2012); Goldman et al. (2010a); Goldman et al. (2010b)*

#### The Quito Water Conservation Fund

About 80% of the water for the nearly two million inhabitants of the city of Quito, Ecuador, comes from three protected areas. A variety of activities threaten the availability of this regular clean water supply mainly due to land conversion for farming in the watershed.

The Quito Water Conservation Fund (Fondo para la Conservación del Agua – FONAG) was created with an initial investment of US\$ 1,000 from The Nature Conservancy (TNC) and US\$ 20,000 from the Quito water company. Other water users have since joined the water fund, such as the Quito electric company and private organizations including a beer company (Cervecería Nacional), a water bottling company (Tesalia Springs Co.) and a Swiss Cooperation (COSUDE). The endowment reached US\$ 5.4 million at the end of December 2008 and is now almost US\$ 8 million. In 2008 alone, the endowment yielded US\$ 800,000 which FONAG invested in conservation projects. After a 7-year process a municipal by-law was passed by which the Quito water company will provide 2% of their revenue to the water fund (up from the initial 1% commitment).

FONAG uses the revenue from the water fund to finance various programs and projects including control and monitoring of protected areas, restoration of natural vegetation, environmental education and outreach, training in watershed management, productive projects with local communities and a hydrological monitoring program. One of the main beneficiaries of the activities is the local communities that live close to the water

sources.

Showing results has been crucial for maintaining support. According to Arias et al. (2010), during 10 years FONAG has:

- Helped conserve the watersheds that provide 80% of the water upon which the citizens of Quito, a population of 1.8 million, depend;
- Involved 500,000 ha land;
- Involved 30,500 children in Environmental Education Programs;
- Re-vegetated and maintained ~600 hectares of land/year for the past 4 years;
- Reforested 2,033 ha with over 2,000,000 trees;
- Hired, trained, and employed 11 community parks guards;
- Engaged over 200 families in community development projects in rural basins.

The municipality of Quito now looks to watershed conservation in addition to built infrastructure as a way to provide clean water to its citizens.

*Sources: Arias et al. (2010); Echavarría (2002)*

#### The water fund in East Cauca Valley, Colombia

In the East Cauca Valley of Colombia, The Nature Conservancy (TNC) and Asocaña, an association of sugar cane producers who provided most of the funding, led to the creation of a water fund, called Fondo de Agua por la Vida y la Sostenibilidad (FAVS) – Water Fund for Life and Sustainability. Asocaña relies on a regular supply of clean water for sugar cane production. The capital fund is currently worth US\$ 1.8 million. Several other groups, including community-based grassroot organizations, the regional environmental authority, and a peace and social justice organization also participate in the fund. Activities carried out through investments by the fund include conserving at least 125,000 hectares of the natural ecosystems and improving management of the landscape. These activities will benefit 920,000 people downstream and sugar cane production, an important industry for the Colombian economy.

*Source: Goldman et al. (2010c)*

## **5.8 Conclusions: transforming our approach to water and wetlands**

An understanding of the values and benefits that people derive from water and wetlands should be central to the development and implementation of regional, national and international policies addressing these habitats as well as specific management decisions for individual sites. In many cases ensuring these values are fully taken into account requires that our approach to water and wetlands is transformed. Furthermore, this approach needs to be considered within the wider context of our management of the natural environment and our relationship with it. Thus transforming our approach to water and wetland management is part of an overall transition to a sustainable global economy.

The transformation starts with an appreciation of the full suite of values and benefits that water and wetlands provides to society. These habitats are the source of multiple benefits, but so often these are either not recognised, or only one is recognised. Understanding the multiple benefits means having access to sufficient information to make the necessary assessments, engaging with local communities, and having robust tools to determine values and changes in these.

Understanding the values is only a first step in the transformation. Taking full account of these values requires a more integrated decision-making approach than has commonly been the case to date. Because of the significant economic benefits derived from wetland ecosystem services, there are consequences for many different decision makers. Hence there is a need for effective and integrated decision making. For example, improving the state of water and wetlands can have a positive effect on poverty alleviation, by ensuring food, water and energy security. By addressing several policy objectives, it creates a more robust foundation for management action to protect and enhance water and wetland ecosystem services. It can help with meeting the MDGs and also the Rio+20 endorsements that access to water is a human right and be a core element not only of local and regional development but also of international development cooperation.

The many benefits that society receives from water and wetland ecosystem services should transform our immediate relationship to these habitats. We must prioritise the protection of these ecosystems and restore them where possible. Further loss of such systems is very likely to lead to a net loss in ecosystem services and economic value to local communities and will have a negative impact on human well-being.

Engagement with people is critical in transforming our management approach. Understanding ecosystems' values often requires discussion with communities to determine the services derived from water and wetlands, not least taking account of traditional knowledge. Such knowledge is often also critical for developing good management solutions to protect and enhance the ecosystem services. Awareness raising and education is also crucial for the transition. It can help with water and wetland protection and improvement, since it increases acceptance and participation. This is critical for stakeholder buy in and for transition management. It is important to be able demonstrate that the transition is one to an overall improvement.

Collective action between governments, NGOs, local communities and indigenous peoples is needed to ensure the long-term sustainability of water and wetlands, and the global economy. Given the increasing human population and its dependence on water and wetlands, full recognition of the values and benefits of nature is a pressing imperative.

#### **Practical recommendations for stakeholders to respond to the value of water and wetlands in decision-making**

At the **global level** there is a need to ensure implementation of the Strategic Plan for Biodiversity 2011-2020, the Ramar Strategic Plan 2009-2015, the UNFCCC, the MDGs, and strategic planning and implementation of the many MEAs. The role and value of water and wetlands should be integrated in each of these. This is an awareness and governance challenge, with potential for significant efficiency gains.

##### **National and international policy makers**

- Integrate the values of water and wetlands into decision making – for policies, regulation and land use planning, incentives and investment, and enforcement;
- Regulate to protect wetlands from pressures that do not lead to improvements in public goods and overall societal benefits;
- Regulate to ensure that wetland ecosystem services options and benefits are fully considered as solutions to land and water use management objectives and development;
- Commit to and develop improved measurement and address knowledge gaps – using biodiversity and ecosystem services indicators and environmental accounts (notably SEEA & water accounts). This will require an improved science-policy interface and support for the scientific/research communities;
- Reform price signals (*getting prices right*) via water cost recovery, resource pricing and

reforming subsidies;

- Commit to restoration targets and/or programmes, improving ecosystem health and functioning, the water cycle, addressing poverty and development concerns and achieving the multiple benefits of working with nature.

