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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.

Acknowledgements

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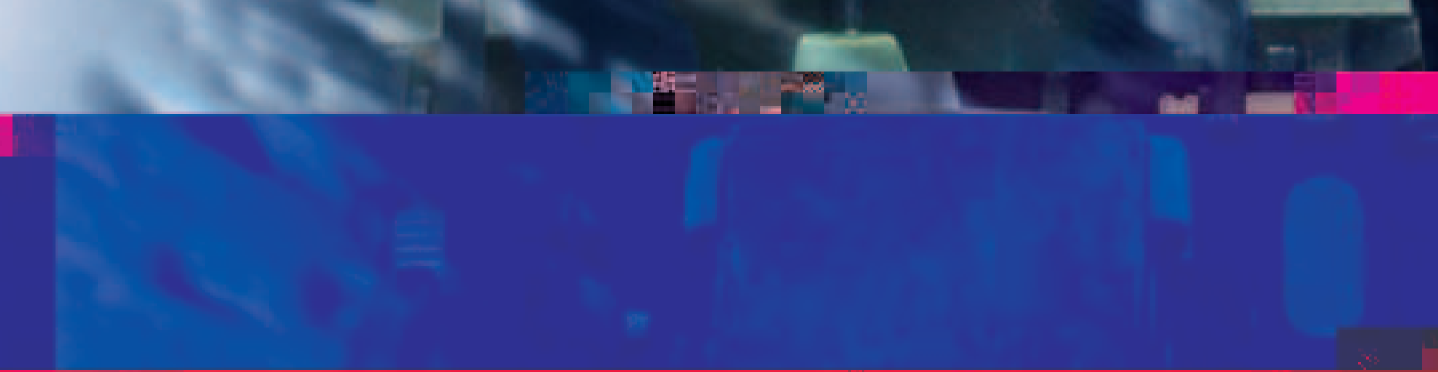


Chapter 1

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]

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.

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. Furthermore, 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.

[illegible]

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.

VALUE

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.

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."

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 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 Ec e al e ha e bee ig ed i deci i - aki g

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 I cl i f ec e al e be efi i e

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 Ec e al e hel achie e ai able de el e

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

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):

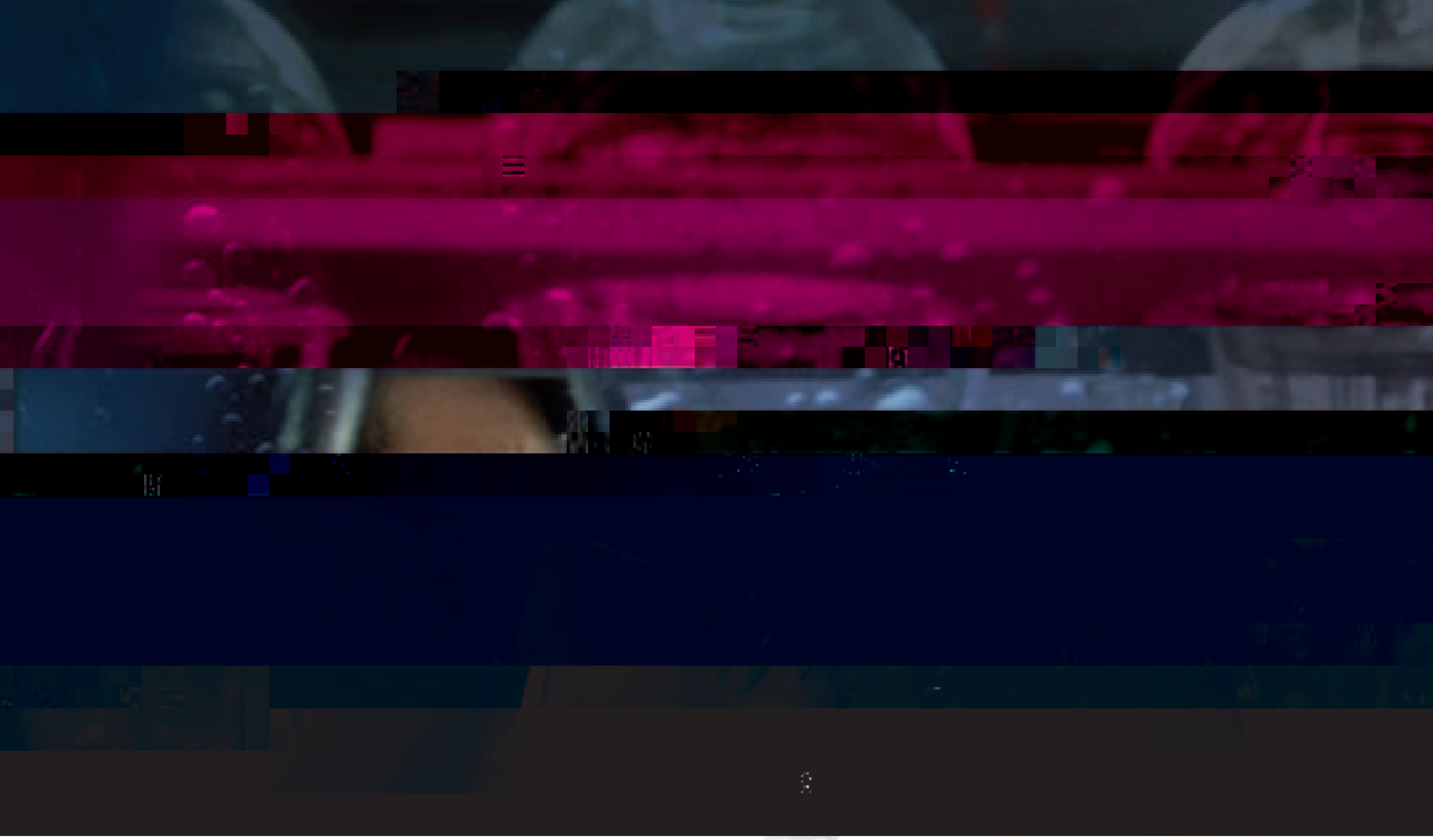
- Direct values: water-based or water-dependent raw materials and physical products which are used directly for production, consumption and sale such as those providing energy,shelter, foods, agricultural production, timber, medicines, transport and recreational facilities.
- Indirect values: ecological 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 al ec ic al e f ec e f a e

