Value

Counting ecosystems as water infrastructure

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Water & Nature Initiative

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This publication has been made possible in part by funding from the Government of the United Kingdom, the Government of the Netherlands, and the Water & Nature Initiative.

Published by: IUCN, Gland, Switzerland and Cambridge, UK

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The World Conservation Union

Citation: Emerton, L., Bos, E. Value. Counting Ecosystems as an Economic Part of Water Infrastructure. IUCN, Gland, Switzerland and Cambridge, UK. 88 pp.

ISBN: 2-8317-0720-X

Design by: Melanie Kandelaars

Printed by: Atar

Available from: IUCN Publications Services Unit
219c Huntingdon Road, Cambridge CB3 ODL, United Kingdom
Tel: +44 1223 277894, Fax: +44 1223 277175
E-mail: info@books.iucn.org
http://www.iucn.org

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Contents

Key messages

1. Putting ecosystems into water equations

Ecosystems matter for people and water services
Forests, floodplains and coastal areas need water to provide goods and services for production and consumption. On the supply-side of the equation, natural ecosystems generate important economic services when they maintain the quantity and quality of water supplies and help to mitigate or avert water-related disasters.

Under-investment in ecosystems results in reduced water services
Ecosystems form an important component of water infrastructure. Yet, typically, ecosystems are not allocated sufficient water or funding. As a result, water decisions have in many cases proved to be financially and economically sub-optimal. Ecosystems can no longer be ignored when formulating policies, shaping markets or setting prices.

Including ecosystem values in economic analysis improves decision-making
Valuing ecosystems in water equations can help us to better meet the ambitious Millennium Development Goals for poverty alleviation and clean and adequate water for all. Practical tools and techniques for factoring natural ecosystems into economic planning for water development are urgently needed.

2. Correcting the balance sheet

Understanding how ecosystems contribute to human welfare is critical
Ecosystems maintain water flow and supplies, regulate water quality, and minimize water-related disasters. Water, in turn, allows ecosystems to provide natural resources, for instance fish, pasture, and forest products. They thereby support a wide range of production and consumption processes, often representing a high economic value.

Recognise that ecosystem values have been ignored in decision-making
Ecosystems have an economic value in relation to water, but this value is poorly understood and rarely articulated. As a result, it is frequently omitted from decision-making, leading to a lack of funding and a lack of water for ecosystems. Consequently, those ecosystems lose their economic value as they are degraded and destroyed.

Include ecosystem values to save costs and safeguard profits
Ecosystem degradation leads to declining future profits, increasing future costs, and additional remedial measures for water investors. These costs are typically passed on to the end-users of water products as higher fees or lower quality services. Investments in ecosystems today can safeguard profits in the future, and save considerable costs.

Include ecosystem values to achieve sustainable development goals
Recognising the values of ecosystems, and investing in them accordingly, will be key to achieving the Millennium Development Goals and poverty alleviation: ecosystems will remain a vital lifeline for the poorest until these goals are met.

Start from a framework of total economic value to determine benefits
The total economic value of ecosystems has four components: direct values (e.g. raw materials), indirect values (e.g. flood control), option values (the premium placed to maintain future development options and uses), and existence values (e.g. spiritual values). All those values are important in decision-making.

Economic valuation of ecosystem services is only part of the solution
Valuation provides us with powerful arguments to integrate ecosystem values in water management decision. However, there are other criteria and considerations that play an important role, for instance the cultural or intrinsic value of an ecosystem.

Clearly define the scope of your valuation
It is rarely necessary or appropriate to quantify each and every component of the total economic value of an ecosystem. The most practical approach in a particular study is to pick those values that are directly related to the water management issue at hand.

3. Adding up the benefits and costs

Quantify ecosystem value to put them on the planning agenda
Economics remains a powerful factor in decision-making. Quantification of ecosystem benefits also allows comparison to other economic sectors and activities. Economic valuation can thus provide a convincing argument for placing ecosystems on the water and development agendas, alongside other considerations in decision-making.

Ecosystem values can be determined through direct profits and market prices
The simplest and most commonly used method for valuing any good or service is to take its market price. Thus the price of products directly harvested from ecosystems determines their value. When these products and services are not directly traded in markets, their value can be derived from their contribution to other production processes or their impact on the prices of other commodities.

Cost-based approaches are commonly used to calculate ecosystem services
Ecosystem values can also be determined through assessing the cost of man-made products, infrastructure or technologies that could replace ecosystem goods and services. Alternatively, the costs of mitigating or averting the impacts of lost ecosystem services can be used to determine their value. Finally, the damage that is avoided to downstream infrastructure, productivity or populations by the presence of ecosystem services can be ascertained.

People's willingness to pay or accept compensation for loss of ecosystem values
Ecosystem values can also be defined by asking people directly what they are willing to pay for ecosystem goods and services or their willingness to accept compensation for their loss. More complex methods that measure people's appreciation for ecosystem values also exist.

4. Using valuation in water decisions

Embed valuation in decision-making
Economic valuation of ecosystem services provides a set of tools to make better and more informed decisions. However, these tools need to be embedded within the planning and decision-making process if they are to be effective.

Translate ecosystem values into management decisions
To close the gap between research and decision-making, ecosystem values need to be translated into measures that make sense to decision-makers when they weigh up different funding and management choices.

Generate information on the impacts of water decisions on ecosystem values
Decisionmakers want to understand and express the advantages and disadvantages of different choices in uses of land, water, resources or investments. Applying a simple bio-economic model can clarify the economic impacts of particular water decisions in terms of changes in ecosystem service gains or losses, costs and benefits.

Express ecosystem values as economic measures to support decision-making
With the bio-economic model in hand, the possible impacts can be expressed using indicators that compare the relative economic or financial desirability of different water development options. Several tools exist. Cost-benefit analysis assesses profitability by calculating total benefits minus total costs for each year of analysis. Other tools that can be used are cost-effectiveness analysis, risk-benefit analysis and decision analysis.

Relate ecosystem values to non-monetary decision tools
There will always be non-economic considerations in deciding between alternative projects, policies and programmes. Multi-criteria analysis provides a tool to integrate different types of monetary and non-monetary decision criteria, based on ecological, economic and social criteria.

5. Improving standard planning practice

Mainstream valuation in planning
Economic valuation of ecosystem services is increasingly part of development planning. A wide range of cases exist today that provide solid evidence of the benefits of ecosystem services. Also, expert guidance helps to apply existing methodologies. There is now an urgent need to make economic valuation an integral part of and standard practice for planning and decision-making.

Communicate convincingly and build involvement and awareness
Critical for making ecosystem values known is involving key stakeholders before, during and after an assessment. If their perspectives and interests are represented, they will be more open to use the outcomes of the study. Using professional communicators and implementing a well-designed communications strategy is often critical to have ecosystem values used in planning and decision making.

Seek opportunities in sector planning and economic frameworks
There are many higher-level policies, strategies and plans that frame economic decisions. They determine whether making investments in ecosystem services pay off. It is therefore critical for mainstreaming ecosystem values in planning to seek opportunities to incorporate the requirement for and results of economic valuation in sector policies, economic and spatial planning, and poverty reduction strategies.

Foster cooperation and promote balancing competing interests
Valuation of ecosystem goods and services articulates costs and benefits that traditionally were ignored in or excluded from water decision-making. Demonstrating to key actors how specific water decisions can act in their favour is critical to foster co-operation amongst stakeholders and gain political support. For instance, political leaders may invest in ecosystems when they see their values and the economic gains it brings to their constituency.

Strengthen capacity and build a pool of know-how
In many countries, there is still the need for more expertise on ecosystem valuation and its application to determine the importance of ecosystem services for people's livelihoods, as well as local and national economies. Training economists, planners and senior officials in the use of economic valuation is vital. Countries and donors need to invest in making methods and information easily accessible, building up adequate technical expertise, and creating institutional capacity.

Preface

It is my honour to address you in this preface of the third publication of the IUCN Water and Nature Initiative, entitled "Value – counting ecosystems as water infrastructure", which tells the story of an exciting journey.

This tool book reflects the growing awareness that ecosystems are important to water management. In the past, we did not realize the many benefits of ecosystems and consequently ignored them in our management decisions. The result was environmental degradation, oftentimes leading to increased poverty for water- and wetland-dependent communities.

Now, we are increasingly recognizing that ecosystems play a very important role in the demand and supply side of water: ecosystems use water, regulate water supply, and provide a range of products and services on which people depend. Moreover, we increasingly have, at our disposal, the policy frameworks, the tools and the willingness to put that insight into practice.

Economic valuation of ecosystem services is an important tool for effective and efficient water management as it offers us a way to make the roles of healthy ecosystems visible and to factor these into decision-making.

It tells us what may be lost due to management interventions, and helps identify compensation measures. In other cases, it may lead to investments in conservation measures, such as forest management or wetland protection, and realization of sustainability of new infrastructure.

I have found this tool book very interesting but what I found most interesting is that economic valuation may find that some investments in ecosystems lead to long-term financial or economic gain. In those cases, investments in nature deliver tangible and sustainable profits.

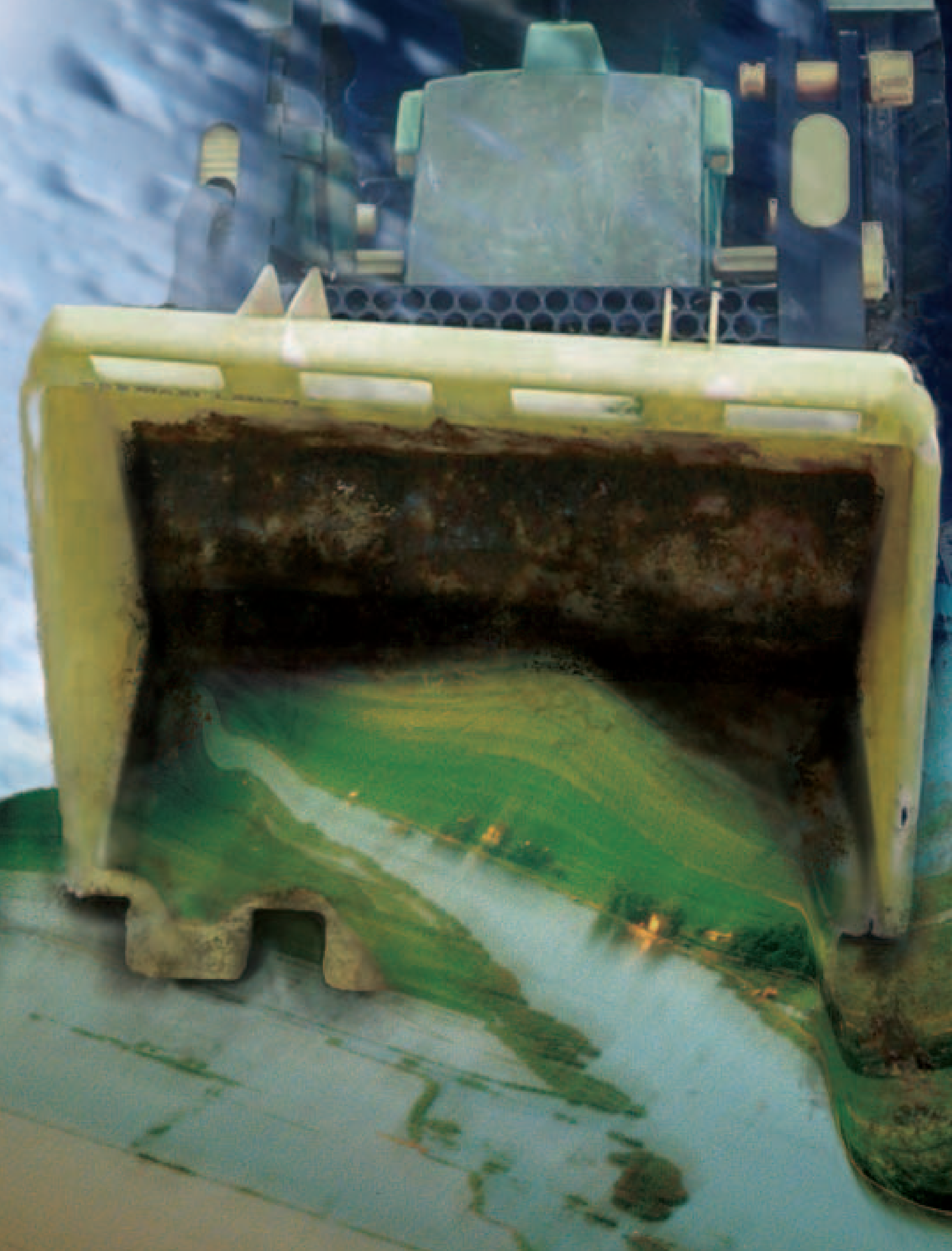
While the usefulness of economic valuation is becoming clearer, its application is still not widespread. This tool book will help us go forward on our journey, which will end when the application of economic valuation is standard procedure in water and development decisions.

Washington Nyakale Mutayoba
Ministry of Water and Livestock Development
Government of the United Republic of Tanzania

Acknowledgements

Many have contributed to this practical guide. We would like to thank David Barton and Mikkel Kallesøe for reviewing this guide and contributing case studies. We also acknowledge the contributions of our colleagues on economic valuation: Bhathiya Kekulandala and Shamen Vidanage (Sri Lanka); Usman Iftikhar (Pakistan); Jane Turpie, Brad Smith and Jon Barnes, (Southern Africa); Francis Karanja, Willy Kakuru, Lucy Iyango, Andrew Malinga and Julius Mafumbo (Uganda); and Ros Seilava and Heng Pearith (Cambodia). We thank Ger Bergkamp for his involvement in producing this guide and Melanie Kandelaars for her designs.

Finally, we thank the Department for International Development of the Government of the United Kingdom, the Directorate-General for International Cooperation of the Government of the Netherlands, and the IUCN Water & Nature Initiative for supporting our work.



Chapter 1

Putting ecosystems into water equations

1.1 Increasing investments for water supply and sanitation

Clean and adequate water for all is perhaps the most basic requirement for human survival. It is also one of the most pressing challenges on today's sustainable development agenda. Although the focus on water is nothing new, and the water sector has long formed the cornerstone of government and donor investment strategies, there has recently been a strong reiteration of the need to develop and fund water infrastructure.

For example, one of the eight Millennium Development Goals aims to improve access to safe water supplies. The Johannesburg Plan of Action restates this target, and also flags the need to increase access to sanitation and to develop integrated water resources management and efficiency plans.

All over the world, governments are attempting to meet these goals by formulating new water policies and investment strategies. Over the last few years considerable new financial resources have been pledged to the water sector from both international donors and domestic sources, and from the private and public sector. As a result, there is a much needed injection of funds into water infrastructure.

With regard to overseas development assistance for water, these renewed commitments may reverse the downward trend from US$ 3.5 billion before 1998 to US$ 3.1 billion in 2001 per year.[1] Following the 2002 World Summit on Sustainable Development, the European Union outlined its "Water for Life" initiative, the United States announced investments of almost $1 billion for water and sanitation over the next three years, and the United Nations received more than twenty other water-related commitments worth at least an extra $20 million.[2]

"ARE THE RENEWED INVESTMENTS IN WATER SUFFICIENT; AND GOING TO THE RIGHT PLACES AND PEOPLE?"

These new investments cover most parts of the globe. In 2002, the Asian Development Bank committed $5 million in fast-track credit for the "Water for Asian Cities Programme". The African Water Facility, hosted by the African Development Bank, was also launched with an estimated funding requirement of at least $500 million. And in August of last year the Inter-American Development Bank and the Netherlands Government established a $10 million Water Partnership Programme for Latin America and the Caribbean.

Most recently, the World Panel on Financing Water Infrastructure has recommended that financial flows to the water sector must at least double[3] if the Millennium Development Goals are to be met. And there is every sign that governments are making major efforts to meet these financing needs.

But despite these positive trends in the water sector, questions still remain: are such investment funds sufficient, and are they actually going to the right places and people who will ensure clean and adequate water, and sustainable livelihoods, for all?

1.2 The omission of ecosystem goods and services

Renewed investment and development efforts, and especially their focus on securing water for the poor, are to be welcomed. But it is also clear that meeting these global development goals and managing these new financial resources successfully will be a major challenge. Dealing with this challenge will require a change in the way of looking at investment in water infrastructure.

One essential condition for success will be the ability of planners and investors to factor in environmental concerns - and particularly the links between natural ecosystems, water demand and supply. Despite the importance of healthy ecosystems for secure water supplies, and the importance of secure water supplies for healthy ecosystems, recognition of the relationship between ecosystem status and water infrastructure has long been missing from water rhetoric and practice.

It is interesting to note that the Millennium Development Goals group together the need to reverse the loss of environmental resources with the need to improve safe water supplies. But this relationship is never made explicit, or developed further.

"AN ESSENTIAL CONDITION FOR SUCCESS WILL BE THE ABILITY TO FACTOR IN ENVIRONMENTAL CONCERNS."

There is also a growing - although by no means universal - recognition that the environment demands water. For example, both the 1993 Dublin Statement on Water and Sustainable Development and the WSSD Plan of Implementation highlight the need to maintain freshwater flows for the environment. Again, the relationship remains implicit and is not translated into useable tools. The role of ecosystems in the supply of water has received far less attention. In short, the link between water and the environment has rarely been perceived beyond pollution and water quality concerns.

Leaving ecosystems out of water rhetoric and practice may ultimately undermine the very sustainable development and poverty alleviation goals that the international community is working hard, and investing heavily, to achieve: cost-effective, equitable and sustainable access to water resources and services for all. Recognising ecosystem values will help increase the sustainability of our efforts.

But there is an added bonus: ecosystem values may also offer a pathway to increase investment and human well-being. If these values are made visible, they can also be integrated into existing economic arrangements and lead to a new field of incentives, investments and value chains that support the Millennium Development Goals. Even though such efforts are beyond the scope of this book, experiments with and schemes of payment for environmental services are underway that may lead to the emergence of a new economic sector.

1.3 Ecosystems matter

Ecosystems are still largely left out of water equations – for example the equations that balance decisions about how to allocate water, how much to charge for water products and services, where to channel investment funds, or what type of water infrastructure to construct. And yet there are huge and far-reaching economic and development costs to this omission – especially for the poorest sectors of the world's population.

Decisions of how to allocate, price and invest in water are usually made by a comparison between the economic returns of different water demands, and the economic costs of supplying water. Conventional wisdom decrees that water is allocated to its highest value use and invested in water infrastructure to generate the lowest costs and highest profits. Furthmore, it also says both the costs of supply and the value of demand need to be considered when pricing water goods and services.

On both demand and supply sides, ecosystems form an important – yet frequently ignored – component of these equations.

Ecosystems, through their demand for water, provide a wide range of goods and services for human production and consumption – for example fish, timber, fuel, food, medicines, crops and pasture. On the supply-side of the equation, natural ecosystems such as forests and wetlands generate important economic services which maintain the quantity and quality of water supplies. Furthermore, they help to mitigate or avert water-related disasters such as flooding and drought. Often ecosystems provide a far more effective, cost-efficient, equitable and affordable means of providing these goods and services than artificial alternatives. Yet, typically, ecosystems are not allocated sufficient water or funding when water decisions are made and water investments are planned.

"WATER DECISIONS HAVE IN MANY CASES PROVED TO BE FINANCIALLY AND ECONOMICALLY SUB-OPTIMAL."