#### **Local and regional policy-makers**

- Assess the interactions between wetland ecosystems, communities, man-made infrastructures and the economy and ensure the evidence base is available to decision makers, whether spatial planners, permit authorities, investment programme responsables, inspectors or the judiciary;
- Integrate into river basin and coastal management the ecosystem functions and the interaction between hydrological, social and economic systems;
- Integrate planning systems - e.g. water supply and management to take into account both ecosystem-based infrastructure and man-made infrastructures;
- Ensure due engagement/participation of communities (including indigenous peoples) and ensure that traditional knowledge is duly integrated into management solutions.

#### **Site managers**

- When possible and relevant, assess the values of sites and trade-offs of different land use decisions to help inform site management decisions to protect and enhance the values of wetland ecosystems being managed;
- Communicate the values at the local level - to get buy-in for the site management, attract funding for protection and management measures, and reduce the pressures on wetlands, including risks of land use permit decisions that may undermine public goods.

#### **Valuation research and statistical communities**

- Systematically contribute to filling the gaps in knowledge on the the values of water and wetlands, on improved governance solutions, on measures and tools to support the development of environmental accounts;
- Improve the understanding of public goods and trade-offs between public goods and private benefits from policies and investment choices.

#### **Development cooperation community**

- Integrate the appreciation of the multiple values of wetlands and potential cost savings/to meet objectives of development cooperation:
  - e.g. ecosystem restoration to improve water security, poverty alleviation, local development and wellbeing;
  - e.g. investment in ecosystem-based adaptation to climate change.

#### **Business**

- Assess the dependency of the business on water and wetlands related ecosystem services from the short to long term;
- Assess the risks to operation inputs, eventual liabilities, risk to reputation and to the licence to operate from both resource availability and impacts, including pollution pressures;
- Develop corporate ecosystem valuation and environmental profit and loss accounts to improve disclosures;
- Explore synergies between private interests and public goods and realise opportunities for synergies whether via restoration activities, engagement in markets or wider commitments to no net loss of biodiversity (or net positive gain); commit to water footprint reduction, in order to safeguard future resource availability for private and public benefits.

## Annexes

### **Annex I: Case study example applying the six steps**

Applying the stepwise approach: A PES scheme for improving water provisioning in Moyobamba, Peru

Ecosystem services in regional planning in Sumatra, Indonesia

Tracing the steps of the TEEB approach: building a conservation constituency by balancing costs and benefits in the Tubbataha Reef National Park, Philippines

### **Annex II: The Evidence base on the values of wetlands**

### **Annex III: Further information: TEEB**

## **ANNEX 1: Applying the stepwise approach: A PES scheme for improving water provisioning in Moyobamba, Peru (TEEB 2012, p245 based on Renner 2010).**

### **Step 1: Specify and agree on the problem**

The water supply for Moyobamba, a city with about 42,000 inhabitants located in the Andean foothills in northern Peru, depends on the three watersheds Rumiyacu, Mishquiyacu and Almendra. These biodiverse areas have been impacted by land-use change during the last decades. As a consequence, the quality and quantity of water coming from these watersheds declined which negatively impacted city inhabitants. The public company EPS is responsible for supplying the city with water and considered increasing measures for water treatment and to restrict water supply. This would have increased the costs for potable water production (León and Renner, 2010; TEEBcase: Compensation scheme for upstream farmers, Peru by I. Renner 2010). A significant improvement in land use was needed for the conservation and restoration of ecosystem services that support water quality and supply, in order to satisfy demand from water enterprise and city inhabitants on the one hand, and to improve the livelihoods of farmers on the other.

Public authorities and representatives from civil society, with advice from GIZ, started a dialogue in order to identify the causes for the degradation and necessary actions for improving the management of the watersheds (León and Renner, 2010). As there was no scheme for water management, a steering committee that included the relevant upstream and downstream stakeholders was established.

### **Step 2: Identify which ecosystem services are relevant**

Preliminary assessments pointed out that the underlying cause of ecosystem degradation and deteriorating water quality was in particular the migration of poor families from the high Andean regions. Due to lack of knowledge on appropriate land practices for the Amazon ecosystem and economic alternatives, they converted forests of the upstream areas to agriculture causing changes in the provision of ecosystem services. Livestock, together with wastewater from processing coffee as well as soil erosion, were identified to be major causes for decreasing water quality. In particular forests on slopes and along rivers were directly relevant for erosion control and the filtration of nutrient rich water from farmland.

### **Step 3: Define the information needs and select appropriate methods**

Due to the recognition of the importance of forests for water provision the municipality declared Rumiyacu-Mishquiyacu and Almendra as municipal conservation areas. Furthermore, it was agreed between the public water company ESP and other stakeholders within the steering committee to carry out a series of assessments: 1) characterize ecosystem services, 2) understand stakeholder relations, 3) characterize the socio-economic context and 4) identify land use alternatives.

The assessment included:

- hydrological modelling based on the Soil and Water Assessment Tool (SWAT) to estimate water supply and sedimentation rates;
- calculations of the socio-economic and environmental costs and benefits associated with different land uses as perceived on site by farmers and off site by downstream communities, using the assessment model ECOSAUT;
- demand-based assessment for water for household purposes and irrigation;

- assessment of the costs of water treatment by the EPS;
- a survey on the willingness to pay of city inhabitants for better water quality.

#### **Step 4: Assess the changes in the flow of ecosystem services**

The change in the delivery of ecosystem services was estimated for different land-use scenarios. For monitoring the impact of the actions taken to enhance ecosystem services and to reduce pollutants the steering committee decided to focus on measuring water quality (i.e. pH and the concentration of faecal coliform bacteria). Noticeable improvements in water quality within a short time were likely to encourage commitment to the process. The information collected during the assessment phase (2004–2005) contributed to the understanding of interests and needs of the involved stakeholders and in supporting the activities of the design and consolidation phase (2006–2009).

It was found that in the past, the pollutants coming from upstream farmland contributed to the deterioration of water quality. As a consequence the decline of water quality increased the costs for water treatment by EPS from US\$80,000 in 2001 to US\$250,000 in 2004. Therefore, critical areas such as forests that provide ecosystem services for water filtration and erosion control were identified within the watersheds and actions for their protection or restoration were taken. Agro-forests fulfill similar functions and could help to restore ecosystem services if planted in critical areas. Also trees and shrubs along the margins of fields would reduce erosion and increase water filtration.

After implementing first measures for enhancing ecosystem services and reducing pollutants, the concentration of microorganisms (faecal coliform bacteria) decreased, indicating an improvement in water quality (Renner, personal communication).