USE VALUES	NON- USE VALUES
Direct values [illegible]	Existence values [illegible]
Indirect values [illegible]	
Option values [illegible]	

2.7 Se i g he c e f al a i

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



C h a e 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 Q a if i g ec e al e f deci i - aki g

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."

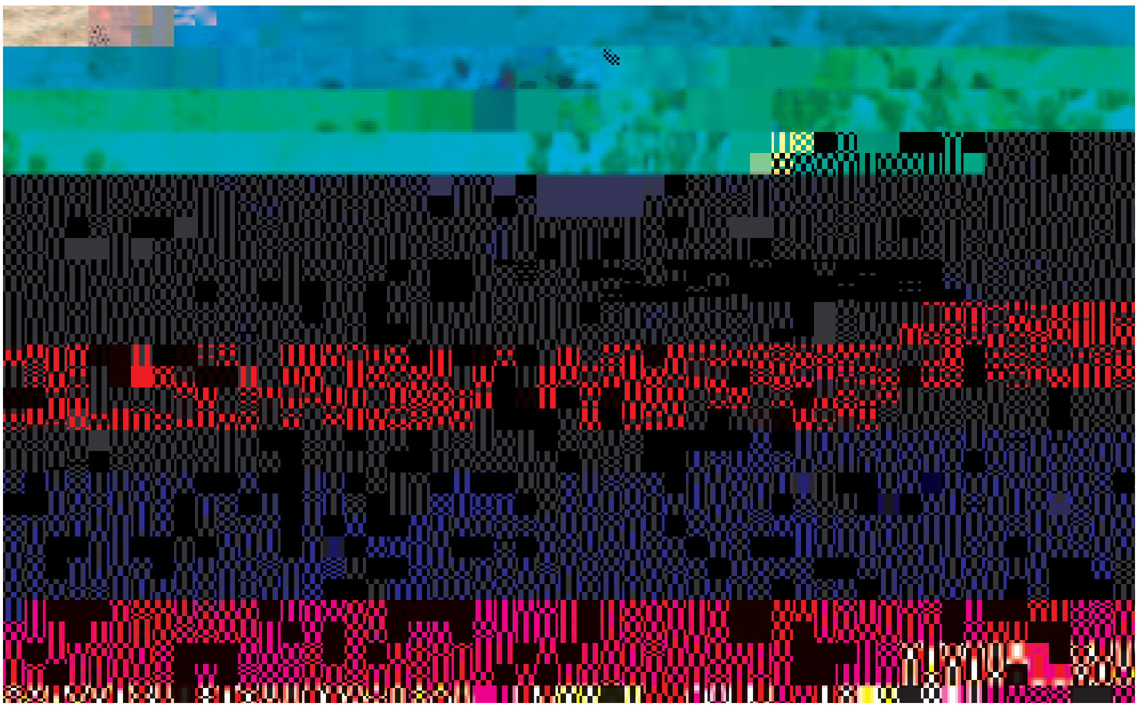
The basic aim of valuation is to determine people's preferences: how much they are willing to pay for ecosystem goods and services, and how much better or worse off they would consider themselves to be as a result of changes in their supply. By expressing these preferences, valuation aims to level the 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 a f ec e al a i ech i e

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):

- *Ma ke ice :* This approach looks at the market price of ecosystem goods and services.