Of particular concern has been the slowness of economic planners to take proper account of ecosystems when they perform water calculations. Economic arguments (for example the returns of water use, or the cost of providing particular water services) and economic decision-support tools (for example cost-benefit analysis and other types of investment appraisal) are an especially important determinant of how water is allocated, used and funded. There however remains little recognition of the fact that ecosystems are economic users of water, economic components of the water supply chain, and form an essential (and yet classically under-funded) part of investment in the water sector. Ecosystem values are rarely factored into economic decision-making.

As a result, water decisions have in many cases proved to be financially and economically sub-optimal – for investors and water developers themselves, but also for the human populations that require clean and secure water supplies. For example, when ecosystems are omitted from water equations, large sectors of the population can be cut off from access to the vital economic goods that ecosystems, through their demand for water, produce. Or, by failing to invest in the ecosystems which maintain water quality and quantity, the lifespan and future profits of infrastructure developments are reduced, or their running costs increased.

Experience tells us that the loss of vital economic goods and services, which has arisen from a failure to factor ecosystem values into water decisions, is really a cost that water users and investors, or development agencies, cannot afford to bear over the long-term. It also tells us that, conversely, investing in ecosystem goods and services can be an excellent strategy to reduce costs and increase returns.

1.4 Making ecosystems a part of water business

If the Millennium Development Goals are to be met, if all of the new investments in the water sector are to reach their potential, and if the poorest are really going to be provided with equitable and cheap access to adequate and clean water, then a major challenge will be to overcome these omissions, and to include ecosystems in water decisions.

Developing the economic tools and understanding the role of ecosystems in water demand and supply will be central to this process. And this means starting to count ecosystems as an economic part of water infrastructure.

"INVESTING IN ECOSYSTEM GOODS AND SERVICES CAN BE AN EXCELLENT STRATEGY TO REDUCE COSTS AND INCREASE RETURNS."

VALUE responds to this vision for the future. It presents a series of practical tools and techniques for factoring natural ecosystems into economic planning for water development. The document looks at how to value ecosystems as economic users and suppliers of water, and how to use the resulting information to influence water decision-making.

VALUE has the ultimate aim of showing how valuing ecosystems in water equations can help us to better meet the ambitious goals of securing clean and adequate water for all. It also tells us that ignoring ecosystems in decision-making, formulating policies, shaping markets and setting prices comes with severe economic repercussions.

To these ends, VALUE follows through the chain of events that results in ecosystems not being counted as an economic part of water infrastructure. It highlights ecosystem value gaps and issues in the decision-making process, and identifies economic approaches that can be used to overcome and address them. Each of the techniques in this book responds to a different stage in the decision-making process, and in the economic valuation of ecosystems.

Natural ecosystems are often used as direct source of water. Here, a woman bathes in the Pangalanes canal, Madagascar.

VALUE provides a series of logical steps, which together provide the necessary conditions to count ecosystems as an economic part of water infrastructure:

- First of all, the issue of correcting the balance sheet is addressed, so that ecosystems are included as economic components of the water supply chain, and economic users of water. A major issue in water decision-making is that the relationships between ecosystems and water have rarely been made explicit, or articulated in economic terms. Ecosystem under-valuation has, in turn, penalised both water investors and users, and undermined sustainable development goals. Chapter 2 presents the links between ecosystems, water and the economy, and presents some useful pointers to account for the economic value of ecosystems for water.

- After defining and presenting a framework for assessing the total economic value of ecosystems for water, the next step is to look at the individual components of this value, and add up the benefits and costs. This addresses an important information need in decision-making - that of generating sufficient data to enable ecosystem goods and services to be measured in economic terms, and compared with other activities and sectors in the economy. Chapter 3 outlines the quantitative methods that can be used to value ecosystems as water infrastructure.

- The next step is to set values to work by translating the figures of ecosystem costs and benefits into useful information for water decision-making. Investment appraisal and economic analysis techniques have not, traditionally, included ecosystem costs and benefits when they calculate the profitability, viability or sustainability of different programmes, projects and policies, or weigh up the relative desirability of alternative uses of funds, land and resources. Chapter 4 identifies techniques for representing ecosystems in the measures, criteria and indicators that are involved in using valuation for water decisions.

- Having identified the techniques that can be used to count ecosystems as an economic part of water infrastructure, ecosystem values can be firmly placed on the agenda of water decision-makers. But being able to express ecosystem-water linkages as economic values is not the end of the story in the move from decisions to actions in the water world. Practical realities mean that the generated information must also be backed up by supportive political, policy, communications, awareness and capacity frameworks. Chapter 5 points to additional tools and measures that can be used to convince stakeholders and decision-makers. By changing the way in which projects are designed, programmes planned and policies formulated, they make ecosystem values a part of their water business.

Chapter 2

Correcting the Balance Sheet

Before moving into the techniques of economic valuation, it is useful to first take a step back and look at the framework within which it can help improve decision-making. This entails the acknowledgement of the different links between ecosystems and water and understanding how they support a wide range of production and consumption processes. Recognition of the wide range of benefits of healthy ecosystems is necessary to meet sustainable development goals, invest wisely in development projects, and implement a valuation exercise. Within that framework, the valuation study needs to pick specific benefits for evaluation, in order to respond effectively to the specific water management issue at hand.

2.1 Why ecosystems and water are inextricably linked

It is first useful to consider what is exactly under scrutiny when we value ecosystem goods and services. A valuation exercise is basically concerned with the functions or biophysical processes that take place within ecosystems, which in turn generate particular goods and services for humankind.[4] This can be simply defined as the conditions and relationships through which natural ecosystems, and the species that make them up, sustain and fulfil human life.[5] In the water context, this translates to the contribution that ecosystems make to water supply and quality, and the ways in which they use water to generate other economic goods and services (Table 1).

It is self-evident that the exact nature, and magnitude, of these services will depend on the type, size, complexity and physical characteristics, state and management of the ecosystem in question – as well as to the alternative land use to which one is comparing it.[7] However, it is possible to define two broad categories of water-related ecosystem goods and services, those linked to water supply, and those linked to water demand:

Supply-side: the services that ecosystems provide as components in the water supply chain, including:

- Maintenance of waterflow and supplies, for example replenishment of water sources, water storage and regulation of flows.
- Regulation of water quality, for example wastewater purification and control of sedimentation and siltation.
- Miminisation of water-related hazards and disasters, for example flood attenuation, and maintenance of water supplies in dry seasons and droughts.

Demand-side: the goods and services that ecosystems provide that are related to their demand for and use of water, including:

- Maintenance of aquatic and terrestrial resource productivity and the associated products that this yields, for example fisheries, plants, pasture and forest products.

It is these goods and services that have to be considered when talking of the linkages between ecosystems, water and the economy.

Table 1: Forests and wetlands: ecosystem water services[6]

WETLANDS	FORESTS
Water supply and flow regulation Through their role in the hydrological cycle, rivers, lakes and underground aquifers provide a renewable source of fresh water. Most types of wetlands store, regulate and recharge both surface and sub-surface water supplies, as well as groundwater. By acting as reservoirs and sponges for holding water, wetlands also tend to help to even out water releases over time. They can delay and even out peak flow releases, thereby attenuating downstream flooding. In the dry season, they can act as storage reservoirs and gradually release water so as to maintain flows.	**Water supply and flow regulation** Forest cover helps to break the impact of rainfall, and forest vegetation takes up the water, meaning that it percolates steadily into the soil or runs off into streams and rivers gradually. Forest soils also usually have a higher water storage capacity than non-forest soils. By slowing the rate of runoff, forests can help to minimise flooding and may sometimes also increase minimum stream flows during the dry season.
Water quality Many types of wetlands absorb, filter, process and dilute nutrients, pollutants and wastes. They tend to have a high nutrient retention capacity, and are effective in removing bacteria and microbes. Wetlands plants physically, chemically and biologically eliminate pollutants and trap sediments; suspended solids, pollutants and pathogenic organisms accumulate and decompose in wetland bottom sediments; and wetlands help to dilute pollutants.	**Silt and sediment control** Ground cover, understorey forest vegetation and leaf litter protect the soil from the impact of rain that falls through the canopy. Extensive root systems help hold soil more firmly in place and resist landslides. This generally acts to minimise the sediment and silt loads carried downstream by watercourses.
Aquatic productivity Wetlands occupy an important niche in the food chain. They provide a rich source of nutrients for all forms of life, including fish, and are favoured breeding grounds and nurseries for both freshwater and marine species. A wide range of products are harvested from wetlands, such as fish and other aquatic species, construction materials, fuel, wild foods and medicines, fodder and pasture, etc.	**Water quality** Forest soils are more waterlogged than most other soils and contain more nutrients, allowing them to filter out contaminants. Clearing and cultivating forest

2.2 Ecosystem services contribute to the economy

These demand and supply-side linkages are not just biological, ecological or hydrological. Ecosystem water demand and ecosystem water supply also provide support to a wide range of production and consumption processes - and as such, they typically have a high economic value. Ecosystem water values are reflected in economic output and production, in consumption, as costs saved and as expenditures minimised. They accrue in many different forms, to many different groups and sectors.

"FRESHWATER ECOSYSTEMS TYPICALLY HAVE A HIGH ECONOMIC VALUE."

For example, wetland resources support a large percentage of the human population, especially poorer groups, and wetland services offer water supply and quality benefits that are often essential to maintaining a basic standard of living in both urban and rural areas. The wetlands in the Pallisa District of Uganda exemplify this point.

Case 1: The value of water-based ecosystems for urban and rural livelihoods in Pallisa District, Uganda[8]

Pallisa District lies in Eastern Uganda, containing a population of almost half a million people and covering an area of just under 2,000 km2. More than a third of the District, or 71,100 hectare, is occupied by wetlands, which form an important part of local livelihood systems. Yet, although wetland goods and services generate high economic benefits, little is known about these values. As a result, wetlands are often seen by District and National planners as "wastelands", rather than as valuable stocks of natural capital which, if managed sustainably and used wisely, can yield a flow of economic benefits for current and future generations.

Most of the inundated and flood recession areas in and around Pallisa's wetlands are used for subsistence agriculture, mainly rice growing, and for grazing. Wetlands provide a wide range of other benefits to local communities, including handcraft and building materials, food resources such as fish and wild vegetables, medicine for various ailments, and transport. Wetlands also provide other services which are valuable for both rural farmers and for the District's urban population, such as flood control, water purification, and maintenance of year-round water supplies for urban, industrial and irrigated agricultural use.

In total, wetland goods and services have been calculated to be worth more than $34 million a year to the Pallisa District economy, or almost $500/ha, including both direct and indirect use values as well as value-added through processing and marketing wetland products. The majority of value accrues at the household subsistence level, although wetland resource use and marketing also generates appreciable local income, and generates revenues and cost-savings for the District government.

Wetland resources have a particularly high value, both in absolute terms and relative to other sources of livelihood, for poorer and more vulnerable sectors of the population and for women. As well as yielding a large proportion of people's day-to-day income and subsistence, they constitute a vital source of fallback and security during drought, dry seasons and when other sources of production (such as crops) fail. Wetland services also provide an important source of economic and development support. In particular, their water supply and quality services play an important role in filling the gap between the level of basic services that a rapidly growing urban population requires, and those which the government are currently able to provide.

More evidence for the fact that millions of people, from small villages to large industries, rely on the products, earnings and employment that aquatic resources and water-dependent ecosystems provide, comes from the case of the Indus Delta of Pakistan.

Case 2: The costs of allocating inadequate freshwater to ecosystems in the Indus Delta, Pakistan[9]

Pakistan's vast irrigation network comprises three major storage reservoirs, 19 barrages or head-works, 43 main canals with a conveyance length of 57,000 km, and 89,000 watercourses with a running length of more than 1.65 million km. They feed more than 15 million hectares of farmland, affording the country the highest irrigated to rain-fed agricultural land ratio in the world. Unsurprisingly, water use for irrigation accounts for a major proportion of the volume of river abstractions.

The Indus is one of Pakistan's most important river systems, with a total length of more than 3,000 km, a drainage area of some 950,000 km2 and a total available freshwater flow of about 180 billion m3. Over the last sixty years a series of dams, barrages and irrigation schemes have been built in upstream areas of the Indus, and are used to feed more than 80% of the country's irrigated farmland.

As a result of this upstream water abstraction, there is inadequate downstream flow left to maintain the natural ecosystems of the Delta area, where the Indus River flows out into the Arabian Sea. Land in the area has become unsuitable for agriculture, and potable water sources have become very scarce or have disappeared altogether. In Thatta District, which is located on the mouth of the Delta, mangrove areas have suffered heavy destruction, almost a third of land has been affected by saltwater intrusion and about 12% of cultivable land has been lost.

The ecosystem degradation that has occurred as a result of low freshwater flows has had devastating economic impacts. A wide range of land and resource opportunities have diminished or disappeared altogether in the Indus Delta area, including arable and livestock production, fisheries and forest products collection. This has impacted on annual catches from mangrove-dependent fish species worth more than $20 million a year, fuelwood to a value of more than $0.5 million, fodder and pasture of almost $1.5 million and crop production worth hundreds of thousands of dollars. As more than three quarters of the local population depend on these products for their livelihoods, there has been a resulting mass migration out of the area.

2.3 Ecosystem values have been ignored in decision-making

Unfortunately, decision-makers and planners in the water world and in other development and economic sectors have traditionally paid little attention to such benefits, despite their high economic value. The role of ecosystems in water demand and supply has persistently been under-valued in economic terms.

In fact, the problem is not that ecosystems have no economic value in relation to water, but rather that this value is poorly understood, rarely articulated, and as a result is frequently omitted from decision-making. Conventional economic analysis decrees that the "best" or most efficient allocation of resources is one that maximises economic returns. This principle has not been put fully into practice: calculations of the returns to different land, resource and investment options have for the most part failed to deal adequately with ecosystem values. As such, their workings and results remain incomplete.

"ECOSYSTEM VALUES ARE POORLY UNDERSTOOD, RARELY ARTICULATED AND FREQUENTLY OMITTED FROM DECISION-MAKING."

Under-valuation leads to the marginalisation of ecosystems when land use decisions are made, water is allocated and infrastructure developments are planned. Decision-makers have in the past seen little economic or financial benefit of managing ecosystems as part of water infrastructure and few economic or financial costs arising from their degradation and loss.

The classic problem of ecosystem under-valuation is a common theme in the examples presented above. Wetlands such as Pallisa continue to be reclaimed because they are seen as an uneconomic use of land which could be better developed to generate profits and development benefits through other means (Case 1). Inadequate freshwater flows are allocated to downstream ecosystems such as the Indus Delta, because they are not considered as productive water uses when compared to the immediate short-term benefits of irrigated agriculture (Case 2). Investment appraisals, project assessments and policy analyses rarely consider the economic benefits of investing in ecosystems as part of water supply, or the economic costs of ecosystem degradation and loss resulting from insufficient water allocation.

Such omissions have had devastating impacts on the status of the natural ecosystems that themselves generate water goods and services. They have suffered persistently from a lack of funding and a lack of water, and have been subjected to a range of destructive land and resource uses. Also, because they under-value ecosystems, water decisions have tended to have been made on the basis of only partial information, and have thus favoured short-term (and often unsustainable) development imperatives.

"UNDER-VALUATION MAY UNDERMINE WATER AVAILABILITY, WATER PROFITS AND SUSTAINABLE DEVELOPMENT GOALS."

In the absence of information about ecosystem values, substantial misallocation of resources has occurred and gone unrecognised,[10]and immense economic costs have often arisen. Under-valuation impacts on the status and integrity of natural ecosystems themselves, and also runs the risk of undermining water availability, water profits and sustainable development goals.

2.4 Inclusion of ecosystem values benefits investors

In many cases ecosystem under-valuation has proved to be economically short-sighted as regards water users' and investors' expectations of future payments and paybacks. It is increasingly apparent that investment in ecosystems now can safeguard profits in the future, and save considerable costs. For instance, wise management of ecosystems for water services can help to prolong the economic lifespan of dams and reservoirs, ensure future domestic and industrial water supplies, and maintain the productivity of commercially valuable fish and plant stocks.

Ecosystem management often proves to be much more cost-effective than employing artificial technologies or taking mitigative measures when essential goods and services are lost. Conserving an upstream forest, for example, typically costs far less than investing in new water filtration and treatment plants, or undertaking expensive de-siltation activities, when these services are lost. Maintaining wetlands for flood control is usually a cheaper option than rebuilding roads, bridges and buildings that get washed away by floods. Declining future profits, increasing future costs, and additional remedial measures are all more expensive for water investors. They are also costs that are typically passed on to the consumers or end-users of water products in terms of higher charges and fees or lower quality services. In reality, few people gain over the long-term from ecosystem loss and degradation.

"INVESTMENTS IN ECOSYSTEMS NOW CAN SAFEGUARD PROFITS IN FUTURE."

Overall, it is estimated that about 13% of the world's land area is needed to protect water supplies, an area which will grow as the world's population increases.[11] This target is nowhere near being met - even though there would be significant economic benefits from doing so. For example, in Portland Oregon, Portland Maine and Seattle Washington it has been found that every US$ 1 invested in watershed protection can save anywhere from US$ 7.50 to nearly US$ 200 in costs for new water treatment and filtration facilities.[12] Through conserving upstream forests in the Catskills range, New York City hopes to have avoided investing an extra US$ 4-6 billion on infrastructure to maintain the quality of urban water supplies.[13] In Vientiane, the capital of Lao PDR, wetlands offer flood attenuation and wastewater treatment services at a value of US$ 2 million per year,[14] which existing urban infrastructure is unable to provide. It has been estimated that these ecosystem services constitute investment savings of more than $18 million in damage costs avoided and $1.5 million in the artificial technologies that would be required to fulfil the same functions.[15]

2.5 Ecosystem values help achieve sustainable development

Ecosystem under-valuation also matters to sustainable development, and particularly to the poverty alleviation goals that have become the driving force behind today's government socio-economic policies and donor aid programmes.

At local, national and international levels, a series of elaborate targets are set as regards economic growth, reduction in the incidence of poverty, and improved access to water and sanitation. On a global scale, the WSSD Plan of Implementation and Millennium Development Goals aim to halve the proportion of the world's people whose income is less than US$ 1 a day, who suffer from hunger, who lack safe drinking water, and who do not have access to basic sanitation by 2015. Recognising the value of ecosystems, and investing in them accordingly, will be key to achieving these goals, and improving sustainable development indicators over the long-term.

Ecosystems, and the water goods and services they yield, will also continue to provide a vital lifeline for the poorest until such a time these sustainable development and poverty alleviation goals are met. Still, more than one billion people lack access to safe drinking water and perhaps as many as three billion do not have basic sanitation services.[16] 800 million people are chronically malnourished and approximately a third of the world's population lack food security.[17] Ecosystems are often the only source of these water-related goods and services that are accessible or affordable to the poorest sectors of the population, their only fallback in times of stress, and their only protection against disasters such as floods and drought.

"ECOSYSTEMS CONTINUE TO PROVIDE A VITAL LIFELINE FOR THE POOREST."

The existence value of ecosystems is illustrated by the morning bath Hindus take in the river Ganges, India.