#### **Step 5: Identify and assess policy options**

During the consolidation phase (2006–2009) different policy options were assessed. The willingness to pay survey showed that 82 per cent of the interviewees were positive about paying a fee for improving water quality (Nowack 2005). Based on this, a compensation mechanism through PES was agreed in a public hearing. City inhabitants pay roughly US\$0.33 per household/month, amounting to approximately US\$30,000 per year, and the collected funds go to a separate account of the EPS water company, which is supervised by the steering committee. It does not provide compensation to upstream farmers (service providers) in cash but in the form of technical and material support and environmental education besides others, which helps farmers to change their management practices. Currently a public investment project of the Regional Government of San Martin takes on part of the transaction costs of about US\$800 per hectare related to the switch from slash and burn agriculture to agro-forestry systems.

Upstream farmers qualify for receiving compensation if they:

- reduce unsustainable forest use, refrain from intensive agricultural practices and introduce agro-forestry systems (e.g. shade-grown coffee);
- avoid water contamination by livestock and coffee wastewater;
- increase the margins around agricultural land for enhancing natural vegetation and the ecosystem services it provides in terms of water filtration and erosion control.



Currently the scheme is in its implementation phase which includes the negotiation of formal contracts with the farmers (service providers) (MINAM 2010; León and Renner 2010). At the same time measures to restore the watershed are already being undertaken.

#### **Step 6: Assess distributional impacts**

Besides the benefits upstream farmers derive from the compensation, they feel socially more accepted. Instead of being the reason for the problem they become part of the solution. In terms of economics switching farming practices to shade-grown coffee also provides economic benefits. In general civil society is beginning to take part in decision-making processes, and local governance structures are being strengthened which opens up opportunities for an equitable management of resources. As the process is still in its beginning, results in terms of regeneration of ecosystems and their services and the self-sufficiency of the compensation scheme will have to be assessed within the medium to long term. This local initiative was supported by the Ministry of Environment (MINAM) and the National Sanitation Services Superintendence (SUNASS). This commitment from key stakeholders, government authorities from all levels as well as the civil society, contributed considerably to the success.

**Source:** León and Renner (2010), MINAM (2010), Nowack (2005), Renner (2010), TEEB (2012)

## **Ecosystem services in regional planning in Sumatra, Indonesia (TEEB 2012, Box 6.5, p177 based on Barano et al. 2010)**

On Sumatra, in Indonesia, local communities rely on many ecosystem services: the provision of a clean, regular water supply for drinking, hydropower and irrigation is one of them, but the forests also protect them from floods, droughts and landslides while regulating for air pollution and maintaining the fertility of the soils for agriculture. However, deforestation and land conversion is threatening biodiversity and affects many ecosystem services.

### **Step 1: Specify and agree on the problem**

In October 2008, the ten provincial governors of Sumatra and four Indonesian government ministers made a historic commitment to protect the remaining forests and critical ecosystems of Sumatra. Spatial planning is critical for achieving this commitment but only had a legal basis for measures to enforce compliance since 2007, following the Spatial Planning Law 26/2007 (see Hudalah and Woltjer 2007).

Having developed national and several island-wide spatial plans in 2009, the Indonesian government has begun to design spatial plans at province and district levels as recently as 2010. District and provincial governments are integrating ecosystem services and biodiversity into spatial plans, through a Roadmap Action Plan, which sets out an 'Ecosystem Vision' for conserving Sumatran ecosystems. This roadmap was developed by a forum of NGOs known as Forum Tata Ruang Sumatera (ForTRUST) and several national government agencies, and promoted by the Ministry of Environment. Considerable decision-making power has been transferred to the local level by decentralization.

### **Step 2: Identify which ecosystem services are relevant**

Forest conversion, mostly for palm oil, pulp and paper plantations and illegal logging, is causing losses of biodiversity and degrading many ecosystem services. The conversion of lowland deep peat forests – mostly in eastern Sumatra – is the most prominent example of such degradation and is considered as a major contributor to global carbon emissions. Existing and prospective forest concessions threaten to have even greater adverse impacts since the role of forests in the provision of valuable ecosystem services is commonly overlooked, beyond standing timber. The lack of incentives to sustain ecosystem services is one of several root causes of these problems.

### **Step 3: Define the information needs and select appropriate methods**

The goal of district level planning is to determine high priority protection zones as well as zones where conversion to other uses can take place without heavily degrading ecosystem services. Habitat conservation was also considered important. A tool developed by the Natural Capital Project for mapping and valuing ecosystem services, InVEST (Integrated Valuation of Ecosystem Services and Trade-offs – see Tallis et al. 2010), is being used to inform the Sumatra spatial plan. Its application is one of the actions specified in the Roadmap Action Plan to help integrate ecosystem services into land-use decisions.

### **Step 4: Assess the changes in the flow of ecosystem services**

Following a request by government decision-makers, InVEST is being applied by the World Wildlife Fund as part of the forum of NGOs who are assisting with land-use planning in Sumatra, known as Forum Tata Ruang Sumatera (ForTRUST). InVEST provides mapped information on where, and how much, ecosystem services are supplied on the landscape, and how these patterns might change under future land-use scenarios. It can be overlaid with biodiversity information to see where

ecosystem services and conservation priorities overlap. InVEST was used to model the quantity and location of high-quality habitat, carbon storage and sequestration, annual water yield, erosion control and water purification under two scenarios: the Sumatra ecosystem vision as proposed in the Roadmap Action Plan and a business-as-usual scenario corresponding to the government's current spatial plan.

#### **Step 5: Identify and assess policy options**

In June 2010, the results were disseminated and preliminary recommendations were offered to government representatives from 18 districts in central Sumatra based on the potential gains or losses in ecosystem services if the ecosystem vision (as outlined in the Roadmap Action Plan) was implemented. For example, on the basis of InVEST results, recommendations were made on how to prioritize areas for forest restoration where nearby habitat quality indicated the potential to create forest corridors for wildlife and where forests could help reduce erosion and sedimentation of water sources. Information on ecosystem services was also used to implement incentive mechanisms that reward sustainable land use and conservation, which local government policy makers had committed to establish. Projects for the Roadmap include forest carbon projects, payments for watershed services, certified forestry and agriculture, and ecotourism. InVEST resulted in informed discussions of forest carbon projects by identifying where carbon storage and sequestration potential is high.

Results were also relevant to the design of payments for watershed services, by identifying where the services of water yield and avoided erosion are provided, and where beneficiaries are located who could pay to ensure continued service delivery. For instance, a district that gains in sediment retention if a sustainable spatial plan is implemented, and has a town or dam downstream from the sediment retention area, could be a potential location for a payment for watershed services scheme to control erosion.

#### **Step 6: Assess distributional impacts**

The potential for land-use change to create winners and losers has been assessed at the relatively coarse scale of individual settlements and dams. The potential for new income sources has also been identified: given the high levels of carbon emissions from conversion of peatlands in Riau, this spatial plan has the potential to make a major contribution to the commitment by the Indonesian government to reduce green-house gas emissions by 26 percent by 2020 (from the 2005 level). It can also support the two-year moratorium on new permits to convert natural forests and peatlands, announced in May 2010. Building on partnerships between the Indonesian Government and the governments of Norway and Australia, forest carbon projects are being planned in the central Sumatra, particularly in carbon-rich peat land areas. Local communities may thus access new sources of income from these emerging markets and payments.