- *P d ci f ci a ache :* 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 bio-physical 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

- *S ga e a ke a ache :* 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.

- *C -ba ed a ache :* These approaches, including replacement costs, mitigative or avertive expenditures and damage costs avoided, look at the market trade-offs or costs

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.

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The greatest advantage of this technique is that it is relatively easy to use, as it relies on observing actual marketns,eqaviurc91.7(, Faewas producer is thh3eewThe)tail so different locations.

3.2.2 Effec d c i ech i e

O e ie f he e h d

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.

Ca e 4: U i g effec d c i ech i e al e f e fl d a e a- i be efi i Ea e Madaga ca [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.

Ca e 5: U i g effec d c i ech i e al e he le f cl d f e i ae l i G a e ala[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.

Da a c llec i a d a al i e ie e

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.

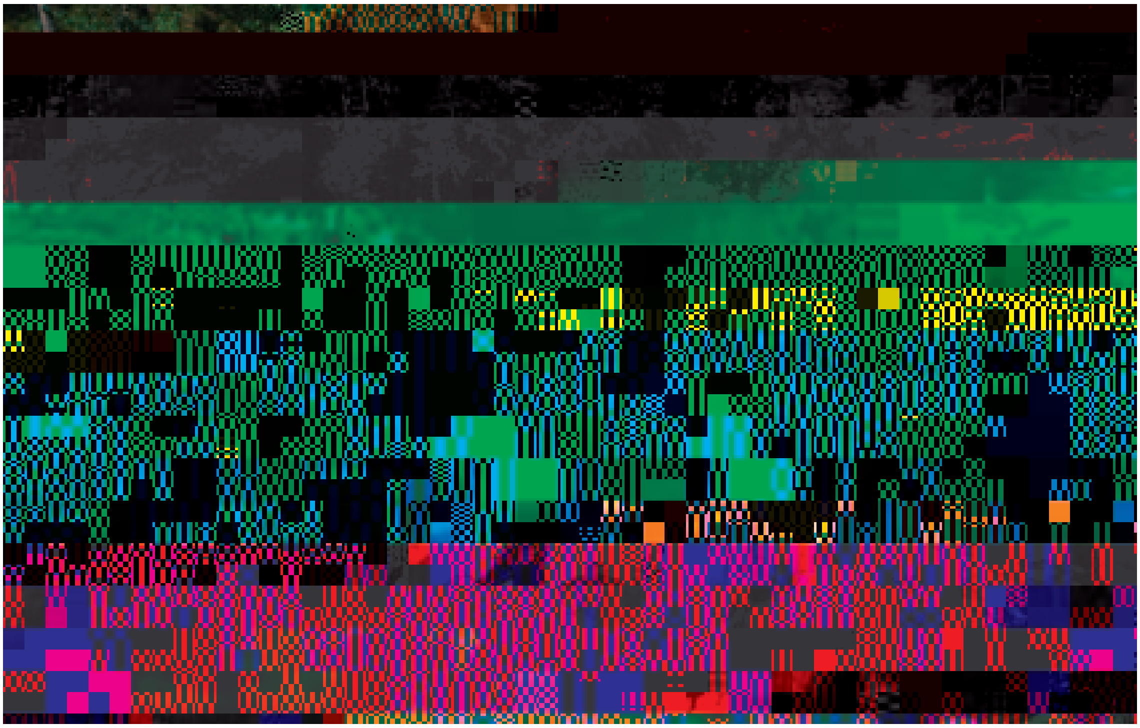
Effect on production techniques rely on a simple logic, and it is relatively easy to collect and analyse the market information that is required to value changes in production of ecosystem-dependent products (see above, market price techniques).

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.

A licabili , e g h a d eak e e

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.



Ca e 7: U i g a el c ech i e al e he i ac f i ed e i - e al ali f e h a e ec ea i i he 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.

Da a c llec i a d a al i e ie e

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.

A licabili , e g h a d eak e e

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 Hed ic ici g ech i e

O e ie f he e h d

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.

Ca e 8: U i g hed ic ici g ech i e al e ba e la d i he 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.

Da a c llec i a d a al i e ie e

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."

A licabili , e g h a d eak e e

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 Re lace e c ech i e

O e ie f he e h d

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.

Ca e 9: U i g e lace e c ech i e al e ela d a e ali e - ice i Naki b S a , Uga da[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 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

3.2.6 Mi iga i e   a e i e e   e di   e ech i   e

O e ie   f he   e h d

When an economically valuable ecosystem good or service is lost, or there is a decline in its 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.