The sustainable development benefits of water-related ecosystem goods and services are considerable. In Lao PDR, for example, fish and other aquatic animals comprise between one third and one half of total protein consumption at the national level, contribute over a fifth of income and subsistence for the country's predominantly rural population, and are worth an estimated US$ 100 million a year.[18] In Uganda, the use of inland water resources is worth almost US$ 300 million a year, forest catchment protection and erosion control services contribute more than US$ 100 million a year to the national economy, and almost one million urban dwellers rely on natural wetlands for wastewater retention and purification services.[19] Work carried out in the Zambezi Basin in Southern Africa shows that natural wetlands have a net present value of more than US$ 3 million in reducing flood-related damage costs, are worth some US$ 16 million in terms of groundwater recharge, and generate water purification and treatment services to an estimated US$ 45 million.[20]

Ecosystems yield appreciable economic and development values through providing these basic goods and services. They are especially important to the poorest for their basic production and consumption, who can ill-afford to obtain these elsewhere. Ignoring these benefits may jeopardise the provision of economically important goods and services that are worth so much for human populations, sustainable development and poverty alleviation.

2.6 Using total economic value to assess water-ecosystem links

It has become apparent that under-valuation of the economically important goods and services that ecosystems provide can prove to be a costly exercise. It damages the environment, and the many people, industries and investors who rely on clean and reliable water supplies. Ignoring the goods that ecosystems generate means making economic decisions that ultimately undermine the provision of these valuable sources of production, consumption and life support. There are long-term costs to these omissions, for example through reduced profits, diminished food security, and high expenditures required to replace them or mitigate the effects of their loss.

It is also clear that if these costs are to be avoided in the future, and economic and financial benefits are to be secured for water users and investors, then there needs to be a major shift in the way in which ecosystem water values are conceptualised, expressed and analysed.

A major reason that ecosystems have been under-valued for water is that concepts of economic value have, traditionally, been based on a very narrow definition of benefits. Economists have tended to see the value of ecosystems just in terms of raw materials and physical products that are traded in formal markets. However, such direct uses represent only a small proportion of the total value of ecosystems, which generate economic benefits and services far in excess of physical or marketed products.

Excluding these wider benefits from concepts of economic value has meant that some of the most important water-related goods and services that are yielded by ecosystems have been ignored. Despite their high economic value and importance, many ecosystem goods and services do not appear as directly traded products or raw materials. Therefore, quite simply, they have dropped out of the economic equations and accounts that govern water allocation, water use and water development.

Luckily, there is light at the end of the tunnel. Over recent years, economic definitions have advanced. They are now much better able to cope with ecosystem goods and services, including water-related ones. The concept of total economic value was introduced a decade or so ago,[21] and has now become one of the most widely-used frameworks for identifying and categorising environmental benefits.[22] Instead of focusing only on direct commercial values, total economic value also encompasses subsistence and non-market benefits, ecosystem services and non-use values.

"THE CONCEPT OF 'TOTAL ECONOMIC VALUE' CAPTURES THE MANY BENEFITS OF ECOSYSTEMS."

Total economic value thus provides a useful framework for considering water-related ecosystem goods and services, and for factoring them into economic calculations. Looking at the total economic value of ecosystems essentially involves considering their full range of characteristics as integrated systems: resource stocks or assets, flows of environmental services, and the attributes of the ecosystem as a whole. In other words, it incorporates all of the different present and future, marketed and non-marketed, goods and services that ecosystems generate in relation to water.

Broadly defined, the total economic value of ecosystems for water includes (Table 2):

- Direct values: water-based or water-dependent raw materials and physical products which are used directly for production, consumption and sale such as those providing energy,shelter, foods, agricultural production, timber, medicines, transport and recreational facilities.
- Indirect values: ecological services that maintain and protect natural and human systems, such as maintenance of water quality and flow, flood control and storm protection, nutrient retention and micro-climate stabilisation, and the production and consumption activities they support.
- Option values: the premium placed on maintaining a pool of water-based or water-dependent species, genetic resources and landscapes for future possible uses, some of which may not be known now, such as leisure, commercial, industrial, agricultural and pharmaceutical applications and water-based developments.
- Existence values: the intrinsic value of water-related ecosystems and their component parts, regardless of their current or future use possibilities, such as cultural, aesthetic, heritage and bequest significance.

Table 2: The total economic value of ecosystems for water

USE VALUES	*NON- USE VALUES*
Direct values Outputs that can be consumed or processed directly, such as timber, fodder, fuel, non-timber forest products, fish, meat, medicines, wild foods, etc.	**Existence values** Intrinsic value of resources and landscapes, irrespective of its use such as cultural, aesthetic, bequest significance, etc.
Indirect values Ecological services, such as flood control, regulation of water flows and supplies, carbon sequestration, nutrient retention, climate regulation, etc.	
Option values Premium placed on maintaining resources and landscapes for future possible direct and indirect uses, some of which may not be known now.	

2.7 Setting the scope of valuation

The concept of total economic value is useful to define the broad parameters of a valuation study, and assess the economic linkages between a particular ecosystem and water goods and services. But it is rarely necessary, appropriate, or even possible, to quantify each and every component of the total economic value of an ecosystem. Only in a few cases are studies of total economic value policy-relevant and useful: for example where an ecosystem is facing complete and irreversible destruction, or in raising awareness about the multiple values of ecosystems to the whole economy.

"VALUATION FOCUSES ON SPECIFIC VALUES, DEPENDING ON THE WATER MANAGEMENT ISSUE."

Yet in the majority of cases, the focus will be only on certain elements of the total economic value of an ecosystem. Which elements these are, and how far the valuation goes, will depend very much on the aims, focus and water management issue that is being addressed and the type of decision that is being analysed. For example, in many cases it just is not possible to express option or existence values in monetary terms. Quantifying the returns to timber and non-timber product use may not be useful or necessary in a study to assess the economic value of forest catchment services for downstream hydropower schemes. Presenting a development justification for ecosystem restoration may focus only on the direct use values of ecosystem resources for poor households or the local economy.

The examples of ecosystem valuation that are presented below, in Chapters 3 and 4, demonstrate this point – they describe partial economic valuation studies, which are targeted to particular goals, management issues, or types of benefits, costs and beneficiaries.


WATER SUPPLY
WATER PURIFICATION

Chapter 3

Valuing ecosystems as water infrastructure

It is within this framework of total economic value that water-ecosystem linkages can best be understood and expressed in economic terms. Total economic value provides a framework to assess the economic benefits of ecosystems for water and to select those that will form the focus of a particular study.

Having defined the total economic value of ecosystems for water, a next step is to fill in the gaps by generating the figures that express ecosystem values in quantifiable terms. For many years, these methods were just not available, or even where they were available they were rarely used by economic planners and decision-makers.

"A WIDE RANGE OF METHODS ARE AVAILABLE TO VALUE ECOSYSTEM BENEFITS."

Parallel to the advances that have been made in the definition and conceptualisation of total economic value, techniques for quantifying environmental benefits and expressing those in monetary terms have also moved forward over the last decade.[23] Today, a wide range of methods are available, and used, for valuing ecosystem water benefits. These techniques are described in the following sections.

3.1 Quantifying ecosystem values for decision-making

It is indisputable that ecosystems are under-valued when water decisions are made, and that this often acts to the detriment of water sector goals and interests. Still, one may question why there is a need to express ecosystem benefits in monetary terms. Multiple factors influence water decisions, and there are many ways in which the role of ecosystems in water demand and supply is under-valued - in social, cultural and spiritual terms, for example. So why the focus on monetary valuation?

An answer is that economic concerns remain a powerful determinant of how people behave, how decisions are made and how policies are formulated (the role of ecosystem valuation in economic decision-support tools, such as cost-benefit analysis, is discussed in Chapter 4). Money is also a basic, and comparable, indicator of economic value. For these reasons, economic valuation can provide a convincing argument for placing ecosystems on the water agenda - even though it is certainly not the only consideration when people make decisions about water. It is also a good way of measuring ecosystem benefits in terms that can be judged alongside other economic sectors and activities.

"VALUATION MAKES ECOSYSTEM GOODS AND SERVICES COMPARABLE WITH OTHER SECTORS WHEN INVESTMENTS ARE APPRAISED."

The basic aim of valuation is to determine people's preferences: how much they are willing to pay for ecosystem goods and services, and how much better or worse off they would consider themselves to be as a result of changes in their supply. By expressing these preferences, valuation aims to level the playing field. It makes ecosystem goods and services directly comparable with other sectors of the economy when investments are appraised, activities are planned, policies are formulated, or resource use decisions are made. Although a better understanding of the economic value of ecosystems does not necessarily favour their conservation and sustainable use, it at least permits them to be considered as economically productive systems, alongside other possible uses of water, land, resources and funds.

3.2 A summary of ecosystem valuation techniques

A wide range of techniques now exist to value the different components of the total economic value of ecosystems, the most commonly-used of which can be broadly categorised into five main groups (Figure 1):

- *Market prices:* This approach looks at the market price of ecosystem goods and services.

- *Production function approaches:* These approaches, including effect on production, attempt to relate changes in the output of a marketed good or service to a measurable change in the quality of quantity of ecosystem goods and services by establishing a biophysical or dose-response relationship between ecosystem quality, the provision of particular services, and related production.

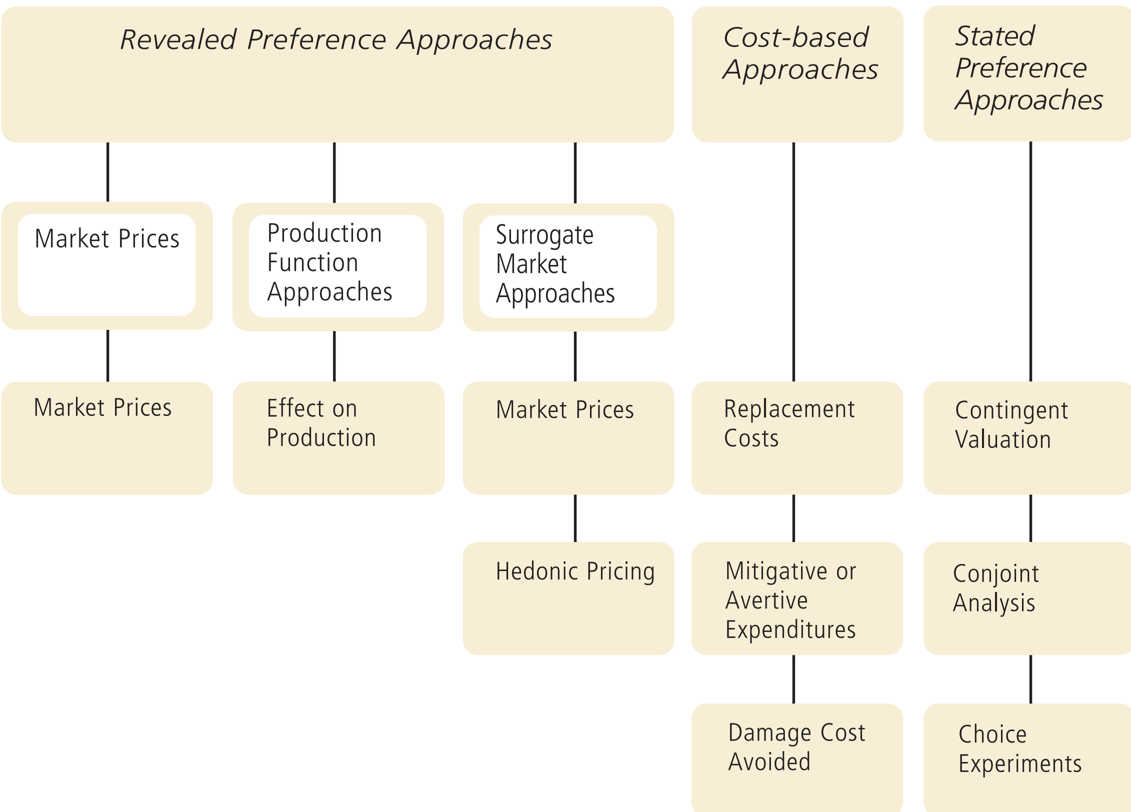
People gather water from a huge well in the village of Natwarghad, India during the drought of 2003

- *Surrogate market approaches:* These approaches, including travel costs and hedonic pricing, look at the ways in which the value of ecosystem goods and services are reflected indirectly in people's expenditures, or in the prices of other market goods and services.

- *Cost-based approaches:* These approaches, including replacement costs, mitigative or avertive expenditures and damage costs avoided, look at the market trade-offs or costs avoided of maintaining ecosystems for their goods and services.

- *Stated preference approaches:* Rather than looking at the way in which people reveal their preferences for ecosystem goods and services through market production and consumption, these approaches ask consumers to state their preference directly. The most well-known technique is contingent valuation, while less commonly-used stated preference valuation methods include conjoint analysis and choice experiments.

Figure 1: Categories of commonly-used ecosystem valuation methods



The sections on the next pages describe how each of these methods can be used, in practice, to value ecosystem water services.

3.2.1 Market price techniques

Overview of the method

The simplest, most straightforward and commonly-used method for valuing any good or service is to look at its market price: how much it costs to buy, or what it is worth to sell. In a well-operating and competitive[24] market these prices are determined by the relative demand for and supply of the good or service in question, reflect its true scarcity, and equate to its marginal value.[25]

"THE SIMPLEST METHOD IS TO LOOK AT THE MARKET PRICE OF GOODS AND SERVICES."

In theory, market price techniques are applicable to any ecosystem good or service that can be freely bought or sold. They are particularly useful for valuing the resources and products that are harvested from water-dependent ecosystems, for example timber, fuelwood, fish, or non-timber forest products. For example, the case of the Zambezi Basin estimated the value of wetland products including crops, livestock, fish and tourism using market prices.

Case 3: Using market price techniques to value freshwater wetlands in the Zambezi Basin, Southern Africa[26]

The Zambezi River runs through Angola, Zambia, Botswana, Namibia, Zimbabwe, Malawi and Mozambique in Southern Africa. It is associated with a large number of wetlands, which yield a wide range of economically valuable goods and services. Wetland-dependent products and services include flood recession agriculture, fish, wildlife, grazing, forest resources, natural products and medicines and ecotourism.

A study was carried out to estimate the value of the Zambezi's wetland goods using market price techniques. First, an inventory of the products and services was made for each wetland. Market prices were then used to calculate the value derived from each wetland. Crops and livestock were valued at their production value, and fish catches were valued according to their local sale price. Tourism earnings and utilisation charges were used to calculate the value of wildlife, and the market price of wetland products was applied to natural resource use. Donor contributions were assumed to reflect biodiversity conservation values.

Inputs and other production costs were deducted from these figures, so as to yield the marginal value of wetland resources. Total use values were extrapolated through making assumptions about the extent and intensity of wetland land and resource use. This yielded a marginal value of $145 million a year for the 10 major wetlands in the Zambezi Basin, or an average of $48 per hectare.

Data collection and analysis requirements

There are three main steps involved in collecting and analysing the data required to use market price techniques to value ecosystem goods and services:

- Find out the quantity of the good used, produced or exchanged;
- Collect data on its market price;
- Multiply price by quantity to determine its value.

These data are generally easy to collect and analyse. Market information, including historical trends, can usually be obtained from a wide variety of sources such as government statistics, income and expenditure surveys, or market research studies. In most cases it will be necessary to supplement these secondary sources with original data, for example through performing market checks or conducting some form of socio-economic survey.

When applying this technique it is important to ensure that the data collected covers an adequate period of time and sample of consumers and/or producers. Factors to bear in mind include the possibility that prices, consumption and production may vary between seasons, for different socio-economic groups, at different stages of the marketing or value-added chain, and in different locations.

Applicability, strengths and weaknesses

The greatest advantage of this technique is that it is relatively easy to use, as it relies on observing actual market behaviour. Few assumptions, little detailed modelling, and only simple statistical analysis are required to apply it.

"MANY ECOSYSTEM GOODS AND SERVICES DO NOT HAVE MARKETS."

A major disadvantage is the fact that many ecosystem goods and services do not have markets or are subject to markets which are highly distorted or irregular. In such cases, it is inappropriate to use market price techniques:

- Ecosystem services such as catchment protection or nutrient retention are rarely available for purchase or sale. Because they have many of the characteristics of public goods,[27] it is in fact questionable whether the market can ever accurately allocate or price them.
- Many ecosystem goods and natural products are utilised at the subsistence level. They are not traded in formal markets, and are consumed only within the household.
- There exist a wide variety of subsidies and market interventions which distort the price of natural products or ecosystem-dependent goods. Examples include subsidies to water and electricity, centrally-set royalties and fees for products such as timber, and state controlled prices for basic food and consumer items.
- Because markets for most ecosystem goods and services are not well-developed, they tend not to be competitive, and prices are a poor indicator of true social and economic values. This may be the case where there is an additional social or environmental premium attached to natural goods and services, where there are only a small number of buyers and sellers, or where there is imperfect market information.
- In many cases, even where an ecosystem good has a market and a price, it is impossible to measure the quantities produced or consumed. Especially at the subsistence level, natural resource consumption and sale is often highly seasonal or irregular. For example, particular products are only available at particular times of the year, are used under special conditions, or are collected and used on an opportunistic basis. Ecosystem goods are also often collected and consumed as part of a bundle of items or have high levels of substitution[28].or complementarity[29].with other goods. For example, they are used only when other products are unavailable or unaffordable, or they form occasional inputs into the production of other goods.
- Even where an ecosystem good or service has a market, and quantities bought or sold can be measured, prices do not tell us how important this good or service is to society, nor how much some buyers would actually be willing to pay.

In such cases it is usually necessary to use alternative valuation techniques, such as those described on the next pages.

3.2.2 Effect on production techniques

Overview of the method

Even when ecosystem goods and services do not themselves have a market price, other marketed products often rely on them as basic inputs. For example, downstream hydropower and irrigation depend on upper catchment protection services, fisheries depend on clean water supplies, and many sources of industrial production utilise natural products as raw materials. In these cases it is possible to assess the value of ecosystem goods and services by looking at their contribution to other sources of production, and to assess the effects of a change in the quality or quantity of ecosystem goods and services on these broader outputs and profits.

"DOWNSTREAM HYDROPOWER AND IRRIGATION DEPEND ON UPPER CATCHMENT PROTECTION."

Effect on production techniques can thus be used to value ecosystem goods and services that clearly form a part of other, marketed, sources of production - for example watershed protection and water quality services, or natural resources that are used as raw materials. In the cases below both the value of flood attenuation benefits and the hydrological value of cloud forests were estimated through contributions to crop production.

Case 4: Using effect on production techniques to value forest flood attenuation benefits in Eastern Madagascar[30]

This study looked at the value of Mantadia National Park in conserving the upland forests that form the watershed for the Vohitra River in Eastern Madagascar. It employed effect on production techniques to do so. The productivity analysis measured the forest's watershed benefits in terms of increased economic welfare for farmers. These benefits result from reduced flooding as a consequence of reduced deforestation, which is in turn associated with the establishment of the national park and buffer zone.

The study used a three stage model to examine the relationship between economic value and the biophysical dimensions of the protected area. First, a relationship between land use changes and the extent of downstream flooding was established. Remote sensing was used to construct a deforestation history of the study area, and to ascertain an annual deforestation rate. Records of monthly river discharge were analysed for flood frequency and time trend, and the effects of land conversion on flooding were quantified.