Another option would be to identify in which areas local population depends most heavily on ecosystem services for their well-being and to take this information into account in the planning process. For example, when including the direct dependence of people on ecosystem services in the calculation of the gross domestic product (GDP) – the so-called 'GDP of the poor' – it was found that ecosystem services make up 75 percent of the GDP of the 99 million rural poor people in Indonesia (TEEB in National Policy 2011, Chapter 3).

Source: Barano et al. (2010), Hudalah and Woltjer (2007), Tallis et al. (2010)

## **Tracing the steps of the TEEB approach: building a conservation constituency by balancing costs and benefits in the Tubbataha Reef National Park, Philippines (TEEB 2012, Box 7.14, p. 212)**

The Tubbataha Reefs are one of the largest true coral formations in the Philippines, lying in the very centre of the Sulu Sea. In the late 1980s, intensification of fishing and the use of destructive fishing methods seriously threatened the Tubbataha Reefs.

This example illustrates that the TEEB steps (compare Section 3.6) can apply in a different order as well: here, an increasing awareness that certain ecosystem services were at risk (Step 2) which led to a national decision for setting up a marine protected area (Step 5). Then, it became apparent that the problem could only be understood and tackled jointly with local stakeholders (Step 1), which came along with a definition of information needs (Step 3) and the identification of additional policy instruments (Step 5 refined). These were subsequently backed up with studies confirming the local benefits resulting from a no-take zone for fisheries (Steps 4 and 6).

### **Step 2: Identify which ecosystem services are relevant**

The Tubbataha reefs are the habitat for a multitude of species and genetic diversity. In addition, it is believed that the Tubbataha Reefs provide the Sulu Sea and eastern coastline of Palawan with fish and invertebrate larvae (Provisioning of Food). Biologists hypothesized that the water current disperses these larvae and that a marine protected area would have important beneficial spill-over effects to surrounding fishing grounds (as confirmed, for example, by Alcala and Russ, 1990, 2006). Furthermore the reefs are an appealing destination for diving tourism (cultural ecosystem services).

### **Step 5: Implementation of policy option**

In response to growing threats, the Tubbataha Reef National Marine Park (TRNMP) was declared in 1988 by means of a presidential decree. This transferred the area's management authority from the Municipal Government of Cagayancillo to the national government through the Department of Environment and Natural Resources.

### **Step 1 and 3: Specify and agree on the problem and identify information needs**

In the following years, it became apparent that defining a new protected area was insufficient to solve the problem. Interests were divided between those pushing for a fishing ban within the park and those claiming their rights to extract resources in the park. Externally imposed park rules were not respected. Finally in 1999 a workshop was held involving all interest groups – preservationists as well as fishers. Fishers were not convinced of the benefits of a no-take zone. Information on this could not be provided in the short term. However, a willingness-to-pay study among tourists visiting the area opened up options for better balancing the costs and benefits of conservation between the stakeholders in a way that all stakeholders were willing to accept the no-take policy, even without proofs of the medium-term benefits to fisheries.

### **Step 5: Assess and identify policy options addressing distributional impacts (Step 6)**

This method provided quick results and informed the user fee system for divers, which was introduced in 2000. It included a sharing scheme regulating the distribution of the collected entrance fees to also cover compensation payments to local fishermen for their lost access to the park. Fishermen agreed to respect the no-take zone. The direct benefits from entrance fees provided the incentive to change at a moment when future increases in catch due to spill-over from the no-take zone were still to be confirmed.

### **Step 4 and 6: Assess impacts on ecosystem services and on distribution**

Only several years after these measures were successfully implanted could increases in the ecosystem services flowing from this area be assessed. Local monitoring of biophysical indicators showed that compared to other offshore reefs, Tubbataha as a no-take zone has a higher fish biomass. Also, fish biomass in the nearby reef Jessie Beazly had doubled since 2000, which to a large extent can be attributed to its proximity to Tubbataha (Dygico, 2006). Reef health, fish biomass and densities have improved or have stabilized. Live coral cover stabilized at 40 per cent from 1999 to 2003 before reaching 50 per cent in 2004 (Sabater and Ledesma, 2004).

Perhaps, most importantly, perceived fish catches by fishermen near the marine protected areas increased from 10kg/day to 15-20kg/day for the period 1999-2004 (Todd and Nunez, 2004). Additional analysis by means of socio-economic indicators (lot and house ownership, quality of construction materials and household utilities, electricity access, toilet ownership) point to a considerable increase in living standards from 2000 to 2004 in Cagayancillo (Tongson and Cola, 2007). The no-take policy favoured divers, dive operators, researchers, environmental NGOs and government agencies. On the side, fishers from the municipality of Cagayancillo, which traditionally depended on fishing, bore the cost by giving up their access rights. The combined benefits of a share in entrance fees and the subsequent increases in catch due to spill-over effects seem to have offset those costs.

After a decade of difficulties, this marine protected area was swiftly and successfully implemented. Critical for this was the well-facilitated involvement of all stakeholders, the identification of significant income potential from visitors, and a short term re-distribution of funds which could provide sufficient incentive for local fishermen to accept the no-take zone, so that the future benefits of this measure could become tangible.

#### **Case Sources:**

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## **Annex II: The Evidence base on the values of wetlands**

### **Introduction**

This annex provides an overview of the research aiming to assess the monetary values of wetland ecosystem services across the globe. It is intended to support this report by providing evidence on the monetary values of wetlands and, by doing so, help to support better informed policy-making. Furthermore, this annex provides an analysis of what the future needs for valuation research are and where the priorities of forthcoming valuation studies should lie in order to build a stronger and more comprehensive knowledge-base on the values of wetland ecosystem services. The information provided in this annex extensively builds on the overview of the valuation literature provided in TEEB (2010) and associated TEEB database (Van der Ploeg and de Groot, 2010; Van der Ploeg et al., 2010). The database of values is likely to be regularly updated (see Ecosystem Service Partnership (<http://www.es-partnership.org/esp>)).

### **Values of wetlands**

The tables below present a summary of the values available from literature across five identified types of wetlands, as summarised by TEEB (2010) appendix 3. As noted in TEEB (2010) and wider literature, there remains a range of gaps in the literature on the values of wetlands and therefore the existing data should be seen as indicative. Furthermore, it has to be acknowledged that valuation of ecosystem services has many limitations. Values by definition are; instrumental, anthropocentric, individual-based, subjective, context dependent, marginal and state dependent (TEEB, 2010). Nevertheless, information about the economic importance of ecosystems is an essential tool for supporting better informed decisions regarding the trade-offs in land-use options and resource use.

Tables A3, 1-5 provide an overview of the monetary values of ecosystem services for five categories of wetlands: 1) coral reefs; 2) coastal systems (habitat complexes e.g. shallow seas, rocky shores & estuaries); 3) mangroves and tidal marshes 4) inland wetlands (floodplains, swamps/marshes and peatlands); and 5) rivers and lakes. An analysis of the coverage and gaps in this area of research is provided in the next section.

**Table A3.1 Monetary value of services provided by coral reefs**  
Int.\$/ha/year – 2007 values

Coral reefs	No. of used estimates	Minimum values (Int.\$/ha/y)	Maximum values (Int.\$/ha/y)
<b>TOTAL:</b>	<b>101</b>	<b>14</b>	<b>1,195,478</b>
<b>PROVISIONING SERVICES</b>	<b>33</b>	<b>6</b>	<b>20,892</b>
1 Food	22	0	3752
3 Raw materials	6	0	16,792
4 Genetic resources			
5 Medicinal resources	?		
6 Ornamental resources	5	6	348
<b>REGULATING SERVICES</b>	<b>17</b>	<b>8</b>	<b>33,640</b>
7 Influence on air quality	?		
8 Climate regulation			
9 Moderation of extreme events	13	2	33,556
11 Waste treatment / water purification	2	5	77
12 Erosion prevention			
13 Nutrient cycling	?		
15 Biological control	2	1	7
<b>HABITAT SERVICES</b>	<b>8</b>	<b>0</b>	<b>56,137</b>
16 Lifecycle maintenance (esp. nursery service)	?		
17 Gene pool protection (conservation)	8	0	56,137
<b>CULTURAL SERVICES</b>	<b>43</b>	<b>0</b>	<b>1,084,809</b>
18 Aesthetic information	12	0	27,317
19 Opportunities for recreation and tourism	31	0	1,057,492
20 Inspiration for culture, art and design	?		
21 Spiritual experience	?		
22 Cognitive information (education and science)	?		

Source: TEEB (2010); de Groot et al. (2010)

**Table A3.2 Monetary value of services provided by coastal systems** (habitat complexes e.g. shallow seas, rocky shores & estuaries)  
Int.\$/ha/year – 2007 values

Coastal systems (habitat complexes e.g. shallow seas, rocky shores & estuaries)	No. of used estimates	Minimum value (int.\$/ha/y)	Maximum value (Int.\$/ha/y)
<b>TOTAL:</b>	<b>32</b>	<b>248</b>	<b>79,580</b>
<b>PROVISIONING SERVICES</b>	<b>19</b>	<b>1</b>	<b>7549</b>
1 Food	14	1	7517
2 (Fresh) water supply			
3 Raw materials	5	0	32
4 Genetic resources	?		
5 Medicinal resources	?		
6 Ornamental resources	?		
<b>REGULATING SERVICES</b>	<b>4</b>	<b>170</b>	<b>30,451</b>
7 Influence on air quality	?		
8 Climate regulation	?		
9 Moderation of extreme events			
10 Regulation of water flows	?		
11 Waste treatment / water purification	?		
12 Erosion prevention	?		
13 Nutrient cycling / maintenance of soil fertility	4	170	30,451
14 Pollination	?		
15 Biological control			
<b>HABITAT SERVICES</b>	<b>2</b>	<b>77</b>	<b>164</b>
16 Lifecycle maintenance (esp. nursery service)	2	77	164
17 Gene pool protection (conservation)			
<b>CULTURAL SERVICES</b>	<b>7</b>	<b>0</b>	<b>41,416</b>
18 Aesthetic information			
19 Opportunities for recreation and tourism	7	0	41,416
20 Inspiration for culture, art and design	?		
21 Spiritual experience	?		
22 Cognitive information (education and science)			

Source: TEEB (2010); de Groot et al. (2010)



**Table A3.3 Monetary value of services provided by mangroves & tidal marshes**  
Int.\$/ha/year – 2007 values

Mangroves & tidal marshes	No. of used estimates	Minimum value (Int.\$/ha/y)	Maximum value (Int.\$/ha/y)
<b>TOTAL:</b>	<b>112</b>	<b>1995</b>	<b>215,349</b>
<b>PROVISIONING SERVICES</b>	<b>35</b>	<b>44</b>	<b>8289</b>
1 Food	12	0	2600
2 (Fresh) water supply	3	41	4240
3 Raw materials	18	1	1414
4 Genetic resources	?		
5 Medicinal resources	2	2	35
6 Ornamental resources	?		
<b>REGULATING SERVICES</b>	<b>26</b>	<b>1914</b>	<b>135,361</b>
7 Influence on air quality			
8 Climate regulation	6	2	4677
9 Moderation of extreme events	13	4	9729
10 Regulation of water flows	?		
11 Waste treatment / water purification	4	1811	120,200
12 Erosion prevention	3	97	755
13 Nutrient cycling and maintenance of soil fertility			
14 Pollination	?		
15 Biological control	?		
<b>HABITAT SERVICES</b>	<b>38</b>	<b>27</b>	<b>68,795</b>
16 Lifecycle maintenance (esp. nursery service)	33	2	59,645
17 Gene pool protection (conservation)	5	25	9150
<b>CULTURAL SERVICES</b>	<b>13</b>	<b>10</b>	<b>2904</b>
18 Aesthetic information	?		
19 Opportunities for recreation and tourism	13	10	2904
20 Inspiration for culture, art and design	?		
21 Spiritual experience	?		
22 Cognitive information (education and science)	?		

Source: TEEB (2010); de Groot et al. (2010)

**Table A3.4 Monetary value of services provided by inland wetlands** (floodplains, swamps/marshes and peatlands)

Int.\$/ha/year – 2007 values

Inland wetlands (floodplains, swamps/marshes and peatlands)	No. of used estimates	Minimum value (US\$/ha/y)	Maximum Value (US\$/ha/y)
<b>TOTAL:</b>	<b>86</b>	<b>981</b>	<b>44,597</b>
<b>PROVISIONING SERVICES</b>	<b>34</b>	<b>2</b>	<b>9709</b>
1 Food	16	0	2090
2 (Fresh) water supply	6	1	5189
3 Raw materials	12	1	2430
4 Genetic resources			
5 Medicinal resources			
6 Ornamental resources			
<b>REGULATING SERVICES</b>	<b>30</b>	<b>321</b>	<b>23,018</b>
7 Influence on air quality	?		
8 Climate regulation	5	4	351
9 Moderation of extreme events	7	237	4430
10 Regulation of water flows	4	14	9369
11 Waste treatment / water purification	9	40	4280
12 Erosion prevention			
13 Nutrient cycling and maintenance of soil fertility	5	26	4588
14 Pollination			
15 Biological control			
<b>HABITAT SERVICES</b>	<b>9</b>	<b>10</b>	<b>3471</b>
16 Lifecycle maintenance (esp. nursery service)	2	10	917
17 Gene pool protection (conservation)	7	0	2554
<b>CULTURAL SERVICES</b>	<b>13</b>	<b>648</b>	<b>8399</b>
18 Aesthetic information	2	83	3906
19 Opportunities for recreation and tourism	9	1	3700
20 Inspiration for culture, art and design	2	564	793
21 Spiritual experience	?		
22 Cognitive information (education and science)	?		