A second stage was to ascertain the impacts of increased flooding on crop production. Flood damage to crops was estimated taking into account a range of parameters such as area of inundation, flood depth, duration, seasonality and frequency. Analysis focused on paddy rice cultivation, a high value and locally important form of agricultural production which is tied closely to flooding.

The final stage in the valuation study was to adopt a productivity analysis approach to evaluate flood damage in terms of lost producer surplus. The economic impact of changes in ecosystem quality was established using the net market value of paddy damaged by flooding. This found that a net present value for forest watershed protection benefits of $126,700 resulting from the establishment of Mantadia National Park.

Case 5: Using effect on production techniques to value the role of cloud forests in water supply in Guatemala[31]

This study looked at the value of the services that cloud forests provide in assuring water supply via the horizontal precipitation that adds extra water to the hydrological cycle. It focused on the hydrological and socio-economic benefits of cloud forests in the Sierra de las Minas Biosphere Reserve in Guatemala. More than sixty permanent rivers flow out of this protected forest area, providing water for irrigation, domestic supplies, industry and hydropower.

The study focused on the value of cloud forest water services for irrigated agriculture. Thousands of campesinos and numerous large-scale farms depend on the rivers that rise in the Sierra de las Minas Biosphere Reserve to irrigate basic staples such as maize and beans, traditional cash crops such as sugar-cane and coffee, and export crops such as melons, tobacco, cardamom, grapes and vegetables.

First, the study measured horizontal precipitation in the cloud forests, and related the effects of land use to stream flow. Then socio-economic surveys were carried out to determine the value of irrigation, and to relate the extent of irrigation to available stream flow. The value of water used for irrigation was assessed by comparing the productivity of irrigated agriculture with rain-fed farming, which is carried out in areas where irrigation is not possible. The study assumed that between 20-30% deforestation took place in two river basins, meaning that irrigated land was taken out of production as a result of reduced stream flow. The cost of this deforestation and reduced stream flow was calculated at between $15,000 and $52,000 in terms of lost agricultural net profits.

Data collection and analysis requirements

There are three main steps to collect and analyse the data required for effect on production techniques to value ecosystem goods and services:

- Determine the contribution of ecosystem goods and services to the related source of production, and specify the relationship between changes in the quality or quantity of a particular ecosystem good or service and output;
- Relate a specified change in the provision of the ecosystem good or service to a physical change in the output or availability of the related product;
- Estimate the market value of the change in production.

Effect on production techniques rely on a simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem-dependent products (see above, market price techniques).

The most difficult aspect of this method is determining and quantifying the biophysical or dose-response relationship that links changes in the supply or quality of ecosystem goods and services with other sources of production. For example, detailed data are required to relate catchment deforestation to a particular rate of soil erosion, consequent siltation of a hydropower dam and reduced power outputs, or to assess exactly the impacts of the loss of wetland habitat and water purification services on local fisheries production. To be able to specify these kinds of relationships with confidence usually involves wide consultation with other experts, and may require situation-specific laboratory or field research, controlled experiments, detailed modelling and statistical regression.

Applicability, strengths and weaknesses

Effect on production techniques are commonly used, and have applicability to a wide range of ecosystem goods and services. Their weakness relates to the difficulties that are often involved in collecting sufficient data to be able to accurately predict the biophysical or dose-response relationships upon which the technique is based. Such relationships are often unclear, unproven, or hard to demonstrate in quantified terms. Simplifying assumptions are often needed to apply the production function approach.

An additional concern is the large number of possible influences on product markets and prices. Some of these should be excluded when using effect on production techniques. In some cases changes in the provision of an ecosystem good or service may lead not just to a change in related production, but also to a change in the price of its outputs. That product may become scarcer, or more costly to produce. In other cases consumers and producers may switch to other products or technologies in response to ecosystem change or to a scarcity of ecosystem goods and services. Furthermore, general trends and exogenous factors unrelated to ecosystem goods and services may influence the market price of related production and consumption items. They must be isolated and eliminated from analysis.

3.2.3 Travel cost techniques

Overview of the method

Ecosystems often hold a high value as recreational resources or leisure destinations. Even when there is no direct charge made to enjoy these benefits, people still spend time and money to visit ecosystems. These travel costs can be taken as an expression of the recreational value of ecosystems. We can use this technique at the whole ecosystem level, taking into account all of its attributes and components in combination, or for specific goods or services such as rare wildlife, opportunities for extractive utilisation of products such as fishing or resource collection, or for activities such as hiking or boating that are related to its services.

"PEOPLE SPEND TIME AND MONEY TO VISIT ECOSYSTEMS."

For example, in the next two cases the value of tropical forest tourism (Case 6) and improved freshwater ecosystem quality (Case 7) were estimated through looking at visitor travel costs.

Case 6: Using travel cost techniques to value tropical rainforest tourism in Costa Rica[32]

The Monteverde Cloud Forest Biological Reserve is an important recreational destination for both foreign tourists and domestic visitors. In 1988 more than 3,000 Costa Ricans visited the Reserve. A study was carried out to estimate the domestic recreational value of Monteverde, using travel cost techniques.

Survey questionnaires were prepared and distributed to visitors, and collected at the Reserve Headquarters. These obtained a variety of information about the costs of visiting Monteverde, and the socio-economic characteristics of the respondent. The opportunity to win wildlife photographs was offered as an incentive for visitors to fill in the survey forms.

The survey treated each cantón of Costa Rica as an observation zone, and calculated visitation rates per cantón by dividing the observed number of trips by census populations. Distances between each cantón and the Reserve along main roads and access routes were measured on maps. Travel costs per kilometre were calculated to include out-of-pocket expenses, a proportion of fixed costs, and travel time. A linear demand function was then constructed relating visitation rates to these travel costs. A travel cost of $0.15 per kilometre yielded an annual consumer surplus of between $2.4 million and $2.9 million, or about $35 per domestic visit.

Free-flowing rivers in Norway allow kayaking and support a wide range of tourism and recreational opportunities

Case 7: Using travel cost techniques to value the impacts of improved environmental quality on freshwater recreation in the US[33]

The Conservation Reserve Programme (CRP) in the United States aims to mitigate the environmental effects of agriculture. A study was carried out to see how non-market valuation models could help in targeting conservation programmes such as the CRP. One component of this study focused on the impacts of improved environmental quality on freshwater recreation.

This study was based on data generated by surveys that had been carried out to ascertain the value of water-based recreation, fishing, hunting and wildlife. These surveys sampled 1,500 respondents in four sub-State regions who were asked to recall the number of visits made over the last year to wetlands, lakes and rivers where water was an important reason for their trip. The cost of these trips was imputed using the travel cost method.

The influence of CRP programmes on improved environmental quality and on consumer welfare was then modelled. The study found that the combined benefit of all freshwater-based recreation in the US was worth slightly over $37 billion a year. The contribution of CRP efforts to environmental quality, as reflected in recreational travel values, was estimated at just over $35 million, or about $2.57 per hectare.

Data collection and analysis requirements

There are six main steps involved in collecting and analysing the data required to use travel cost techniques to value ecosystem goods and services:

- Ascertain the total area from which recreational visitors come to visit an ecosystem, and dividing this into zones within which travel costs are approximately equal;

- Within each zone, sample visitors to collect information about the costs incurred in visiting the ecosystem, motives for the trip, frequency of visits, site attributes and socio-economic variables such as the visitor's place of origin, income, age, education and so on;
- Obtain the visitation rates for each zone, and use this information to estimate the total number of visitor days per head of the local population;
- Estimate travel costs, including both direct expenses (such as fuel and fares, food, equipment, accommodation) and time spent on the trip;
- Carry out a statistical regression to test the relationship between visitation rates and other explanatory factors such as travel cost and socio-economic variables;
- Construct a demand curve relating number of visits to travel cost, model visitation rates at different prices, and calculate visitor consumer surplus.[34]

Travel cost techniques depend on a relatively large data set. Quite complex statistical analysis and modelling are required in order to construct visitor demand curves. Basic data are usually collected via visitor interviews and questionnaires, which make special efforts to cover different seasons or times of the year, and to ensure that various types of visitors from different locations are represented.

Applicability, strengths and weaknesses

The travel cost method is mainly limited to calculating recreational values, although it has in some cases been applied to the consumptive use of ecosystem goods.

Its main weakness is its dependence on large and detailed data sets, and relatively complex analytical techniques. Travel cost surveys are typically expensive and time consuming to carry out. An additional source of complication is that several factors make it difficult to isolate the value of a particular ecosystem in relation to travel costs, and these must be taken into account in order to avoid over-estimating ecosystem values. Visitors frequently have several motives or destinations on a single trip, some of which are unrelated to the ecosystem being studied. They also usually enjoy multiple aspects and attributes of a single ecosystem. In some cases travel, not the destination per se, may be an end in itself.

3.2.4 Hedonic pricing techniques

Overview of the method

Even if they do not have a market price themselves, the presence, absence or quality of ecosystem goods and services influences the price that people pay for, or accept for providing, other goods and services. Hedonic pricing techniques look at the difference in prices that can be ascribed to the existence or level of ecosystem goods and services. Most commonly this method examines differences in property prices and wage rates between two locations, which have different environmental qualities or landscape values. For example, in the case below the value of urban wetlands was estimated through looking at impacts on property prices.

Case 8: Using hedonic pricing techniques to value urban wetlands in the US[35]

This study aimed to value wetland environmental amenities in Portland, Oregon metropolitan region. It used hedonic pricing techniques to calculate urban residents' willingness to pay to live close to wetlands.

The study used a data set of almost 15,000 observations, with each observation representing a residential home sale. For each sale information was obtained about the property price and a variety of structural, neighbourhood and environmental characteristics associated with the property, as well as socio-economic characteristics associated with the buyer. Wetlands were classified into four types - open water, emergent vegetation, forested, and scrub-shrub - and their area and distance from the property were recorded.

The first stage analysis used ordinary least squares regression to estimate a hedonic price function relating property sales prices to the structural characteristics of the property, neighbourhood attributes, and amenity value of nearby wetlands and other environmental resources. The second stage analysis consisted of constructing a willingness-to-pay function for the size of the nearest wetland to a residence. Results showed that wetland proximity and size exerted a significant influence on property values, especially for open water and larger wetlands.

Data collection and analysis requirements

There are five main steps involved in collecting and analysing the data required to use hedonic pricing techniques to value ecosystem goods and services:

- Decide on the indicator to be used to measure the quality or quantity of an ecosystem good or service associated with a particular job or property;
- Specify the functional relationship between wages or property prices and all of the relevant attributes that are associated with them, including ecosystem goods and services;
- Collect data on wages or property prices in different situations and areas which have varying quality and quantity of ecosystem goods and services;
- Use multiple regression analysis to obtain a correlation between wages or property prices and the ecosystem good or service;
- Derive a demand curve for the ecosystem good or service.

Hedonic pricing techniques require the collection of a large amount of data, which must be subject to detailed and complex analysis. Data are usually gathered through market observation, questionnaires and interviews, which aim to represent a wide variety of situations and time periods.

"THE PROXIMITY OF OPEN WATER AND WETLANDS HAD A SIGNIFICANT INFLUENCE ON THE VALUE OF PROPERTIES."

Applicability, strengths and weaknesses

Although hedonic pricing techniques can, in theory, be applied to any good or service they are most commonly used within the context of wage and property markets.

In practice, there remain very few examples of the application of hedonic pricing techniques to water-related ecosystem goods and services. One reason for this, and a weakness in this technique, is the very large data sets and detailed information that must be collected, covering all of the principal features affecting prices. It is often difficult to isolate specific ecosystem effects from other determinants of wages and property prices.

Another potential problem arises from the fact that this technique relies on the underlying assumption that wages and property prices are sensitive to the quality and supply of ecosystem goods and services. In many cases markets for property and employment are not perfectly competitive, and ecosystem quality is not a defining characteristic of where people buy property or engage in employment.

3.2.5 Replacement cost techniques

Overview of the method

It is sometimes possible to replace or replicate a particular ecosystem good or service with artificial or man-made products, infrastructure or technologies. For example, constructed reservoirs can replace natural lakes, sewage treatment plants can replace wetland wastewater treatment services, and many natural products have artificial alternatives. The cost of replacing an ecosystem good or service with such an alternative or substitute can be taken as an indicator of its value in terms of expenditures saved. In the cases below both the value of wetland water quality services and life-support services were estimated through looking at the costs of replacing these services by artificial means.

Case 9: Using replacement costs techniques to value wetland water quality services in Nakivubo Swamp, Uganda[36]

This study used replacement cost techniques to value the wastewater treatment services provided by Nakivubo Swamp, Uganda. Covering an area of some 5.5 km2 and a catchment of over 40 km2, the wetland runs from the central industrial district of Kampala, Uganda's capital city, passing through dense residential settlements before entering Lake Victoria at Murchison Bay.

One of the most important values associated with Nakivubo wetland is the role that it plays in assuring urban water quality in Kampala. Both the outflow of the only sewage treatment plant in the city, and – far more importantly, because over 90% of Kampala's population have no access to a piped sewage supply – the main drainage channel for the city, enter the top end of the wetland. Nakivubo functions as a buffer through which most of the city's industrial and urban wastewater passes before entering nearby Lake Victoria, and physically, chemically and biologically removes nutrients and pollution from these wastewaters. These services are important - the purified water flowing out of the wetland enters Lake Victoria only about 3 kilometres from the intake to Ggaba Water Works, which supplies all of the city's piped water supplies.

The study looked at the cost of replacing wetland wastewater processing services with artificial technologies. Replacement costs included two components: connecting Nakivubo channel to an upgraded sewage treatment plant which could cope with additional wastewater loads, and constructing elevated pit latrines to process sewage from nearby slum settlements. Data were collected from the National Water and Sewerage Corporation, from civil engineering companies, and from a donor-funded water supply and sanitation project that had been operating in a nearby urban wetland area. It also took into account the fact that some level of intervention would be required to manage Nakivubo more efficiently for water treatment, mainly through extending and reticulating the wastewater channels that flow into the swamp. These costs were deducted when wetland benefits were valued. The study found that the infrastructure required to achieve a similar level of wastewater treatment to that provided by the wetland would incur costs of up to US$2 million a year in terms of extending sewerage and treatment facilities.

Case 10: Using replacement cost techniques to value the life support services of the Martebo mire, Sweden[37]

The Martebo mire, on the island of Gotland, has been subject to extensive draining, and most of its ecosystem-derived goods and services have been lost. A study was carried out to assess the value of these lost life-support services by calculating the value of replacing them with human-made technologies.

The study recorded each of the main life support services associated with the Martebo mire, and assessed the technologies that would be required to replicate them. These services (and their replacements) included peat accumulation (assumed to be replaced by artificial fertilisers and re-draining of ditches), maintenance of water quality and quantity (installing pipelines, well drilling, filtering, quality controls, purification plants, treatment of manure, pumps, dams), moderation of waterflow (pumps and water transport), waste processing and filtering (sewage plants), food production (increased agricultural production and import of foods), fisheries support (fish farming), as well as certain goods and services which could not be replaced. Replacement costs were calculated at market prices. The results of the study indicated that the annual cost of replacing the wetland's services was between $350,000 and $1 million.

An interesting aspect of this study was that it also used energy analysis to provide complementary estimates of life support capacity. This was done by comparing industrial energy used throughout the economy to produce and maintain the replacement technologies with the solar energy required by the wetland to produce and maintain similar ecological services. Analysis indicated that the biophysical cost of producing technical replacement in the economy (15-50TJ of fossil fuel equivalents a year) was almost as high as the loss of life-support services measured as solar energy fixing ability by plants (55-75 TJ of fossil fuel equivalents a year).

Data collection and analysis requirements

There are three main steps involved in collecting and analysing the data required to use replacement cost techniques to value ecosystem goods and services:

- Ascertain the benefits that are associated with a given ecosystem good or service, how it is used and by whom, and the magnitude and extent of these benefits;
- Identify the most likely alternative source of product, infrastructure or technology that would provide an equivalent level of benefits to an equivalent population;
- Calculate the costs of introducing and distributing, or installing and running, the replacement to the ecosystem good or service.

Data collection is relatively straightforward, and usually relies on secondary information about the benefits associated with a particular ecosystem good or service and alternatives that are available to replace it. In most cases this can be ascertained through expert consultation and professional estimates, supplemented with direct observation.

Applicability, strengths and weaknesses

Replacement cost techniques are particularly useful for valuing ecosystem services, and have the great advantage that they are simple to apply and analyse. They are particularly useful where only limited time or financial resources are available for a valuation study, or where it is not possible to carry out detailed surveys and fieldwork.

"IT IS DIFFICULT TO FIND PERFECT ARTIFICIAL ALTERNATIVES FOR ECOSYSTEM GOODS AND SERVICES."

The main weakness of this technique is that it is often difficult to find perfect replacements or substitutes for ecosystem goods and services that would provide an equivalent level of benefits to the same population. In some cases this results in ecosystem under-valuation, as artificial alternatives generate a lower quantity or quality of goods and services. Yet this technique may also lead to the over-valuation of ecosystem benefits, as in some instances the replacement product, infrastructure or technology may be associated with secondary benefits or additional positive impacts. The reality of the replacement cost technique is also sometimes questionable: we may question whether, in the absence of a well-functioning ecosystem, such expenditures would actually be made or considered worthwhile.

3.2.6 Mitigative or avertive expenditure techniques

Overview of the method

When an economically valuable ecosystem good or service is lost, or there is a decline in its quantity or quality, this almost always has negative effects. It may become necessary to take steps to mitigate or avert these negative effects so as to avoid economic losses. For example, the loss of upstream catchment protection can make it necessary to desilt reservoirs and dams, the loss of wetland treatment services may require upgrading water purification facilities, and the loss of ecosystem flood control may require the construction of flood control barriers. These mitigative or avertive expenditures can be taken as indicators of the value of maintaining ecosystem goods and services in terms of costs avoided. In the cases below both the value of wetland flood attenuation (Case 11) and nitrogen abatement services (Case 12) were estimated through looking at the expenditures that would be required to mitigate or avert the effects of the loss of these services.

Case 11: Using mitigative or avertive expenditure techniques to value wetland flood attenuation in Sri Lanka[38]

This study used avertive expenditure techniques to value the flood attenuation services of Muthurajawela Marsh in Sri Lanka. Muthurajawela is a coastal peat bog which covers an area of some 3,100 hectares, running alongside the Indian Ocean between 10-30 km north of Colombo, Sri Lanka's capital city. One of its most important functions is its role in local flood control.

The study first involved investigating the biophysical characteristics of the marsh, and their relationship to local flooding patterns. Data were obtained from hydrological surveys, which estimated the maximum water storage capacity of the marsh at 11 million cubic metres, with a maximum discharge of 12.5 cubic metres per second and a retention period of more than 10 days. Analysis of historical rainfall and streamflow data found that during the rainy season large volumes of water enter the wetland system, from rainfall, through run-off from surrounding higher grounds and via floodwaters from the Dandugam Oya, Kala Oya and Kelani Ganga Rivers. Muthurajawela buffers these floodwaters and discharges them slowly into the sea.

The value of these services was calculated by looking at the flood control measures that would be necessary to mitigate or avert the effects of wetland loss. Consultation with civil engineers showed that this would involve constructing a drainage system and pumping station, deepening and widening the channels of water courses flowing between the marsh area and the sea, installing infrastructure to divert floodwaters into a retention area, and pumping water out to sea. Cost estimates for this type of flood control measure were available for Mudu Ela, a nearby wetland that has recently been converted to a housing scheme. Here infrastructure had been installed to ensure that a total of 443 acres of land remains drained, in order to reclaim an area of 360 acres. Extrapolating the capital and maintenance costs from Mudu Ela to Muthurajawela gave an annual value for flood attenuation of more than $5 million, or $1,750 per hectare of wetland area.