Source: TEEB (2010); de Groot et al. (2010)

**Table A3.5 Monetary value of services provided by rivers and lakes**  
Int.\$/ha/year – 2007 values

Rivers and lakes	No. of used estimates	Minimum value (Int.\$/ha/y)	Maximum value (Int.\$/ha/y)
<b>TOTAL:</b>	<b>12</b>	<b>1779</b>	<b>13,488</b>
<b>PROVISIONING SERVICES</b>	<b>5</b>	<b>1169</b>	<b>5776</b>
1 Food	3	27	196
2 (Fresh) water supply	2	1141	5580
3 Raw materials			
4 Genetic resources	?		
5 Medicinal resources	?		
6 Ornamental resources	?		
<b>REGULATING SERVICES</b>	<b>2</b>	<b>305</b>	<b>4978</b>
7 Influence on air quality	?		
8 Climate regulation			
9 Moderation of extreme events	?		
10 Regulation of water flows	?		
11 Waste treatment / water purification	2	305	4978
13 Nutrient cycling and maintenance of soil fertility			
15 Biological control	?		
<b>HABITAT SERVICES</b>	<b>0</b>	<b>0</b>	<b>0</b>
16 Lifecycle maintenance (esp. nursery service)			
17 Gene pool protection (conservation)			
<b>CULTURAL SERVICES</b>	<b>5</b>	<b>305</b>	<b>2733</b>
18 Aesthetic information	?		
19 Opportunities for recreation and tourism	5	305	2733
20 Inspiration for culture, art and design	?		
21 Spiritual experience	?		
22 Cognitive information (education and science)	?		

Source: TEEB (2010); de Groot et al. (2010)

**Analysis of the wetland valuation knowledge-base : coverage and gaps** Of the 364 coastal and inland ecosystem value assessment studies included in TEEB (2010), two-thirds (236; 65%) have been for different types of coastal wetland with much fewer assessments (108; 35%) for types of inland wetlands (Table A3.6). The extent of valuation assessment information is best for coral reefs, mangroves and tidal marshes. For inland wetlands, it is much better for vegetated wetlands than for open-water systems (freshwater lakes and rivers). Evidently, there is a general need to focus on improving the knowledge-base for inland wetlands.

The extent of the knowledge-base for wetland ecosystem service values compares with only 10 assessments for open oceans, 47 for temperate and boreal forests, 24 for woodlands, and 28 for grasslands. Only for tropical forests is there a larger knowledge-base (142 studies) (TEEB 2010).

**Table A3.6.** The number of wetland ecosystem valuation studies for the four main categories of services for different types of wetland (data from TEEB, 2010). Colour-codes are: green  $\geq 10\%$  of studies; amber 5-10%; yellow  $< 5\%$ .

Ecosystem Services/wetland type	Coral reefs	Mangroves & tidal marshes	Coastal systems (habitat complexes)	Inland wetlands	Freshwater lakes & rivers	TOTAL
Provisioning	34	35	20	37	6	132
Regulating	19	28	6	33	4	90
Habitat	8	38	3	9	1	59
Cultural	43	13	9	13	5	83
<b>TOTAL</b>	<b>104</b>	<b>114</b>	<b>38</b>	<b>92</b>	<b>16</b>	<b>364</b>

Source: TEEB (2010); de Groot et al. (2010)

A major focus of attention on the values of wetlands (Table A3.6) has been on provisioning services across all wetland types assessed, followed by regulating services. Cultural services have received a high level of attention for coral reefs but much less so for other coastal wetland types and for inland wetlands. Notably, these estimates have been mostly focused on recreation and tourism services only. Habitat services, which chiefly represent the importance of the wetland for maintaining different stages of the life-cycle of wetland-dependent species, have been a focus of least valuation studies. Moreover, the focus of these studies was mostly on vegetated coastal wetlands (mangroves and tidal marshes), but there is a paucity of such information for other wetland types.

There are also considerable differences in the level of attention of studies on valuing wetlands in different regions of the world (Table A3.7). As assessed from the TEEB database (Van der Ploeg et al., 2010), the majority of the values are available for Asia (126), while other regions have significantly scarcer evidence on wetland ecosystem services values. In particular, Northern and Central Americas (33), Europe (31) and Oceania (26) have the lowest amount of value estimates present in the database, with a stronger representation of Africa (49), and Latin America and the Caribbean (57). This suggests that further valuation research should be more widely distributed across the globe, with a focus on the under-represented continents in order to build a stronger evidence-base on wetlands ecosystem values.

**Table A3.7.** The total number of wetland ecosystem valuation studies on the main ecosystem service categories available from different geographical regions (data calculated from the TEEB database; Van der Ploeg and de Groot, 2010)<sup>12</sup>.

Ecosystem Services/geographical region	Africa	Asia	Europe	Latin America and the Caribbean	Americas	Oceania	TOTAL
Provisioning	30	55	8	18	3	3	117
Regulating	7	30	10	20	9	6	82
Habitat	7	20	4	6	7	4	48
Cultural	5	21	9	13	14	13	75
<b>TOTAL</b>	<b>49</b>	<b>126</b>	<b>31</b>	<b>57</b>	<b>33</b>	<b>26</b>	<b>322</b>

Source: Van der Ploeg and de Groot (2010); Van der Ploeg et al. (2010)

In general, valuation studies have focused on the more important categories of ecosystem service delivered by the different types of wetlands. However, there are a number of services which have received relatively little valuation attention so far (see Table A3.8). A large proportion (58%) of valuation studies for wetlands have been on just four types of ecosystem services: food, raw materials, life-cycle maintenance and recreation/tourism opportunities.

**Table Ax.3. overleaf presents a gap-assessment of the extent of the ecosystem service values knowledge-base in relation to the relative importance of each ecosystem service in coastal and inland wetlands.** Relative ecosystem service importance (● low; ● medium; ● high) is derived from MA (2005b) and Danone Fund for Nature (2010). Number of valuation studies is from TEEB (2010), colour-coded for the proportion of the total number (364) of available studies on wetlands: green ≥10% of studies; amber 5-10%; yellow <5%; red no studies. ‘Smiley-face’ indicates the extent of the valuation knowledge-base compared to the relative ecosystem service importance for that service while ☹ indicates a lack of valuation studies given the relative importance of the service.

#### Inland vegetated wetlands:

For **provisioning** services, the majority of valuation studies have been on food, but surprising few on the value of freshwater supply given its importance and none on genetic, medicinal, or ornamental resources. Likewise for **regulating** services; there are relatively few studies given the importance of wetlands in the moderation of extreme events. More attention has been focused on the role of inland vegetated wetlands in waste water treatment, but for most of the other types of service delivered by these wetlands there is a lack of data, especially for their important roles in regulating water flows and nutrient cycling/maintenance of soil fertility. There are no available assessments of the value of inland vegetated wetlands in erosion prevention, pollination or biological control. There are very few assessments (*contra* the situation for coastal wetlands) on life-cycle maintenance. For **cultural** services, whilst there are some studies on aesthetic and recreation/tourism services, there are no or few assessments for inspiration, spiritual experience or education and science services – all important services.

<sup>12</sup> As can be seen from the total number of monetary values, it differs from the discussion presented in the previous and subsequent analysis. The differing number of studies is mainly caused due to two issues 1) the monetary values for the whole world (n=12) have been excluded; and 2) the database has been updated since the publication of the TEEB (2010) study. Nonetheless, general geographical patterns can be assumed to be the same.

### Freshwater lakes & rivers:

There is generally a lack of information for all types of ecosystem services for freshwater lakes and rivers. Particularly lacking are the estimates for: the **provisioning** services of food and freshwater supply; the **regulating** services of moderation of extreme events, regulation of water flows and nutrient cycling; the **habitat** service of life-cycle maintenance; and for **cultural** services on inspiration, spiritual experience and cognitive information (education and science).

### Coastal wetlands:

For **coral reefs**, there is a need for more assessment of the value of their role in genetic and medicinal resources, erosion prevention, nutrient cycling, and life cycle maintenance. Similarly needed are estimates for **cultural** services - on inspiration, spiritual experience and cognitive information (education and science).

### Mangroves and tidal marshes:

For vegetated coastal wetlands (**mangroves and tidal marshes**), whilst the knowledge-base is relatively good, there are gaps in assessment of the values of genetic and ornamental resources, regulation of water flows and pollination, and especially values of nutrient cycling and biological control. For **cultural services**, there is a major lack of assessment of their values for aesthetic, inspiration and spiritual experience.

Ecosystem services	Coral reefs		Mangroves & tidal marshes		Coastal systems (habitat complexes e.g. shallow seas, rocky shores & estuaries)		Inland vegetated wetlands (floodplains, swamps/marshes and peatlands)		Freshwater lakes & rivers		TOTAL
	Relative ecosystem service importance	No. of valuation studies	Relative ecosystem service importance	No. of valuation studies	Relative ecosystem service importance	No. of valuation studies	Relative ecosystem service importance	No. of valuation studies	Relative ecosystem service importance	No. of valuation studies	
<b>Provisioning</b>											
Food	●	22 😊	●	12 😊	●	14 😊	●	16 😊	●	3 😊	67
(Fresh) water supply	n/a	n/a	●	3 😊	●	1 😊	●	6 😊	●	2 😊	12
Raw materials	●	6 😊	●	18 😊	●	5 😊	●	12 😊	●	1 😊	42
Genetic resources	●	1 😊	●	0 😊	●	0 😊	●	1 😊	●	0 😊	2
Medicinal resources	●	0 😊	●	2 😊	●	0 😊	●	1 😊	●	0 😊	3
Ornamental resources	●	5 😊	●	0 😊	●	0 😊	●	1 😊	●	0 😊	6
<b>Regulating</b>											
Influence on air quality	●	0 😊	●	1 😊	●	0 😊	●	0 😊	●	0 😊	1
Climate regulation	●	1 😊	●	6 😊	●	0 😊	●	5 😊	●	1 😊	13
Moderation of extreme events	●	13 😊	●	13 😊	●	1 😊	●	7 😊	●	0 😊	34
Regulation of water flows	n/a	n/a	●	0 😊	●	0 😊	●	4 😊	●	0 😊	4
Waste treatment/ water purification	●	2 😊	●	4 😊	●	0 😊	●	9 😊	●	2 😊	17
Erosion prevention	●	1 😊	●	3 😊	●	0 😊	●	1 😊	●	0 😊	5
Nutrient cycling/ maintenance of	●	0 😊	●	1 😊	●	4 😊	●	5 😊	●	1 😊	11

soil fertility											
Pollination	n/a	n/a	●	0 ☹️	●	0 ☹️	●	1 ☹️	●	0 ☹️	1
Biological control	●	2 😊	●	0 ☹️☹️	●	1 ☹️	●	1 ☹️	●	0 ☹️	4
<b>Habitat</b>											
Lifecycle maintenance (a.k.a. biodiversity)	●	0 ☹️	●	33 😊	●	2 ☹️	●	2 ☹️	●	0 ☹️☹️	37
Gene pool protection	?	8 😊	?	5 😊	?	1 ☹️	?	7 😊	?	1 ☹️	22
<b>Cultural</b>											
Aesthetic information	●	12 😊	●	0 ☹️	●	1 ☹️	●	2 😊	●	0 ☹️	15
Recreation/ tourism opportunities	●	31 😊	●	13 😊	●	7 😊	●	9 😊	●	5 ☹️	65
Inspiration for culture, art & design	●	0 ☹️☹️	●	0 ☹️	●	0 ☹️	●	2 ☹️	●	0 ☹️☹️	2
Spiritual experience	●	0 ☹️☹️	●	0 ☹️	●	0 ☹️	●	0 ☹️☹️	●	0 ☹️☹️	0
Cognitive information (education & science)	●	0 ☹️	●	0 ☹️	●	1 ☹️	●	0 ☹️☹️	●	0 ☹️☹️	1

Source: TEEB (2010); de Groot et al. (2010)



## Annex III: Further information

### **The Economics of Ecosystems and Biodiversity: Making nature's values visible**

The Economics of Ecosystems and Biodiversity (TEEB) study is an international initiative to draw attention to the global economic benefits of biodiversity. It focuses on values of biodiversity, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of action to address these pressures. It draws together expertise from across the fields of science, economics and policy to enable practical actions to be developed and implemented.

#### **TEEB Books:**

TEEB (2010), *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations* Edited by Pushpam Kumar. Earthscan, London

TEEB (2011), *The Economics of Ecosystems and Biodiversity in National and International Policy Making*. Edited by Patrick ten Brink. Earthscan, London.