Case 12: Using mitigative or avertive expenditure techniques to value wetland nitrogen abatement in Sweden[39]

Poor quality drinking water supplies is a major problem in Gotland, Sweden, and is related to the high levels of nitrates in water - which are about double the WHO-recommended safe concentrations. This study aimed to value the services that natural wetlands provide in terms of reducing nitrate levels in water.

The study used mitigative expenditure techniques, looking at the different measures that can be employed for nitrogen abatement. In addition to wetland restoration, it considered reducing farmers' applications of chemical fertilisers and manure, and increasing the capacity of domestic and industrial sewage treatment plants.

Value functions for improved water quality were obtained from contingent valuation studies of willingness to pay for safe water, and a hydrological model was applied to relate the application of nitrogen to groundwater quality. The nitrogen purification services of wetlands were estimated from secondary sources and related studies, and related to land area. This enabled the total value of investments in wetlands for nitrogen abatement to be calculated, and compared with the costs of upgrading sewage treatment facilities and reducing fertiliser use.

The study found that the total value of investing in wetland restoration and management is at least twice as high as the costs of implementing mitigative or avertive measures. In addition to these secondary benefits of nitrogen abatement, wetlands also generate a variety of primary services and values.

Data collection and analysis requirements

There are four main steps involved in collecting and analysing the data required to use mitigative or avertive expenditure techniques to value ecosystem goods and services:

- Identify the negative effects or hazards that would arise from the loss of a particular ecosystem good or service;
- Locate the area and population who would be affected by the loss of the ecosystem good and service, and determine a cut-off point beyond which the effect will not be analysed;
- Obtain information on people's responses, and measures taken to mitigate or avert the negative effects of the loss of the ecosystem good or service;
- Cost the mitigative or avertive expenditures.

Data collection and analysis is relatively straightforward, and usually relies on a combination of interviews, surveys, direct observation and expert consultation.

Applicability, strengths and weaknesses

Mitigative or avertive expenditure techniques are particularly useful for valuing ecosystem services. In common with other cost-based valuation methods, a major strength is their ease of implementation and analysis, and their relatively small data requirements.

As is the case with the replacement cost technique, the mitigative or avertive measures that are employed in response to the loss of ecosystem goods and services do not always provide an equivalent level of benefits. In some cases it is also questionable whether in fact such expenditures would be made or would be seen as being worth making. An additional important factor to bear in mind when applying this technique is that people's perceptions of what would be the effects of ecosystem loss, and what would be required to mitigate or avert these effects, may not always match those of "expert" opinion.

3.2.7 Damage cost avoided techniques

Overview of the method

Ecosystem services frequently protect other economically valuable assets. For example, the loss of catchment protection services may result in increased downstream siltation and flooding, which leads to the destruction of infrastructure, settlements and agriculture. Such damage costs can be taken to represent the economic value of ecosystems in terms of expenditures avoided. In the cases below both the value of wetland flood attenuation (Case 13) and forest watershed protection services (Case 14) were estimated through looking at costs of damage avoided by conserving ecosystems.

Case 13: Using damage cost avoided techniques to value the role of flood attenuation in the Lower Shire Wetlands, Malawi and Mozambique and Barotse Floodplain, Zambia[40]

The Lower Shire Wetlands in Malawi and Mozambique and the Barotse Floodplain in Zambia cover a combined area of approximately 1.5 million hectares. They generate a number of economically important goods and services, one of which is flood attenuation. The wetlands play an appreciable role in minimising flood peaks and reducing flow velocity, because they store water and even out its release over time. At the onset of the rainy season, or in times of peak riverflow, their large surface area to depth and volume ratios mean that they are able to absorb and spread out water over a large area. The emptying of floodplains may take 4 times as long as the period between initial and peak season. The Barotse floodplain, for example, is capable of storing over 17.2 X 109m3 of water at peak floods, and may delay the downstream flooding peak by some three to five weeks.

The economic value of flood attenuation was valued by looking at the extent to which the wetlands minimise downstream flooding and thereby reduce damage to infrastructure, land and associated settlement and production opportunities. The valuation study involved assessing the frequency of floods, their severity of impact, and the economic damages they gave rise to. Affected areas were identified by land use and settlement maps which showed where human populations and production activities were concentrated, and district-level census and production statistics. Historical records provided estimates of flooding frequency and impacts, and the production and infrastructure damages that had arisen as a result of floods.

Taking account of the costs of temporary relocation of people, replacement of damaged roads and rail infrastructure, loss of farm fields and livestock and settlements destroyed, the study found a flood attenuation value for the two wetlands areas with a present value of over $3 million.

Case 14: Using damage costs avoided techniques to value forest watershed services for the Kamchay Hydropower Scheme, Cambodia[41]

Phnom Bokor National Park is a dense tropical forest that covers an area of almost 1,500 km2 in the coastal zone of south-west Cambodia. It forms the watershed for numerous streams and rivers, including the Kamchay River. The planned Kamchay hydropower scheme, to be located in Bokor National Park, will cover an area of just over 25 km2, with an installed capacity of 120 MW and the potential to generate 470 GWh output annually to meet the electricity demands of surrounding Provinces and the national capital, Phnom Penh. With an estimated investment cost of $280 million, the scheme is expected to be operational by 2008.

"FAILURE TO INVEST IN WATERSHED MANAGEMENT COULD INCUR OVER US$ 2 MILLION IN COSTS OF POWER REVENUE FOREGONE."

This study valued the contribution of Bokor National Park watershed catchment protection services to the proposed Kamchay hydropower scheme using damage costs avoided techniques. It looked at the damages that would be avoided by protecting the upper watershed that both feeds the dam and provides cover for the reservoir area.

First, the study investigated the ways in which continuing degradation of the upper watershed of the Kamchay River would affect the operation and profitability of the dam. This involved examining erosion and soil loss rates under different land use scenarios, and determining the impacts of increased sediment delivery in reducing the service life of the dam, and on power generation losses resulting from a reduction in its storage capacity.

Power generation losses were valued according to the projected price at which power would be sold once the dam was completed. Modelling the increased erosion rates, accompanying soil losses, and consequent delivery to the dam's storage area showed that failure to invest in watershed management as a component of dam maintenance could incur net present costs of over $2 million in terms of power revenues foregone once the scheme is operational.

Data collection and analysis requirements

There are four main steps involved in collecting and analysing the data required to use damage cost avoided techniques to value ecosystem goods and services:

- Identify the protective services of the ecosystem, in terms of the degree of protection afforded and the on and off-site damages that would occur as a result of loss of this protection;
- For the specific change in ecosystem service provision that is being considered, locate the infrastructure, output or human population that would be affected by this damage, and determine a cut-off point beyond which effects will not be analysed;
- Obtain information on the likelihood and frequency of damaging events occurring under different scenarios of ecosystem loss, the spread of their impacts and the magnitude of damage caused;
- Cost these damages, and ascribing the contribution of the ecosystem service towards minimising or avoiding them.

Data collection is for the most part straightforward, usually relying on a combination of analysis of historical records, direct observation, interviews and professional estimates. Predicting and quantifying the likelihood and impacts of damage events under different ecosystem scenarios is however usually a more complex exercise, and may require detailed data and modelling.

Strengths and weaknesses of the method

Damage cost avoided techniques are particularly useful for valuing ecosystem services. There is often confusion between the application of damage costs avoided and production function approaches to valuation. Here it is important to underline that whereas this technique deals with damage avoided such as from pollution and natural hazards (which are typically external effects), change in production techniques usually relate to changes in some input such as water (typically internalised).

A potential weakness is that in most cases estimates of damages avoided remain hypothetical. They are based on predicting what might occur under a situation where ecosystem services decline or are lost. Even when valuation is based on real data from situations where such events and damages have occurred, it is often difficult to relate these damages to changes in ecosystem status, or to be sure that identical impacts would occur if particular ecosystem services declined.

3.2.8 Contingent valuation techniques

Overview of the method

Absence of prices or markets for ecosystem goods and services, of close replacements or substitutes, or of links to other production or consumption processes, does not mean that they have no value to people. Contingent valuation techniques infer the value that people place on ecosystem goods and services by asking them directly what is their willingness to pay (WTP) for them or their willingness to accept compensation (WTA) for their loss, under the hypothetical situation that they could be available for purchase.

"ABSENCE OF MARKET PRICES DOES NOT MEAN THAT ECOSYSTEM GOODS AND SERVICES HAVE NO VALUE TO PEOPLE."

Contingent valuation methods might for example ask how much people would be willing to see their water bills increase in order to uphold quality standards, what they would pay as a voluntary fee to manage an upstream catchment in order to maintain water supplies, how much they would contribute to a fund for the conservation of a beautiful landscape or rare species, or the extent to which they would be willing to share in the costs of maintaining important ecosystem water services. For example, in the cases below the value of watershed drought

Woman sells fish in the town of Epe, Nigeria.

mitigation was estimated through asking local farmers' willingness to pay for this service (Case 15) and household willingness to pay for conservation was taken as an estimate of the value of coastal wetlands (Case 16).

Case 15: Using contingent valuation techniques to value farmers' willingness to pay for watershed drought mitigation services in eastern Indonesia[42]

This study focused on the watershed catchment protection services provided by Ruteng National Park in eastern Indonesia. It used contingent valuation techniques to assess the economic value of drought mitigation for local farmers. This derived farmers' willingness to pay for watershed catchment protection services in terms of incremental agricultural profits arising from drought mitigation.

Surveys were carried out in order to provide socio-economic information about the agricultural populations living around the National Park. Households were then questioned directly to elicit their WTP for drought mitigation services. Contingent valuation questions were introduced with a standard description of National park institutions and management, so as to ensure that respondents received homogeneous information. This was followed by several opinion questions designed to remind farmers about their environmental constraints and substitution possibilities, and drought mitigation services were described. Willingness to pay bids were elicited through a payment vehicle based on a fee to be collected by National Park officials for the protection of the watershed. All households in the survey were asked if they would be willing to pay an annual fee for drought mitigation services, and depending on their response a follow-up question was asked about higher or lower fees.

Responses found that farmers were aware of, and interested in, their environmental conditions, and the way in which these were linked to water availability. Respondents were willing to pay initial and subsequent annual fees for drought control services. Various socio-economic characteristics and environmental conditions were found to have a statistically significant effect on responses. Farmers expecting increases in profits through higher rice revenues were willing to pay more for these services, as were wealthier and more educated households who mark up their perceived benefits from drought control. In contrast, farmers living in watersheds with higher levels of forest cover and greater rainfall were willing to pay less, perhaps because they perceived less need for forest protection and were not exposed to droughts. Overall, the study found that mean annual stated WTP for drought mitigation services was between $2-3 per household, equivalent to about 10% of annual agricultural costs, 75% of annual irrigation fees, or 3% of annual food expenditures.

Case 16: Using contingent valuation techniques to value coastal wetlands in Korea[43]

This study used contingent valuation techniques to estimate the non-extractive benefits of conserving coastal wetlands around the Youngsan River in Korea. It focused primarily on the landscape, recreational, amenity and existence values.

The study involved a survey of more than 1,000 local residents. It elicited willingness to pay for a conservation programme designed to maintain coastal wetlands rather than develop them for alternative uses, measured through additional household taxes. Questionnaires ascertained respondents' attitudes and perceptions of coastal wetlands, their willingness to pay a minimum or maximum tax increase, and collected information about socio-economic variables such as age, education, income, marital status and expenditures on recreation.

Correlating these variables with respondent willingness to pay enabled the study to construct a demand curve for coastal wetlands. Overall, respondents stated that they would be willing to pay almost $40 per household per month to ensure that coastal wetlands were conserved, suggesting an annual aggregate conservation value of more than $176 million.

Data collection and analysis requirements

There are five main steps involved in collecting and analysing the data required to use contingent valuation techniques to value ecosystem goods and services:

- Ask respondents their WTP or WTA for a particular ecosystem good or service;
- Draw up a frequency distribution relating the size of different WTP/WTA statements to the number of people making them;
- Cross-tabulate WTP/WTA responses with respondents' socio-economic characteristics and other relevant factors;
- Use multivariate statistical techniques to correlate responses with respondent's socio-economic attributes;
- Gross up sample results to obtain the value likely to be placed on the ecosystem good or service by the whole population, or the entire group of users.

This valuation technique requires complex data collection and sophisticated statistical analysis and modelling, which are described in detail elsewhere.[44]

Most contingent valuation studies are conducted via interviews or postal surveys with individuals, but sometimes interviews are conducted with groups. A variety of methods are used in order to elicit people's statement or bids of their WTP/WTA for particular ecosystem goods or services in relation to specified changes in their quantity or quality. The two main variants of contingent valuation are:

1. dichotomous choice surveys, which present an upper and lower estimate between which respondents have to choose; and
2. open-ended surveys, which let respondents determine their own bids.

More sophisticated techniques are also sometimes used, such as engaging in trade-off games or using take-it-or-leave it experiments. The Delphi technique uses expert opinion rather than approaching consumers directly.

Applicability, strengths and weaknesses

A major strength of contingent valuation techniques is that, because they do not rely on actual markets or observed behaviour, they can in theory be applied to any situation, good or service. They remain one of the only methods that can be applied to option and existence values, and are widely used to determine the value of ecosystem services. Contingent valuation techniques are often used in combination with other valuation methods, in order to supplement or cross-check their results.

One of the biggest disadvantages of contingent valuation is the large and costly surveys, complex data sets, and sophisticated analysis techniques that it requires. Another constraint arises from the fact that they rely on a hypothetical scenario which may not reflect reality or be convincing to respondents.

Contingent valuation techniques require people to state their preferences for ecosystem goods and services. They are therefore susceptible to various sources of bias, which may influence their results. The most common forms of bias are strategic, design, instrument and starting point bias. Strategic bias occurs when respondents believe that they can influence a real course of events by how they answer WTP/WTA questions. Respondents may for instance think that a survey's hypothetical scenario of the imposition of a water charge or ecosystem fee is actually in preparation. Design bias relates to the way in which information is put across in the survey instrument. For example, a survey may provide inadequate information about the hypothetical scenario , or respondents are misled by its description. Instrument bias arises when respondents react strongly against the proposed payment methods. Respondents may for instance resent new taxes or increased bills. Starting point bias occurs when the starting point for eliciting bids skews the possible range of answers, because it is too high, too low, or varies significantly from respondents' WTP/WTA. With careful survey design, most of these sources of bias can however be reduced or eliminated.

3.2.9 Other stated preference methods: conjoint analysis and choice experiments

Other stated preference valuation methods include conjoint analysis and choice experiments. Due to their complexity in terms of data needs and analysis, and because there exist very few examples of their application to ecosystem water services,[45] these methods are not described in detail here.

Conjoint analysis was originally developed in the fields of marketing and psychology, in order to measure individuals' preferences for different characteristics or attributes of a multi-choice attribute problem. In contrast to contingent valuation, conjoint analysis does not explicitly require individuals to state their willingness to pay for environmental quality. Rather, conjoint asks individuals to consider status quo and alternative states of the world. It describes a specific hypothetical scenario and various environmental goods and services between which they have to make a choice. The method elicits information from the respondent on preferences between various alternatives of environmental goods and services, at different price or cost to the individual.

Choice experiments techniques present a series of alternative resource or ecosystem use options, each of which are defined by various attributes including price. Choice of the preferred option from each set of options indicates the value placed on ecosystem attributes. As is the case for contingent valuation, data collection and analysis for choice experiments is relatively complex. Usually conducted by means of questionnaires and interviews, choice experiments ask respondents to evaluate a series of "sets", each containing different bundles of ecosystem goods and services. Usually, each alternative is defined by a number of attributes. For example, for a specific ecosystem this might include attributes such as species mix, ecosystem status, land-scape, size of area, price or cost. These attributes are varied across the different alternatives, and respondents are asked to choose their most preferred alternative. Aggregate choice frequencies are modelled to infer the relative impact of each attribute on choice, and the marginal value of each attribute for a given option is calculated using statistical methods.

3.3 The applicability and limitations of economic valuation

Ecosystem valuation generates useful and convincing information because it helps to high-light costs and benefits (and cost-bearers and beneficiaries) that have in the past been ignored. However, as mentioned at the beginning of this chapter, it is not the only factor in ecosystems being integrated into water decision-makers' agendas. It may even not always be the most important factor. It is important to bear in mind that valuation only provides a set of tools with which to make better and more informed decisions. As such, it has a number of shortcomings and weaknesses.

"ECOSYSTEM VALUATION IS ONLY A SET OF TOOLS WITH WHICH TO MAKE BETTER DECISIONS."

One important consideration to bear in mind is that the valuation of ecosystem services is not a stand-alone exercise. An exercise to value ecosystem water benefits has little meaning, and is likely to have only limited accuracy, unless it is based on a sound appreciation and good information about ecological, hydrological, institutional and social aspects of ecosystem management and water goods and services. In particular, valuation studies require data which relate ecosystem status to benefit provision, as well as detailed information about the allocation of rights, responsibilities and access to ecosystem management, water goods and services. These aspects are further elaborated below, in Chapter 4.

Valuation is, of necessity, partial. It can deal much more easily with goods and services that are marketed, or are linked to markets. It also does not always accurately represent the full value of ecosystems. It presents estimates, or narrows calculations down to a range of possible values. In many cases valuation methods actually under-estimate the worth of ecosystem water services: Ecosystems work on such a large scale and in such intricate ways, their services cannot be replicated effectively by technology[46].or their impacts extend well beyond effects on other marketed products and indicators. Finally, some ecosystem values will always be immeasurable and unquantifiable because the necessary scientific, technical or economic data are not available.

Other ecosystem benefits relate to attributes such as human life, cultural or religious significance, where valuation raises serious ethical questions. To some extent ecosystem valuation may even be dangerous when it focuses attention only on financial or cash benefits at the expense of other types of values that cannot (or should not) be valued[47].The economic valuation of ecosystems is essentially a utilitarian approach, and has shortcomings as regards cultural, intrinsic and primary aspects of value.[48]

"SOME ECOSYSTEM BENEFITS CANNOT – OR SHOULD NOT –BE VALUED."

It would also be a mistake to think that the results of ecosystem valuation studies are always definitive, exact or transferable between different situations and locations. They are usually based on a particular person's or group's perception of what a particular ecosystem service is worth at a specific point in time and place. Valuation is not necessarily universally valid, or extrapolable between different groups, areas, ecosystems or over time.

Valuation exercises also tend to be heavily influenced by the aims and purposes for which they are carried out. In the case of ecosystem valuation, the desire to demonstrate significant water benefits or to promote a conservation agenda sometimes means that results are biased towards finding high values. When valuation studies are carried out they actually may over-estimate the worth of ecosystem services, or make unwarranted assumptions about their impacts by not properly establishing the biophysical linkages between ecosystems, water and the economy.[49]

Finally, there is no guarantee that the findings of economic valuation will support the wise use and management of ecosystems for water services. Although many ecosystems have been assigned a value by economists, valuation will not guarantee their protection.[50] In some cases, the use of valuation studies, to identify and promote new ways of capturing ecosystem values through markets or payments for services, can be a double-edged sword:[51] if poorly managed, such markets can actually undermine the provision of ecosystem water services.

Chapter 4

Using ecosystem values in water decisions

All of the methods and techniques that have been described in the previous chapter can be used to express the monetary value of water ecosystem goods and services. This overcomes a major problem - that of demonstrating that ecosystems do have economic significance for water, and being able to articulate these values to make them comparable with other sectors of the economy, and other possible uses of land, resources and investment funds.

Valuation thus provides the basis for generating information that has relevance to water planning, policies and management practice. However it does not by itself ensure that ecosystems will be factored into real-world water decisions. Having added up the costs and benefits of ecosystems for water, it is necessary to translate this raw data into practical and policy-relevant information that can be used to influence decision-making. This chapter describes the various analytical frameworks and support tools that can be applied to use valuation data in support of water decisions, and highlights the types of situations where such information is required.

4.1 Translating ecosystem values into management decisions

Environmental economic methodologies have moved forward and we now see a growing body of literature about the value of ecosystems for water. This represents a welcome addition to the information base from which water and ecosystem calculations are performed. But, unfortunately, there has been much less progress in ensuring that the results of such studies, and the figures they generate, are actually fed into decision-making processes and used to influence conservation and development agendas. For this reason, ecosystem valuation is yet to reach its full potential.

It is important to make efforts to close the loop between generating knowledge and influencing policy and practice. Although calculating the economic value of ecosystems for water can be an extremely interesting academic exercise, it is not an end in itself. Rather, it is a means of providing information that can be used to make better and more informed water decisions.

Economic arguments and tools remain a major factor in water decision-making. Project, programme and policy analysis, investment appraisals and profit projections are heavily influenced by measures which express the perceived value of future costs and benefits, and through the use of such decision-support tools as cost-benefit analysis.

Making sure that ecosystem values are factored into these measures is a way of improving the information base upon which decisions are made. It is a way of levelling the playing field, of making sure that ecosystems are considered alongside, and on comparable terms with, other water-related economic costs and benefits. For example, it can include any losses arising from ecosystem degradation as economic costs in the appraisal of development projects, or reflect the benefits associated with using ecosystem resources in calculations of the economic returns to water allocation, or reflect the economic gains from investing in ecosystem management as part of water infrastructure as cost-savings or benefit flows in projections of future output and profits.

Factoring in ecosystem values is also a means of improving the quality of decisions, and maximising the likelihood of positive economic and financial impacts. Failing to consider these values when we make economic decisions means that we run the risk of missing the potential to generate or maintain critical streams of benefits, or running into a situation where we end up incurring untenable future costs or unnecessary expenditures. For example, it allows us to recognise the cost-savings that ecosystem services can provide to water infrastructure in terms of prolonged lifespan and reduced maintenance, or take full account of the development benefits of maintaining the aquatic resources which form the basis of rural livelihoods.

"WE NEED TO EXPRESS ECOSYSTEM VALUES AS MEASURES THAT MAKE SENSE TO DECISION-MAKERS."

When we are able to express the benefits of ecosystems for water as quantified values, a major challenge arises: what we do with these data in order to influence decision-making? For example, how do we make sure that ecosystems are included when river-basin planning decisions assess how to allocate water between different uses and users, cost-benefit analyses are carried out to select which hydropower or irrigation infrastructure design option to construct, projections of profitability are used to decide whether to invest in catchment protection as part of water supply schemes, or the relative returns to different land uses are compared so as to decide whether to zone a wetland for conservation or convert it to agriculture and settlement?

To do this we need to be able to express ecosystem values as measures that make sense to decision-makers when they weigh up the different funding, land and resource management choices that water decisions involve. This chapter describes techniques for translating data on ecosystem values into the measures, indicators and criteria that can be used to balance different options and alternatives in water decision-making in terms of their ecosystem linkages.

4.2 Generating information on the impacts of water decisions on ecosystem values

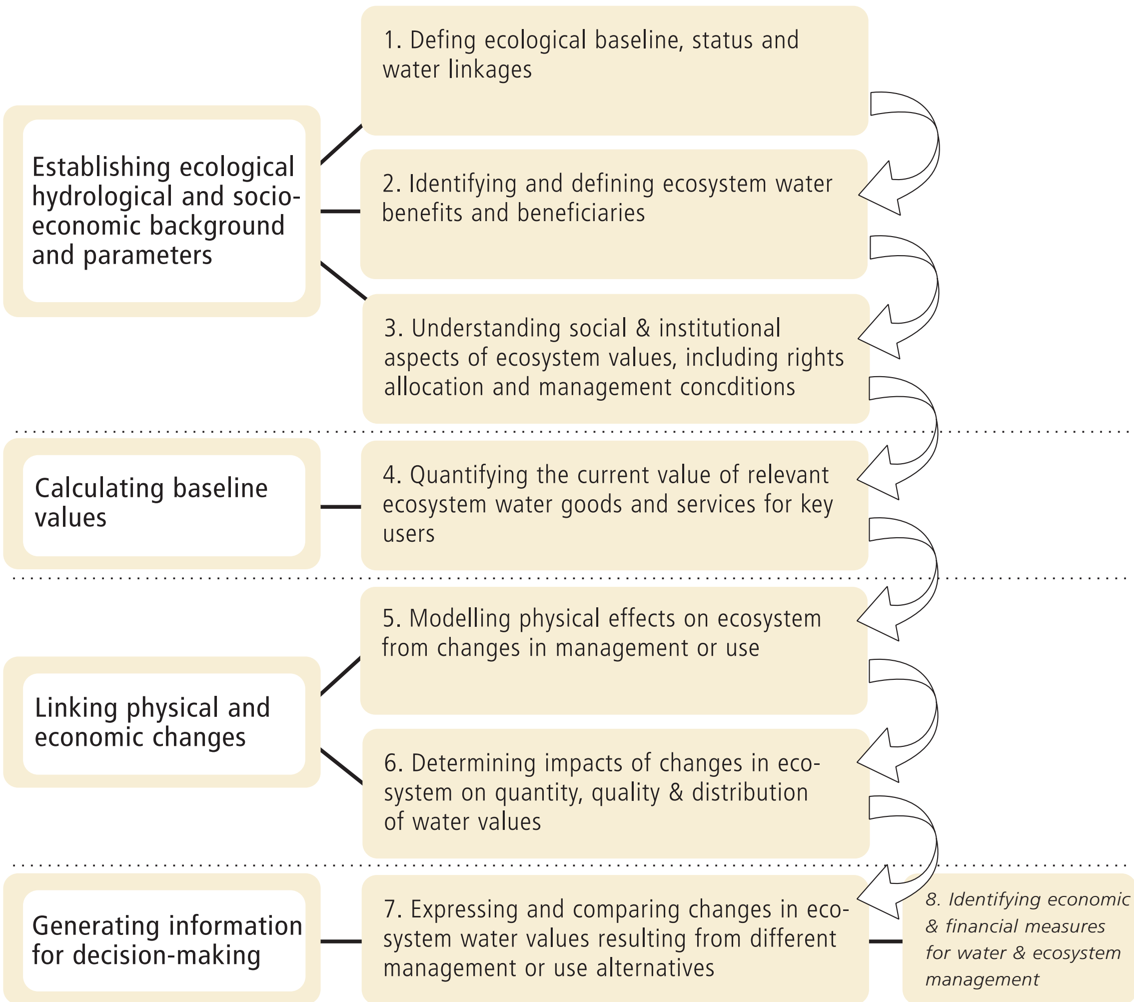
Conducting a valuation study provides us with data about the economic value of particular ecosystem goods and services as they relate to water. For example, it results in the value that a forest contributes towards downstream flood mitigation in terms of damages avoided and how much its function in minimising siltation is worth to a hydropower scheme, what wetland resources contribute to local income and revenues and how much its nutrient retention services save in terms of water treatment costs, or what value urban populations place on maintaining unpolluted rivers and lakes for recreation.

However, what is important for decision-making is to be able to understand and express how making choices between alternative uses of land, water, resources or investment funds will influence these values. For example, how much additional flood-related costs would be incurred if a forest were degraded, and what downstream production losses would arise from additional silt loads? Or what additional investments in water treatment and purification would be required if a particular wetland were reclaimed? Or what potential actually exists for raising revenues from urban dwellers to maintain water quality in a particular river or lake?

"DECISION-MAKERS WANT TO UNDERSTAND AND EXPRESS THE ECONOMIC CONSEQUENCES OF DIFFERENT LAND USES AND INVESTMENT OPTIONS."

To answer these questions we need to move beyond an economic value baseline in order to trace the economic implications of changes in the stock of ecosystem resources, flows of ecosystem services, or attributes of ecosystems that result from following a particular course of action. We then need to factor these changes into measures of its viability, profitability and sustainability. In other words, we need to know what the economic impacts of particular water decisions will be in terms of ecosystem costs and benefits.

Figure 2: Using ecosystem valuation to generate information for decision-making



Bio-economic models

Simple bio-economic models provide a useful technique for tracing the changes in value that occur with different ecosystem impacts and management regimes. They involve a number of steps which translate baseline data on ecosystem values into information that can be used to assess the economic impacts of water decisions (Figure 2):

- Establish ecological and socio-economic background and parameters: This involves identifying, defining and understanding the status of the ecosystem and its links to hydrological goods and services, their water benefits and beneficiaries, and the way in which various social, institutional and management aspects affect it, as described above in Chapter 2.
- Calculate baseline economic values from which to measure ecosystem changes: This involves carrying out the partial or total valuation study, as described above in Chapter 3.
- Link physical changes in ecosystem status and integrity to changes in these economic values: This involves tracing the effects of different water decisions on the provision of ecosystem goods and services, and determining the impacts of these changes on economic values.
- Express the results as indicators or measures that can be integrated into broader economic appraisal or analysis processes: This involves expressing the results of value changes as quantitative indicators or measures that can be integrated into wider decision-support frameworks. We will deal with this in the following section. In some cases such models are taken one step further, and information about ecosystem values is also used to identify financial and economic measures for water and ecosystem management (these financial and economic measures are not covered in VALUE, which focuses on economic valuation and decision-making techniques).

The scope, scale and outputs of bio-economic models vary. The most comprehensive and accurate picture can be gained from adopting an approach which encompasses the total economic value of the whole ecosystem[52].and incorporates the dynamics of economic and environmental processes within a temporally and spatially explicit framework.[53] However, data constraints often force a partial valuation model, and decision-making is often concerned only with specific resources, areas, groups, localities or effects.

"A SIMPLE BIO-ECONOMIC MODEL CAN TRACE THE IMPACTS OF DIFFERENT DECISIONS."

Two examples of the development and application of a bio-economic model come from wetland management interventions in Hail Haor, Bangladesh, and management of the Murrumbidgee River Floodplain in Australia.

Case 17: A bio-economic model of wetland management interventions in Hail Haor, Bangladesh[54]

Wetlands in Bangladesh provide a critical source of income and nutrition for millions of rural poor people. Unfortunately these habitats are being lost and their production is in decline due to over-use, increased rates of sedimentation from watershed degradation, pollution, diversion of water for irrigation, and conversion for agriculture and urban development.

The MACH project aims to develop approaches and to demonstrate sustainable management of water resources including fish, plants, agriculture, livestock, forestry, and wildlife over entire wetland ecosystems. A bio-economic model was developed to analyse the impacts of this programme, and the relative trade-offs and benefits of different wetland management alternatives, for one pilot area - Hail Haor wetland. It incorporated consideration of various wetland goods and services, including fish, other plant and animal products, pasture, transport, agriculture, recreation, water quality, flood control, aquifer recharge and existence values. The model traced the biophysical and economic impacts of different wetland management regimes on these values.

The model yielded an annual economic output of $8 million for Hail Haor. Values were also expressed in terms of the returns to different wetland goods and services, and alternative management options. Under a scenario of sustainable wetland management, increases in wetland productivity and decreases in resource degradation were recorded. This showed that project benefits were some 7.5 times higher than investment costs, and yielded a high rate of return.

Case 18: A bio-economic model of wetland management in Australia[55]

A bio-economic model was applied to the Upper South East of Australia and the Murrumbidgee River Floodplain in New South Wales in order to assess the trade-offs that wetland owners and local communities face when making decisions about how to use their wetlands.

The model looked at the nature and extent of the different values derived from wetlands in a range of alternative uses and management scenarios. Various wetland values were considered, including grazing, fishing, hunting, recreation, timber harvesting, water supply, drainage sink and irrigation supply and storage. Management options included combinations of improved management of existing wetlands, conversion of pasture to wetlands, revegetation, large scale adoption of farm forestry, improved hydrological management, improved grazing management and improved timber harvesting management.

The model involved tracing a number of biophysical and economic impacts and trade-offs through asking the following questions:

- What would be the biophysical impacts of changes in wetland management and environmental quality?
- What values would owners receive from their wetlands under different management regimes?
- What values would the broader community receive from wetlands under different management regimes?
- For different wetland management regimes what is the net impact on society, and which yields the greatest net social benefit?
- How can wetland owners be given incentives to adopt the management strategy identified as preferable?

The model yielded estimates of the economic benefits and costs of different management strategies to wetland owners and to broader society. It found that relatively small changes in wetland management would lead to significant changes in the environmental outputs generated by wetlands, and large changes in the economic values associated with them. However, as generating these economic benefits would also entail a significant monetary cost for wetland owners, the model also examined alternative policy options that would facilitate, induce and in some cases compel changes to wetland management.

4.3 Expressing ecosystem values as economic measures for decision-making support

In short, the first step entails establishing the ways in which water decisions will influence, and are themselves influenced by, ecosystem values. We now need to express these effects as some kind of measure or indicator that can be integrated into decision-making, and used to compare the relative economic or financial desirability of different water decision options. We need to be able to make an informed decision as to which water allocation, infrastructure design option or land use management option will generate the highest returns and profits, and will be the most economically and financially sustainable.

4.3.1 Cost-benefit analysis

Cost-benefit analysis (CBA) remains the most commonly used decision-making framework for assessing and comparing economic and financial trade-offs. It is the standard tool for appraising and evaluating programmes, projects and policies and one that is a required part of many government and donor decision-making procedures. It is also a framework into which ecosystem values can easily be integrated.

CBA is a decision tool which judges alternative courses of action by comparing their costs and benefits.[56] It assesses profitability or desirability according to net present benefits - the total annual benefits minus total annual costs for each year of analysis or project lifetime, expressed as a single measure of value in today's terms. In this context, we want to consider ecosystem values alongside other project costs and benefits when we calculate profitability.

"COST-BENEFIT ANALYSIS IS THE STANDARD TOOL FOR APPRAISING PROGRAMMES, PROJECTS AND POLICIES."

In order to bring a project's benefits and costs over time to their present value, each is discounted. Discounting is essentially the inverse of applying a compound interest rate, and gives values relatively less weight the further into the future they accrue.[57] It accounts for the fact that people generally prefer to enjoy benefits now and costs later, and that any funds tied up in a project could be used productively to generate returns or profits elsewhere. In most cases, the discount rate is therefore based on the opportunity cost of capital - the prevailing rate of return on investments elsewhere in the economy.

CBA presents three basic measures of worth, which allow different projects, programmes or policies to be assessed and compared with each other:

- Net Present Value (NPV) is the sum of discounted net benefits (i.e. benefits minus costs), and shows whether a project generates more benefits than it incurs costs.
- Benefit Cost Ratio (BCR) is the ratio between discounted total benefits and costs, and shows the extent to which project benefits exceed costs.
- Internal Rate of Return (IRR) is the discount rate at which a project's NPV becomes zero.

In general, a project can be considered to be worthwhile if its NPV is positive and its BCR is greater than one and if its IRR exceeds the discount rate. A positive NPV and a BCR greater than one means the project generates benefits that are greater than its costs. An IRR above the discount rate means that the project generates returns in excess of those which could be expected from alternative investments.

Other things being equal, the higher the NPV, BCR or IRR of a project, the more desirable it can be considered to be in economic or financial terms. Bringing ecosystem values into these quantified measures enables them to be counted alongside the other costs and benefits that are considered to assess the desirability of following a given course of action. Thus, we can make a more informed choice between different development or investment options by considering the full range of ecosystem impacts (Case 19).

Case 19: Incorporating ecosystem costs and benefits into economic appraisal of a dam construction project on the Tana River, Kenya[58]

The Tana River is one of Kenya's most important river systems. With a total length of some 1,000 km and a catchment area in excess of 100,000 km2, it forms the only permanent river in a dry region and is associated with a range of highly productive natural ecosystems containing unique and endemic biodiversity. It is also heavily utilised for hydropower. To date, five major reservoirs have been built on the Tana which together provide nearly three quarters of the country's electricity requirements. Dam construction has however had a major influence on the Tana's downstream flow and physical characteristics, most notably by regulating waterflow and decreasing the frequency and magnitude of flooding. In the past, the river would flood its banks, usually twice a year. These biannual floods would inundate the floodplain and delta area up to a depth of 3 metres, supporting grasslands, lakes, seasonal streams, riverine forests and mangroves. Since 1989, when the last dam was commissioned, flooding has decreased dramatically in volume and frequency.

A new hydropower scheme, the Mutonga-Grand Falls Dam, has recently been proposed for construction on the Tana River, downstream of the existing schemes. As is usual in the appraisal of large infrastructure projects, a cost benefit analysis was carried out in order to examine the projected financial profitability and relative economic desirability of various options for dam design, reservoir area and power output. Although they showed high net present values and internal rates of return, none of these economic analyses considered the environmental impacts of the dam, the substantial costs of ecosystem degradation, or related them to the needs to invest in avoiding or mitigating hydrological, ecological and socio-economic impacts.

All of the options for dam construction that were being considered would compound the hydrological effects already experienced as a result of existing dams. The proposed scheme would be the last stage in complete control of the Tana's waters, as after construction there would be no appreciable addition to its flow except in extreme events. This would effectively end the bi-annual flood pattern, and significantly lower the local water table. Existing changes in downstream ecosystems would be hastened and exacerbated, including reduction in the area and composition of floodplain grasslands, lowering of surface and groundwater levels, loss of fertile riverbank sediment depositions, reduction in swamps, ox-bow lakes and seasonal water bodies, senescence of riverine forest and mangrove degradation due to inadequate freshwater flows. In turn, these ecosystem losses would affect more than a million people who directly depend on the Tana's flooding for their livelihoods, and four times this number who rely on it for water supplies.

The environmental costs and benefits of the proposed scheme were calculated, and a revised cost-benefit analysis was conducted to incorporate these values. These led to significant reductions in NPV, BCR and IRR indicators for the scheme if it led to further changes in downstream hydrology. Valuing dam-related changes in freshwater-dependent ecosystems showed that the net present cost of existing dams has been more than $26 million, and that the construction of an additional dam could nearly double this figure. It showed that the largest dam option, which would generate the highest power output and revenues, would give rise to the most significant environmental costs. The environmental economic cost-benefit analysis however also demonstrated that investing in a dam design option which included measures to simulate downstream flooding could not only avoid many of these environmental and economic costs, but also reverse many of the negative impacts that had occurred as a result of past dam construction. At the same time, it would also generate significant profits and would be a financially viable investment option. Taking account of environmental costs and benefits, the additional costs that this design option would incur would be more than justified in economic terms.

Another example of the application of CBA was used to justify private or public investments in ecosystem management or rehabilitation (Case 20).