TEEB (2012) *The Economics of Ecosystems and Biodiversity in Business and Enterprise* Edited by Joshua Bishop. Earthscan, London

TEEB (2012) *The Economics of Ecosystems and Biodiversity in Local and Regional Policy and Management*. Edited by Heidi Wittmer and Haripriya Gundimedda. Earthscan, London

More information about the TEEB study, newsletter, ongoing projects and future work can be found at [www.teebweb.org](http://www.teebweb.org), or by contacting the TEEB Office:

UNEP TEEB Office  
11-13 Chemin des Anémones  
1219 Châtelaine, Geneva, Switzerland  
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<sup>1</sup> The phrase “in the context of sustainable development” is intended to recognize that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the Convention, and it is not appropriate to imply that ‘development’ is an objective for every wetland

<sup>2</sup> Ramsar COP9 Resolution IX.1 Annex A (2005).

<sup>3</sup> Mekong River Awareness Kit: interactive self-study CD-Rom. Mekong River Commission. P.O. Box 6101, Unit 18 Ban Sithane Neua, Sikhottabong District, Vientiane 01000, Lao PDR.

<sup>4</sup> This classification, while internationally broadly accepted, is not the only possible one, and indeed other classifications have been proposed. The choice on the classification to be adopted depends on the purpose for which it is used (Fisher et al., 2009; Costanza, 2008). The MA’s classification in Box 2.1 is a powerful instrument for environmental education and awareness-raising. However, it does not fully distinguish between intermediate and final ecosystem services, potentially leading to double counting (Wallace, 2007; Hein 2006). In fact, with the MA’s classification, the same ecosystem services may be taken into account firstly as a regulation and supporting ecosystem services, and then as a provisioning or cultural ecosystem services (e.g. water regulation and storm protection provided by mangroves, and the resulting cultural ecosystem services enjoyed by tourists). Double counting is to be avoided when carrying out a monetary valuation or environmental accounting (but it is not so relevant if the goal is environmental education), and in order to do so Boyd and Banzhaf (2007) propose a definition of ecosystem services as components of nature that are directly used to produce human welfare, thereby only taking into account the final and not the intermediate ecosystem services. Wallace (2007) proposes a definition based on the human needs satisfied by the ecosystem services, which are grouped into four categories: 1) basic needs (food, oxygen, water, energy), 2) protection from predators, diseases, parasites and 3) physical and chemical benevolent environment (temperature, humidity, electricity, chemicals), and 4) cultural performance. Finally, if the goal is to make a decision that affects a certain area, the most appropriate definition is based on the relation between the production of ecosystem services and the location where they are enjoyed. For example, Hein et al. (2006) propose a spatially explicit definition of ecosystems, i.e. the set of species and populations in a spatially defined area, the interactions among them and with the abiotic elements.

<sup>5</sup> The international dollar, or the Geary–Khamis dollar, is a hypothetical unit of currency that is used to standardize monetary values across countries by correcting to the same purchasing power that the U.S. dollar had in the United States at a given point in time. Figures expressed in international dollars cannot be converted to another country’s currency using current market exchange rates; instead they must be converted using the country’s PPP (purchasing power parity) exchange rate. 1Int.\$=1USD.

<sup>6</sup> Ibid, last footnote.

<sup>7</sup> Habitat ecosystem services is an alternative name for supporting ecosystem services. The change in their denomination was proposed by the TEEB (2010, chapter 1), in order to highlight the ability of ecosystems to provide habitat for migratory species and allow natural selection processes to maintain the vitality of the gene pool.

<sup>8</sup> Net Present Value (NPV) over 9 years (1996-2004) at 10% discount rate

<sup>9</sup> This method uses questionnaires to ask people how much they would be willing to pay to protect or enhance ecosystems and the services they provide, or alternatively how much they would be willing to accept for their loss or degradation, see section 3.4

<sup>10</sup> Useful source of further information: <http://intl.pnas.org/content/109/18/E1111.full.pdf>. mangrove atlas, seagrass atlas

<sup>11</sup> Ramsar COP11 Resolution XI.9 (2012)

<sup>12</sup> This text derived from: Alexander, S., and McInnes, R. 2012. *The benefits of wetland restoration*. Ramsar Scientific and Technical Briefing Note no. 4. Gland, Switzerland: Ramsar Convention Secretariat.

<sup>13</sup> Decision X/2, annex. Biodiversity <http://www.cbd.int/sp/targets>. <http://www.cbd.int/sp/targets>.

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<sup>16</sup> To do: add data

<sup>17</sup> An externality is a negative or positive impact caused by an agent to another one without compensating it. An example of a negative externality is the reduction in a fisherman's income due to the pollution caused by a factory upstream, which reduces the available fish in a river.

<sup>18</sup> The SNA is an internationally agreed standard for national economic accounts. Its first version was adopted in 1953, and is the main source of information for internationally comparable economic aggregates and indicators such as Gross Domestic Production (GDP), value added, income and consumption.

<sup>19</sup> For more information, see

<http://unstats.un.org/unsd/envaccounting/seeaw/seeawaterwebversion.pdf><http://unstats.un.org/unsd/envaccounting/seeaw/seeawaterwebversion.pdf>.

<sup>20</sup> The London Group is an informal group of experts primarily from national statistical agencies but also international organizations that discuss accounting and have been influential in the SEEA process, both on methodologies and on sharing practice. <http://unstats.un.org/unsd/envaccounting/londongroup/>

<sup>21</sup> To do: strengthen the description of the benefits of wetland restoration. Make reference to papers describing the water quality benefits of restored and created wetlands would be valuable, with another 1-2 examples in Box 4.2. Also, various government agencies and private groups are now restoring wetlands on large scales --- mention of this trend (with \$\$ amounts invested).

<sup>22</sup> A reverse auction is an auction where many sellers compete to offer a good/service to a buyer by undercutting their prices, whereas in classical auctions many buyers compete for a good/service to be sold by one seller. Reverse auctions allow reducing the asymmetry of information, and are useful when the ecosystem services buyers are not aware of the opportunity costs associated with the provision of the required ecosystem services, and could therefore set a higher price than needed, with the consequence that fewer ecosystem services are obtained than theoretically possible. Reverse auctions force ecosystem services providers to compete among them, lowering the ecosystem services price to a level close to their opportunity costs. As a disadvantage, they present higher transaction costs and administrative difficulties, and also a higher degree of uncertainty, because the participants' offers may be determined by many often unpredictable factors, e.g. risk aversion, strategic behaviour, and information availability (Ferraro, 2008). See Box 4.7 for an example of an auction-based PES (the salinity credits in the catchment area of Bet Bet, Australia).

<sup>23</sup> The opportunity cost is represented by the benefit which an agent waives when choosing an action rather than another. For example, when deciding to conserve a forest instead of using the land for agriculture, the opportunity cost associated with this decision is the benefit that would have been obtained by selling the crops cultivated on that land.

<sup>24</sup> <http://www.un.org/en/sustainablefuture>.