Case 20: Cost-Benefit Analysis of the Skjern River Project, Denmark[59]

Society is using a considerable share of its resources for the production of public benefits and services which are not traded in markets. Consequently the market mechanism does not ensure that resource use in these sectors is efficient. At the same time environmental policy appraisal is typically complicated by the fact that there are a number of feasible options to a decision problem, each yielding a different mix of environmental services. Decision-makers are confronted with questions: how can generically different benefits be measured in comparable terms and how should different levels of ecosystem restoration costs be weighed against benefits?

During recent decades, much emphasis has been placed on nature restoration in Denmark, especially floodplains in river valleys. This is due to the fact that much of Denmark's unique biodiversity is dependent on functioning wetlands and riparian areas. The Skjern River Project is one of Denmark's most important ecosystem restoration projects. The primary purpose of restoring the Skjern River system to its original state was to establish a large coherent nature conservation area which could accommodate some of Denmark's unique biodiversity - including several species on the IUCN Red List of Threatened Species - provide recreational opportunities for the general public, and improve water quality in the adjacent coastal lagoon. The project involved restoring river habitat, establishing a lake, re-creating a delta, re-establishing contact between the river and riparian areas by permitting floods, and transferring land from arable to extensive grazing

The purpose of this study was to compare the social benefits and costs of the Skjern River restoration project in Denmark, taking both market and non-market goods and services into account. The cost-benefit analysis considered the existence value of increased biodiversity, the use values of improved possibilities for outdoor recreation, angling and hunting, as well as the water purification effects of the project. A variety of market and non-market environmental economic valuation techniques were used, with a particular emphasis on contingent valuation methods. As well as the benefits arising from ecosystem restoration (including savings on pumping expenses, improved land allocation, reduced organic pollution, reed production, reduced flood risk, improved water quality, climatic effects, biodiversity existence values, recreational and extractive resource uses) the CBA also considered its costs, including losses to production (fish farming, loss of rent from agricultural land, and effects on other sectors from changes in land use) as well as the physical costs of construction and maintenance.

Analysis of costs and benefits showed that the Skjern River project turned out to be a good "bargain" for Danish society, and that from an economic point of view ecosystem restoration was worthwhile. It provided a justification that the public and private resources that had been allocated to the project had been put to a good use from a social point of view.

These two cases illustrate also that there are basically two types of Cost-Benefit Analyses: financial and economic. Financial CBAs look only at the private returns accruing to a particular individual or group. They calculate costs and benefits at market prices, reflecting the actual cash profits and expenditures that people face. A financial CBA might for example measure and compare the relative profitability of different dam design options for a hydropower company, the returns to improved water and sanitation facilities for urban consumers, or the highest earning mix of irrigated crops for a farmer. Here, ecosystem values will primarily be incorporated into CBA calculations as they influence private costs and benefits, affect investments and are expressed through market prices.

"FINANCIAL CBA LOOKS AT RETURNS FOR INDIVIDUALS WHEREAS ECONOMIC CBA EXAMINES BENEFITS TO SOCIETY AS A WHOLE."

Flooding of the Mulde river in Germany resulted in immense damage in Grimma, Saxony in 2002. Investments in ecosystems may prevent or mitigate flooding.

In contrast, economic CBAs examine the effects of projects, programmes and policies on society as a whole. They consider all costs and benefits, for all affected groups. Sometimes weights are assigned to prioritise particular groups, benefits or costs that are considered to be of particular importance in economic terms. As such, economic CBAs are mainly carried out by public sector and donor agencies, who are concerned with broad development impacts.

For example, an economic CBA would consider the total costs and benefits of different hydropower design options, such as relocation costs and loss of production incurred by reservoir flooding, income from increased employment in the power sector and benefits associated with improved earning opportunities arising from electrification. An economic CBA of different irrigated crop mixes might include consideration of the premium attached to foreign exchange earnings from export crops, improved food security benefits, and revenues in agro-processing and value-added industries.

Because economic CBAs assess the desirability of a given course of action from the perspective of society as a whole, they usually adjust financial costs and benefits to account for the various imperfections and distortions in the market. It recognises that market prices are not a good indicator of the true social and economic value of goods and services. This means that ecosystem effects and values should form an integral component of economic CBAs.

One might expect an economic CBA of hydropower dam options to include the costs associated with the loss of reservoir habitats and degradation of downstream water-dependent ecosystems, and to factor in the benefits of upstream catchment protection in terms of extended reservoir lifespan and power generation. An economic CBA of irrigated agriculture might for instance look at the costs of agro-chemical runoff and soil erosion rates associated with different crops, and the opportunity costs of diverting water for irrigation from natural ecosystems.

4.3.2 Other economic decision-support tools

CBA remains the most widely used tool for the financial and economic appraisal of projects, programmes and policies. But it is not the only economic decision-support tool that is used in the water world. Other, less commonly-used, value-based measures of profitability or economic/ financial desirability include:

- Cost-effectiveness analysis: This decision-support tool judges the minimum cost way of attaining a particular objective. It is useful where a project has no measurable benefits, or where a particular goal has already been set (for example maintaining a certain water quality level). It involves calculating all the costs of attaining the given objective, discounting them, and pointing to the option with the lowest NPV.
- Risk-benefit analysis: This decision-support tool focuses on the prevention of events carrying serious risks (for example investing in flood prevention). It assesses the costs of inaction as the likelihood of the specified risk occurring. The benefit of inaction is the saving in the cost of preventive measures. It is useful where risk is a major consideration in projects, and can be captured via monetary values.
- Decision analysis: This decision-support tool weights the expected values of a given course of action (in other words, the sum of possible values weighted by their probability of occurring) by attitudes to risk, to give expected utilities. It draws up and assesses decision makers' preferences, judgements and trade-offs in order to obtain weights that are attached to outcomes carrying different levels of risk.

4.4 Relating ecosystem values to non-monetary decision tools

Although they are important and influential decision-making tools in the water world and elsewhere, economic and financial measures are not the only criteria by which decisions are made. There will always be certain water values that cannot be expressed in monetary terms, and there are many non-economic considerations in weighing up alternative projects, policies and programmes, and in deciding which the most desirable one is.

"ECOSYSTEM VALUES CAN BE INTEGRATED INTO WATER DECISION FRAMEWORKS."

Various support frameworks are used to make water decisions, including those which weigh up social costs and benefits, environmental risks and impacts, technical feasibility, and institutional and policy factors. Ecosystem values can be integrated into many of these.

Multi-criteria analysis

Multi-criteria analysis provides one of the most useful and increasingly common tools for integrating different types of monetary and non-monetary decision criteria. It has been developed to deal with situations where decisions must be made taking into account multiple objectives, which cannot be reduced to a single dimension.

Multi-criteria analysis is usually clustered into three dimensions: the ecological, the economic and the social. Within each of these dimensions certain criteria are set, so that decision-makers can weigh the importance of one element in association with the others. Here, monetary values and CBA measures can be incorporated as one of the criteria to be considered, and weighed against the others in decision-making. The following case illustrates the application of multi-criteria assessment of management options for mangroves.

Case 21: Using multi-criteria to assess mangrove management options in the Philippines[60]

The municipality of Pagbilao is located in the southern part of Quezon Province, on the island of Luzon in the Philippines. Pagbilao Bay, with its mangroves and coral reefs, is one of the richest natural marine areas in southern Luzon. Traditionally the mangroves have been exploited by local communities for minor products, but commercial fuelwood and charcoal production, as well as aquaculture developments, are rapidly leading to mangrove destruction.

This study evaluated the different management alternatives for the Pagbilao mangroves, looking at various combinations of preservation, subsistence and commercial forestry, silviculture and aquaculture. It carried out a multi-criteria analysis, combining economic, ecological and social information in order to weigh up the relative desirability of different management options. In addition to economic efficiency and value, the study took account of social equity and ecological sustainability objectives. It analysed these different criteria according to the perspectives and objectives of the different types of decision-makers involved in mangrove management, including fishpond owners, local government, national governments and donor agencies.

The study evaluated these different criteria and objectives by combining valuation and cost-benefit analysis with other indicators and measures of efficiency, equity and sustainability. It concluded that in order to maximise economic efficiency gains, conversion of mangroves to aquaculture maximises returns. However, if sustainability and equity objectives were included, then commercial forestry would be the preferred alternative.

4.5 Closing the loop: using ecosystem values to influence water decisions

Working through the steps outlined above gives us a basis for starting to integrate ecosystem values into water decisions. There are a growing number of cases where ecosystem valuation questions the wisdom of conventional water decisions, or changes the way in which water sector investments are planned and implemented. Integrating ecosystem costs and benefits into measures of the desirability of allocating water, investing funds or using land and resources in a particular way can substantially alter their results, and show that counting ecosystems is actually essential for their long-term financial and economic viability, sustainability and profitability.

"VALUATION CHANGES THE WAY IN WHICH WATER SECTOR INVESTMENTS ARE IMPLEMENTED."

As techniques for counting ecosystems as an economic part of infrastructure become more widely accepted and used, we are seeing more and more cases where valuation information is being used to show that ecosystems form an essential - and economic - component of the water supply chain, and are economic users of water. For example, water decisions are starting to respond to economic and financial arguments and measures for restoring or reversing the damage that has been caused to ecosystems by past infrastructure developments (Case 22), to factor in ecosystems as a necessary component of water investment costs (Case 23), or to weigh up the total costs and benefits of different water and land use planning options (Case 24). Slowly, ecosystem valuation is starting to be used as a decision-making tool in the water world.

Case 22: Using economic analysis to justify restoration of the Waza Logone Floodplain, Cameroon[61]

Covering an area of some 8,000 km2 in northern Cameroon, the Waza Logone floodplain represents a critical area of biodiversity and high productivity in a dry area, where rainfall is uncertain and livelihoods are insecure. The floodplain's natural goods and services provide basic income and subsistence for more than 85% of the region's rural population, or 125,000 people. The biodiversity and high productivity of the floodplain depend to a large extent on the annual inundation of the Logone River. However, in 1979 the construction of a large irrigated rice scheme reduced flooding by almost 1,000 km2. This loss of flooding has had devastating effects on the ecology, biodiversity and human populations of the Waza Logone region.

The hydrological and ecological rehabilitation of the Waza Logone floodplain, through reinundation, is an important element of the Projet de Conservation et de Développement de la Région de Waza-Logone. To date the project has already accomplished two pilot flood releases, which have led to demonstrable recoveries in floodplain flora and fauna, and have been welcomed by local populations. It is intended that further restoration of the previously inundated area will be achieved by constructing engineering works which allow flooding to take place. In order to make the case to Government and donors for investment in reinundation, the Waza Logone Project carried out a study to value the environmental and socio-economic benefits of flood release and costs of flood loss to date.

This study found that the socio-economic effects of flood loss have been significant, incurring livelihood costs of almost $50 million over the 20 or so years since the scheme was constructed. Up to 8,000 households have suffered direct economic losses of more than US$2 million a year through reduction in dry-season grazing, fishing, natural resource harvesting and surface water supplies. The affected population, mainly pastoralists, fisherfolk and dryland farmers, represent some of the poorest and most vulnerable groups in the region.

Reinundation measures have the potential to restore up to 90% of the floodplain area, at a capital cost of approximately US$10 million. The economic value of floodplain restoration will be immense. Adding more than $2.5 million a year to the regional economy, or US$3,000/km2 of flooded area, the benefits of reinundation will have covered initial investment costs in less than 5 years. Ecological and hydrological restoration will also have significant impacts on local poverty alleviation, food security and economic well-being. Flood releases will rehabilitate vital pasture, fisheries and farmland areas used by nearly a third of the population, to a value of almost US$250 per capita.

Case 23: Demonstrating the economic benefits of investing in forest management for water supplies of the Paute hydroelectric scheme, Ecuador[62]

The Paute hydroelectric scheme, in the Andean Highlands of Ecuador, was completed in 1983 at a cost of $600 million. At the time of its construction, INCEL, the Ecuadorian electric power utility, took the unusual measure of investing in a range of upstream catchment management activities in order to generate water supply and quality benefits that would preserve the capacity, output and lifespan of the scheme.

A simple model was constructed in order to assess, and demonstrate, the economic and financial returns to investing in forest management as part of the construction and management of the hydroelectric scheme. This quantified the costs of upper catchment degradation and increased erosion, and the benefits of undertaking measures to avoid them. It examined major effects on dam operations, and ascertained their value. These included the reduction dam in storage capacity and lifespan that would otherwise have necessitated generating additional power from thermal installations at a higher cost, increased delivery of sediments and soils from upstream areas that would have required remediation work to remove stones and boulders and caused turbine blades and other equipment to function less well and require more frequent replacement.

These costs and benefits were analysed in order to ascertain the present value to the hydropower scheme of undertaking watershed management activities, in terms of increased power revenues, lower dredging costs and an extension to the dam's lifespan. The results of the analysis showed sizeable present values, mainly accounted for by the extended lifespan of the scheme. Depending on the pace and extent to which benefits are realised, these range between $15 million and $40 million - making the point that upper watershed management is in the direct financial interests of the power utility.

Case 24: Assessing the economic impacts of alternative land uses on ecosystems to weigh up protection, sustainable use and development of the Barotseland Floodplain, Zambia[63]

The Barotse Floodplain and its associated wetlands cover more than 1.2 million hectares in western Zambia, making it one of the largest wetland complexes in the Zambezi Basin. Almost a quarter of a million people live on the floodplain, and depend on its natural resources for their day-to-day subsistence and income. In total, it is estimated that the wetland has a gross economic direct use value of some $12.25 million a year, yielding net financial benefits of over $400 per household per year from fishing, livestock keeping, cropping, plant and animal harvesting. At the same time it generates a wide range of services which enable and protect off-site production and consumption, including downstream flood attenuation (calculated to have a NPV of $0.4 million), groundwater recharge ($5.2 million), nutrient cycling ($11.3 million) and carbon sequestration ($27 million).

These environmental values have been largely excluded when land and water use decisions have been made in the region. Yet factoring in the economic benefits of wetland goods and services can substantially change the indicators of profitability and economic desirability of development decisions. For the case of the Barotse Floodplain, a dynamic ecological-economic model which simulated the effects of human activity on the wetland system over a 50 year period was used to show the economic and financial implications of different land management scenarios. These included various combinations of a "do nothing" scenario of continuing resource use and human population growth, a "wise use" scenario based on sustainable wetland use and management, a "protected area" scenario which required some levels of extractive resource use to be reduced or curtailed completely, and an "agricultural development" scenario which assumed the gradual transformation of the floodplain to large-scale irrigated rice.

This dynamic modelling indicated clearly that the most economically valuable future management option for the Barotse Floodplain was wise use and conservation of the wetland area. This yielded a NPV of almost $90 million, as compared to just over $80 million under a "do nothing" scenario, less than $70 million for "strict protection", and under $80 million for large-scale agricultural schemes. Whereas a highly protective management regime was found to incur high opportunity costs in terms of sustainable resource use foregone, both local and national economic benefits and financial profits generated by land conversion to agriculture were far outweighed by the economic costs of wetland goods and services lost. Interestingly, the economic and financial values yielded by managing the Barotse Floodplain sustainably was most pronounced at the local level.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Chapter 5

Moving form case studies to standard practice

5.1 Different studies lead to different decisions

This book has presented the techniques that can be used to value ecosystems as economic components of water demand and supply, and shown how to incorporate the resulting information into the economic measures and indicators that are used to make decisions in the water sector.

It recommends identifying ecosystem water benefits within a total economic value framework, and using a range of market and non-market techniques to quantify how much relevant values are worth for different groups. It identifies the steps and additional information that are required to construct a bio-economic model that relates ecosystem quality or status to changes in water goods and services, and to changes in economic value. It then describes the measures and indicators that can be calculated to serve as decision-support tools in the water sector, including economic and financial measures in cost-benefit analysis, cost-effectiveness analysis, risk-benefit analysis and decision analysis and non-monetary decision tools such as multi-criteria analysis.

There have also been concrete examples of the ways in which ecosystem valuation techniques are starting to be used in the real world in order to influence decision-making. These case studies illustrate how techniques for counting ecosystem values can be and have been applied to a wide range of countries, ecosystems, sectors and water management issues. They show what kinds of economic arguments, and management information about ecosystem values, are relevant for influencing different kinds of water decisions in different sectors.

These case studies may also serve another use. They can guide anyone who wishes to apply economic valuation to examples in literature which will assist in defining an actual study. Therefore, table 3 presents some management and policy questions in different sectors and links these to valuation methods and case studies.

On the next pages table 3: Ecosystem values and water management issues: a summary of case studies. This table intends to guide the reader from possible policy and management questions to existing case studies that may help in designing a valuation exercise.

Sector	Management question	Valuation focus	Valuation method or decision-making tool	Decision-making message	Country/Region	Reference
Land use planning	What are the consequences of rezoning this wetland for other land uses?	Life support services of wetlands	Replacement cost	There is a high cost to replacing life support functions of natural wetlands	Sweden	Case 10
	Can this wetland be rezoned for agricultural, housing or industrial development?	Economic value of wetland resources	Market price	Freshwater wetlands have a high economic value	Southern Africa	Case 3
	What are costs and benefits from changes in the land use in and around this wetland?	Contribution of wetland to economic output under different scenarios	Bio-economic model	Relatively small changes in wetland management yield high environmental values, but also entail significant monetary costs to landholders	Australia	Case 18
	What is the best economic use of this particular area?	Value of wetland goods and services for agriculture, resource use, flood attenuation, groundwater recharge, nutrient cycling, carbon sequestration		Conservation and sustainable use is the most economically valuable wetland management option	Southern Africa	Case 24
Rural development	Is the protected area (wetland) of importance to the local communities?	Contribution of wetland to economic output under different scenarios		Sustainable wetland management yields highest economic values, and generates positive return on investment	Bangladesh	Case 17
	Is there a development case to increase government allocation to wetland management?	Value of wetland goods and services to livelihoods and local economy	Market price, replacement cost	High development and livelihood value of wetlands justifies government conservation interventions and budgetary allocations	Uganda	Case 1
	Is more irrigation the best way to stimulate rural development?	Rural development costs of ecosystem degradation arising from insufficient freshwater flows	Market price	Increased poverty and livelihood costs presents strong argument for ensuring environmental flows	Pakistan	Case 2
Conservation	How can I demonstrate that my protected area is generating benefits to the local communities?	Contribution of wetland to economic output under different scenarios		Sustainable wetland management yields highest economic values, and generates positive return on investment	Bangladesh	Case 17
	Are protected areas a worthwhile investment? Do we charge visitors to this protected area appropriately?	Value of domestic forest tourism	Travel cost	Visitors have a high willingness to pay for forest recreation, which exceeds current entry charges	Costa Rica	Case 6
	What is the best way to manage this mangrove area?	Economic, ecological and social value of mangrove goods and services	Cost-benefit analysis	Different goals and intended gains influence which is the "best" mangrove management option	Philippines	Case 21

Sector	Management question	Valuation focus	Valuation method or decision-making tool	Decision-making message	Country/Region	Reference
Energy	Is the upper watershed important to the economic viability of my project?	Value of forests hydrological services	Damage cost	Failing to protect upper watershed reduces output, profits and lifespan of reservoir	Cambodia	Case 14
	What will be the impacts of this proposed project?	Economic value of downstream flooding		Dam construction resulting in loss of downstream flooding would incur significant economic costs	Kenya	Case 19
	Is it economical to invest in the upper watershed?	Value of forest hydrological services	Bio-economic model	There is a sizeable return on investing in catchment management for hydropower water services	Ecuador	Case 23
Health	Do we invest in treatment plants or wetland management to reduce nitrate levels in drinking water?	Wetland nitrogen abatement services	Mitigative / avertive	There is a high return to investing in wetland restoration and management for nitrogen abatement	Sweden	Case 12
Housing, infrastructure and urban	Is the wetland a reason people want to live in this area?	Amenity value of urban wetlands	Hedonic	Conserving urban wetlands is reflected in higher property prices	United States	Case 8
	Should this wetland be protected to prevent flooding of the urban area?	Flood attenuation services of wetlands	Damage cost	High damage costs from flooding justifies wetland conservation and sustainable use	Southern Africa	Case 13
	Should we protect this urban wetland or can we drain it for housing development?	Flood attenuation services of wetlands	Mitigative / avertive	High value of urban wetlands for flood attenuation services justifies their protection from industrial and housing reclamation	Sri Lanka	Case 11
	Should we protect this urban wetland or can we drain it for housing development?	Wastewater treatment services of wetlands	Replacement cost	High value of urban wetlands for water quality services justifies their protection from industrial and housing reclamation	Uganda	Case 9

Sector	Management question	Valuation focus	Valuation method or decision-making tool	Decision-making message	Country/Region	Reference
Irrigation, rural development	Will the investment to change operations of this irrigation scheme and restore the downstream river pay off?	Livelihood costs of floodplain degradation and losses in resource use opportunities from irrigation scheme	Market price, Multi-criteria analysis	Investment in floodplain restoration, and change in flow regime, justified from an economic and poverty alleviation angle	Cameroon	Case 22
	Is protection of this upper watershed area beneficial to downstream irrigation schemes?	Flood attenuation benefits of catchment forests to irrigated agriculture	Effect on production	Local economic welfare benefits of forest hydrological services justify Protected Area conservation	Madagascar Guatemala	Case 4 Case 5
	Is protection of this upper watershed area beneficial to downstream irrigation schemes?	Local value of watershed drought mitigation services	Contingent	Local economic welfare benefits of forest hydrological services justify Protected Area conservation	Indonesia	Case 15
Tourism and recreation	Is the investment of public resources in this restoration programme justified?	Economic value of river ecosystem for recreation, biodiversity, water quality, flood attenuation, climate	Cost-benefit analysis	Investment of public resources in ecosystem restoration justified in economic and social terms	Denmark	Case 20
	Is the investment of public resources in improved environmental quality justified?	Value of improved environmental quality for freshwater recreation	Travel cost	Investing in improved environmental quality in freshwater ecosystems generates high recreational benefits	United States	Case 7
	What is the economic return of tourism in this area?	Local landscape, recreational, amenity and existence value of coastal wetlands	Contingent	Coastal wetlands have a high conservation value	Korea	Case 16

5.2 Maximising the impact of valuation on decision-making

These techniques provide the methods and analytical frameworks that allow us to identify, calculate and articulate the links between ecosystems, water and the economy. But the use of ecosystem valuation is still in its infancy, and remains the exception rather than the rule when water infrastructure is planned, water is allocated and priced, or water sector investments are made.

Here one has to recognise that being able to express ecosystem-water linkages as economic values is not the end of the story. Challenges still remain. How do we help ecosystem valuation to reach its potential to influence economic decisions that are made in the water world? And what types of approaches and strategies can be deployed to give ecosystem valuation the best chance of influencing water sector policies, programmes and plans in reality?

"PRACTICAL REALITIES DETERMINE IF VALUATION WILL PROVE CONVINCING TO DECISION-MAKERS."

There are certain practical realities which determine how far the information generated will prove convincing to water decision-makers and whether they will use it to change the way in which projects are designed, programmes planned and policies formulated in the water sector. Below are some practical pointers to maximise the likelihood that valuation will actually change the way in which water decisions are made.

5.2.1 Communicate convincingly: present useful and relevant information

However good the results of a valuation study are, they will have little impact on decision-making if nobody sees, reads or is persuaded by them. There is an art to presenting information, and communicating it effectively. In many cases, the technical experts who carry out the valuation study itself may not be the best placed to do this – there is often a need for professional communicators and a properly-designed communications strategy. Information about the value of ecosystems for water must be communicated effectively, widely and in a convincing manner.

Information about ecosystem water values will be easiest to communicate when people find it useful, and it is helps them to address or better understand a particular situation or problem. For example, what the implications of wetland degradation will be on household income, how much money can be saved through investing in catchment protection for hydropower production, what the potential is to raise revenues from forest tourism. This is an important factor in designing and conceptualising valuation studies, and presenting their findings. Studies should be practical and policy relevant, and relate or respond to real-world management issues. Valuation for valuation's sake, however interesting, is unlikely to convince people to change their water decisions.

Many people are involved in shaping water decision-making, and communication of the results of valuation studies must usually take place at many levels of scale. Try to reach the wide array of stakeholders, from politicians to villagers, from economic planners to ecosystem managers, and from water engineers to end-users of water goods and services. Making the results of valuation convincing to these different groups requires different types of communications strategies, different messages and different ways of presenting information.

Fish test the quality of Rhine water at Lobith, the Netherlands

5.2.2 Change ways of thinking: build involvement and awareness

Ecosystem valuation studies should not, and cannot, be carried out in isolation from the different groups who use, depend on and manage water. These range from local landholders, through sectoral specialists, water planners and environmental managers, to high-level political decision-makers and foreign donors. They also include the scientists and technical specialists from ecological, biological, hydrological and engineering disciplines who provide other types of information that guide water decision-making.

Gaining the necessary momentum to ensure that ecosystem values are factored into water decisions will require, and affect, many of these groups. It is necessary for them to feel that they are involved when valuation is carried out, and that it accurately reflects their perspectives and interests. Otherwise they are likely to have little interest in taking its results into account when they make water decisions. Unless key stakeholders are involved in, and aware about the utility of, valuation studies, the results are unlikely to gain broader support or influence.

"INVOLVE KEY STAKEHOLDERS IN THE VALUATION STUDY TO GENERATE SUPPORT."

Creating a broad awareness of the linkages between ecosystems, water and the economy, and of their relevance to decision-making, is essential to engaging and involving different groups. And valuation information can in itself provide a powerful tool for building awareness about the role of ecosystems in water demand and supply. Talking about monetary values can exert a powerful influence over people's interest and awareness of ecosystems and water issues.

5.2.3 Respond to strategic opportunities: work with policies, strategies and plans

Because the economic level is concerned with the "bigger picture" perspective, integrating ecosystem valuation into higher-level policies, strategies and plans provides a strategic opportunity to influence the way in which water decisions are shaped.

Water decision-making is shaped by, and itself shapes, policies, strategies and plans both within and outside the water sector. There are close links between water benefits, ecosystem status and decisions which are made in sectors such as finance and economic planning, energy, forestry, agriculture, transport, infrastructure, urban development and so on.

Ensuring that an appreciation of ecosystem values is reflected in macroeconomic and sectoral policies, strategies and plans presents a strategic opportunity to shape water decisions. These represent the highest level instruments which set out development and investment goals, determine how they will be reached, and provide the guiding framework within which water decisions are made. For example, agricultural sector policies impact on natural ecosystems through the type and extent of crop and livestock production they promote, and they also depend heavily on ecosystem water services. Energy policies, especially in the hydropower sector, also have close linkages and impacts to water ecosystems. And financial and economic policies, because they set the overall framework and goals within which people produce and consume, have major impacts on the way in which water decisions are made.

"HIGHER LEVEL POLICIES, STRATEGIES AND PLANS PROVIDE STRATEGIC OPPORTUNITIES FOR INFLUENCING DECISIONS."

Policies, strategies and plans provide an opportunity to introduce requirements for ecosystem valuation. It then has to be included in the project analysis and investment appraisal guidelines for developments in these sectors. Although it is becoming more common for some kind of environmental economic calculations to be incorporated into cost-benefit analyses and environmental impact assessments, ecosystem valuation is rarely required as standard practice. Formalising the type of steps and techniques that have been described in this document at the policy level is an important prerequisite for ecosystem values to be integrated into water decision-making.

5.2.4 Get grounded in reality: balance political agendas and competing interests

In a perfect world where all decisions were made for the good of society, merely making valuation information available might be enough to ensure that water decisions took fair account of ecosystems. Unfortunately this is not usually the case. There exist multiple, and often competing, interests in water and water infrastructure, some of which are more powerful than others. Political agendas are often played out on the stage of water decisions.

Fostering cooperation and balancing these competing interests is critical when the results and recommendations of ecosystem valuation studies are presented. Here, it is important to be tactical and work with the different constituencies who actually have the political will, and power, to influence water decisions. Just as ecosystem valuation aims to articulate particular costs and benefits that have traditionally been ignored in decision-making, it also represents the interests of many of the groups who have often been excluded from these decisions. For example, it may include the landholders who safeguard water ecosystems, or who depend on their goods and services for their livelihoods.

"DEMONSTRATE HOW WATER DECISIONS CAN BE IN FAVOUR OF KEY ACTORS."

Securing support for ecosystem valuation from key actors, and demonstrating to them that certain water decisions can act in their favour, is vital. For example, showing the Ministry of Finance that ecosystem conservation for water can lead to significant gains in national development indicators, pointing out to a community leader that local employment depends largely on ecosystem resources, or convincing a politician that ecosystem water values matter for her constituency. This requires identifying decision-makers or groups who have the power, interest or influence (as well as the responsibility or mandate) to push for changes in water decision-making, to get ecosystem values onto the political and policy agenda, and who are prepared to commit time or resources to do this.

5.2.5 Strengthen capacity: create a pool of knowledge and abilities

Investing in institutional capacity, adequate technical expertise, and accessible methods and information are all essential to make ecosystem valuation a routine part of water decision-making.

Ecosystem valuation remains a relatively new topic and area of expertise – most of the basic tools and concepts that allow us to value ecosystem goods and services have only been developed over the last decade or so, and it is only in recent years that they have started to be applied within water policy and practice.

In most countries and sectors there are few environmental or resource economists, and the skills and training to carry out ecosystem valuation remains in short supply. Few, if any, water agencies have the technical or human resources capacity to undertake ecosystem valuation studies. Developing and strengthening this capacity – at both institutional and individual levels – is an essential part of getting ecosystem values onto decision-making agendas over the long-term.

The methodological and information base for ecosystem valuation in the water sector also remains weak. Many of the tools that are used for ecosystem valuation have been built up and applied in the Europe and North America, and still largely remain in the academic and theoretical, rather than practical, arena. There is an urgent need to develop and demonstrate ecosystem valuation methods that have broad relevance and applicability, are targeted towards generating practical and policy-relevant information, and can be used within the context of limited time, funding and technical capacities – without compromising the quality or credibility of resulting data.

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28 A substitute good or service is one which is used in place of another – for example kerosene instead of firewood, or bottled water instead of tapwater.

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Glossary

Key Economic Terms and Concepts

Benefit Cost Ratio (BCR)
A measure of project desirability or profitability: the ratio between the discounted total benefits and costs of a project.

Bio-economic model
A model of ecological and socio-economic reality that allows us to express the consequences of different management regimes on ecosystem values.

Choice experiment valuation methods
A Stated Preference Approach technique for valuing ecosystems or environmental resources that presents a series of alternative resource or ecosystem use options, each of which is defined by various attributes including price, and uses the choices of respondents as an indication of the value of ecosystem attributes.

Complementary Good
A good or service that is used in conjunction with another.

Conjoint Analysis valuation methods
A Stated Preference Approach technique for valuing ecosystems or environmental resources that asks individuals to consider the status quo and alternative states of the world. It describes a specific hypothetical scenario and various environmental goods and services between which respondents have to make a choice.

Consumer Surplus
The difference between the value of a good and its price, in other words the benefit over and above what is paid that is obtained by a consumer who is willing to pay more for a good or service than is actually charged.

Contingent Valuation methods (CVM)
A Stated Preference Approach technique for valuing ecosystems or environmental resources that elicits expressions of value from respondents for specified increases or decreases in the quantity or quality of an environmental good or service, under the hypothetical situation that it would be available for purchase or sale. This yields their willing to pay (WTP) for the quality of quality of the good or service under question, or willingness to accept compensation (WTA) for its loss.

Cost Based approaches to valuation
A group of techniques for valuation that look at the market trade-offs or costs avoided of maintaining ecosystems for their goods and services, including replacement costs, mitigative or avertive expenditures and damage costs avoided methods.

Cost-Benefit Analysis (CBA)
A decision tool which judges the desirability of projects by comparing their costs and benefits.

Cost-effectiveness analysis (CEA)
A decision tool that judges the desirability of a project according to the minimum cost way of attaining a particular objective.

Damage cost avoided valuation methods
A Cost Based Approach technique for valuing ecosystems or environmental resources that estimates the value of ecosystem goods and services by calculating the damage that is avoided to downstream infrastructure, productivity or populations by the presence of ecosystem services.

Decision analysis
A decision tool that judges the desirability of projects by weighting the expected values of a given course of action (in other words, the sum of possible values weighted by their probability of occurring) by attitudes to risk, to give expected utilities

Direct values
A component of *Total Economic Value*: environmental and natural resources that are used directly as raw materials and physical products for production, consumption and sale.

Discounting
The process of finding the present value of a future stream of benefits, using a discount rate. The present value is obtained by multiplying the future cost or benefit by the expression , where *i* is the discount rate and *n* is the year in question.

Discount rate
The interest rate used to determine the present value of a future stream of costs and benefits.

Economic CBA
Examines the effects of projects, programmes and policies on costs and benefits to society as a whole, valued according to economic or shadow prices.

Economic Rate of Return
A measure of project desirability or profitability: the *Internal Rate of Return* of the flow of net benefits to a project when all costs and benefits are valued at economic or *Shadow Prices*.

Economic Values
Values measured at their "real" cost or benefit to the economy, usually omitting transfer payments and valuing all items at their opportunity cost to society.

Effect on Production valuation methods
A *Production Function Approach* technique for valuing ecosystems or environmental resources that quantifies the relationship between changes in the quality or quantity of a particular ecosystem good or service with changes in market value of production.

Existence values
A component of *Total Economic Value*: the intrinsic value of environmental or natural resources, regardless of their current or future use possibilities.

Financial CBA
Examines the effects of projects, programmes and policies on costs and benefits to the private returns accruing to a particular individual or group, valued according to financial prices.

Financial Rate of Return
A measure of project desirability or profitability: the *Internal Rate of Return* of the flow of net benefits to a project when all costs and benefits are valued at constant market prices.

Financial Values
Values measured at market prices, as outflows or inflows to a particular individual or group.

Hedonic Pricing valuation methods
A *Surrogate Market Approach* technique for valuing ecosystems or environmental resources that values ecosystem goods and services by relating their presence or quality to other prices, for instance housing property or wages.

Indirect values
A component of *Total Economic Value*: environmental services which maintain and protect natural and human systems.

Internal Rate of Return (IRR)
A measure of project desirability or profitability: the *discount rate* at which a project's *Net Present Value* becomes zero.

Marginal Benefit
The change in benefit associated with consuming one additional unit of a good or service.

Marginal Cost
The change in cost associated with producing one additional unit of a good or service.

Marginal Value
The change in value resulting from one more unit of a good or service produced or consumed.

Market Price valuation methods
A technique for valuing ecosystems or environmental resources by using its market price: how much it costs to buy, or what it is worth to sell.

Mitigative or Avertive Expenditure valuation methods
A *Cost Based Approach* technique for valuing ecosystems or environmental resources that assesses the value of ecosystem goods and services by calculating the cost to mitigate or avert economic losses resulting from their loss.

Multi-criteria analysis
A decision tool that integrates and weights different types of monetary and non-monetary information, based on ecological, social and economic criteria: economic valuation of ecosystem goods and services can be incorporated as one of these criteria.

Net Present Value (NPV)
A measure of project desirability or profitability: the sum of *discounted* net benefits and costs of a project.

Opportunity Cost
The value to the economy of a good, service or resource in its next best alternative use.

Option values
A component of *Total Economic Value*: the premium placed on maintaining environmental or natural resources for future possible uses some of which may not be known now, over and above the direct or indirect value of these uses.

Perfect Competition
A market situation in which the number of buyers and sellers is very large, the products offered by sellers are indistinguishable, there are no restrictions on market entry, buyers and sellers have no advantage over each other, and everyone is fully informed about the price of goods. Under such conditions, no individual or company can affect the market price of a good or service by their action.

Production Function approaches to valuation
A group of techniques for valuation that attempt to relate changes in the output of a marketed good or service to a measurable change in the quality of quantity of ecosystem goods and services through establishing a biophysical or dose-response relationship between ecosystem quality, the provision of particular services, and related production, including *effect on production* methods.

Private Good
A good which, if consumed by one person, cannot be consumed by another. The benefits of a private good are both divisible and excludable.

Public Good
A good whose benefits can be provided to all people at no more cost than that required to provide it for one person. The benefits of a public good are indivisible, and people cannot be excluded from enjoying them.

Replacement Cost valuation methods
A *Cost Based Approach* technique for valuing ecosystems or environmental resources that assesses ecosystem values by determining the cost of man-made products, infrastructure or technologies that could replace ecosystem goods and services.

Risk-benefit analysis
A decision tool that focuses on the prevention of events carrying serious risks and assesses the costs of inaction as the likelihood of the specified risk occurring.

Shadow Prices
Prices used in economic analysis, when market price is felt to be a poor estimate of "real" economic value.

Stated Preference approaches to valuation
A group of techniques of valuation that ask consumers to state their valuation of or preference for specific ecosystem goods and services directly, including *contingent valuation*, *conjoint analysis* and *choice experiments* methods.

Substitute Good
A good or service which is used in place of, or competes with, another.

Surrogate Market approaches to valuation
A group of techniques of valuation that look at the ways in which the value of ecosystem goods and services are reflected indirectly in people's expenditures, or in the prices of other market goods and services, including *travel cost* and *hedonic pricing* methods.

Total Economic Value (TEV)
The sum of all marketed and non-marketed benefits associated with an ecosystem or environmental resource, including *direct, indirect, option and existence values*.

Travel Cost valuation methods
A *Surrogate Market Approach* technique for valuing ecosystems or environmental resources that takes the costs people pay to visit an ecosystem as an expression of its recreational value.

WTP
Willingness to pay (for ecosystem goods and services).

WTA
Willingness to accept compensation (for loss of ecosystem goods and services).

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Value – Counting ecosystems as water infrastructure

This practical guide explains the most important techniques for the economic valuation of ecosystem services, and how their results are best incorporated in policy and decision-making. It explains, step by step, how to generate persuasive arguments for more sustainable and equitable development decisions in water resources management. It shows that investments in nature can be investments that pay back.

About IUCN

IUCN-The World Conservation Union brings together States, government agencies, and a diverse range of non-governmental organizations in a unique partnership. As a Union of members, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.
http: //www.iucn.org

About the IUCN Water & Nature Initiative

The IUCN Water and Nature Initiative is a 5-year action programme to demonstrate that ecosystem-based management and stakeholder participation will help to solve the water dilemma of today - bringing rivers back to life and maintaining the resource base for many.
http: //www.waterandnature.org