Da a c llec i a d a al i e ie e

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:

•

Ca e 13: U i g da age c a ided ech i e al e he le f fl d a e ai i he L e Shi e We la d , Mala i a d M a bi e a d Ba e Fl d lai , Za bia[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 down-stream 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 settle-ment 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 con-centrated, 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.

Ca e 14: U i g da age c a ided ech i e al e f e a e hed e ice f he Ka cha H d e Sche e, Ca b dia[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.

3.2.8 C i ge al a i ech i e

O e ie f he e h d

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.

Da a c llec i a d a al i e ie e

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.

A licabili , e gh a d eak e e

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

Cha e 4

Using ecosystem values in water decisions

All of the methods and techniques that have been described in the previous chapter can be 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.

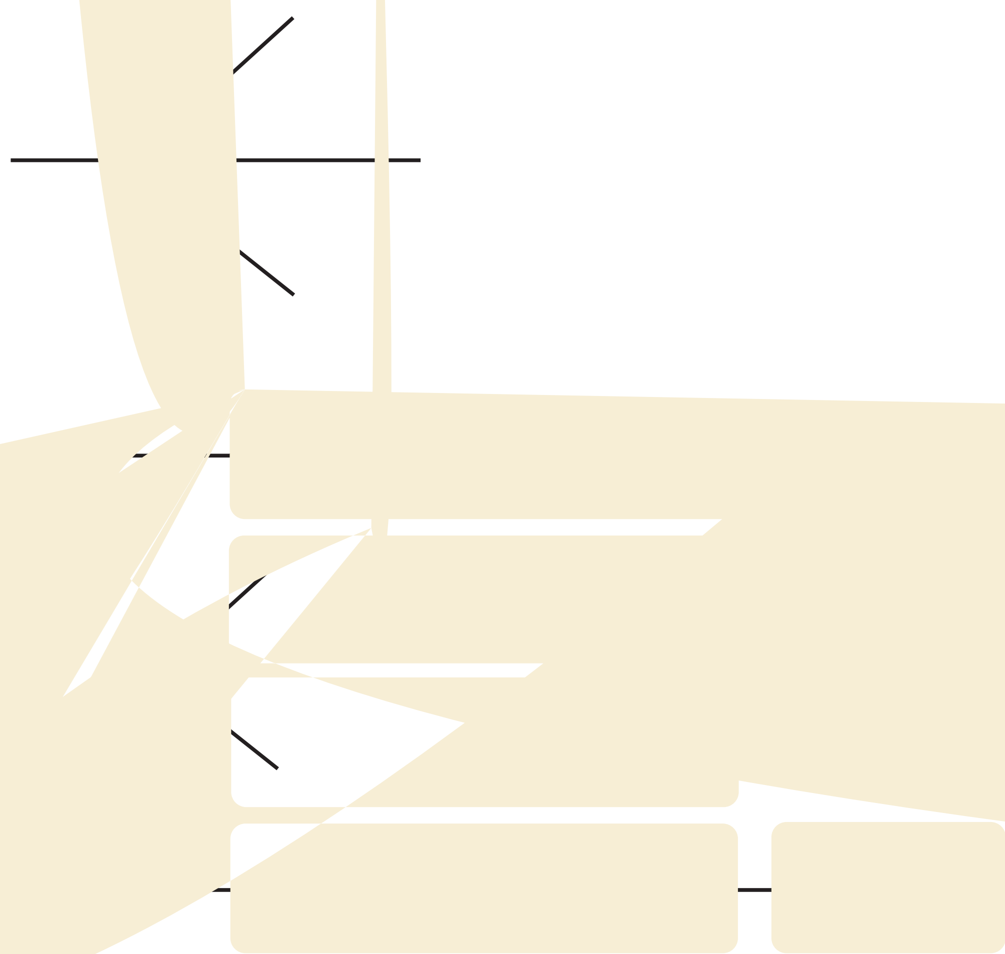
4.2 Ge e a i g i f a i he i ac f a e deci i ec e al e

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 nte9rpSain a particular rivef lam6sriveft3T*0 1 T99.188 -1 a

To answer t[illegible]s we need to move beyond an economic value baseline in order to trace the econo[illegible]ns of changes in the stock of ecosystem resources, flows of ecosystem services, or attr[illegible]ystems that result from following a particular course of action. We then need to fa[illegible]anges into measures of its viability, profitability and sustainability. In other words, [illegible]now what the economic impacts of particular water decisions will be in terms of e[illegible]s and benefits.

Fig e 2: U i g [illegible] l a i ge e a e i f a i f deci i - aki g



Bi[illegible]ec ic del

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.

Ca e 17: A bi -ec ic del f e la d a age e i e e i i Hail Ha , Ba glade h[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.

Ca e 18: A bi -ec ic del f e la d a age e i A alia[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 E e i g ec e al e a ec ic ea e f deci i - aki g

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 C -be efi a al i

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).

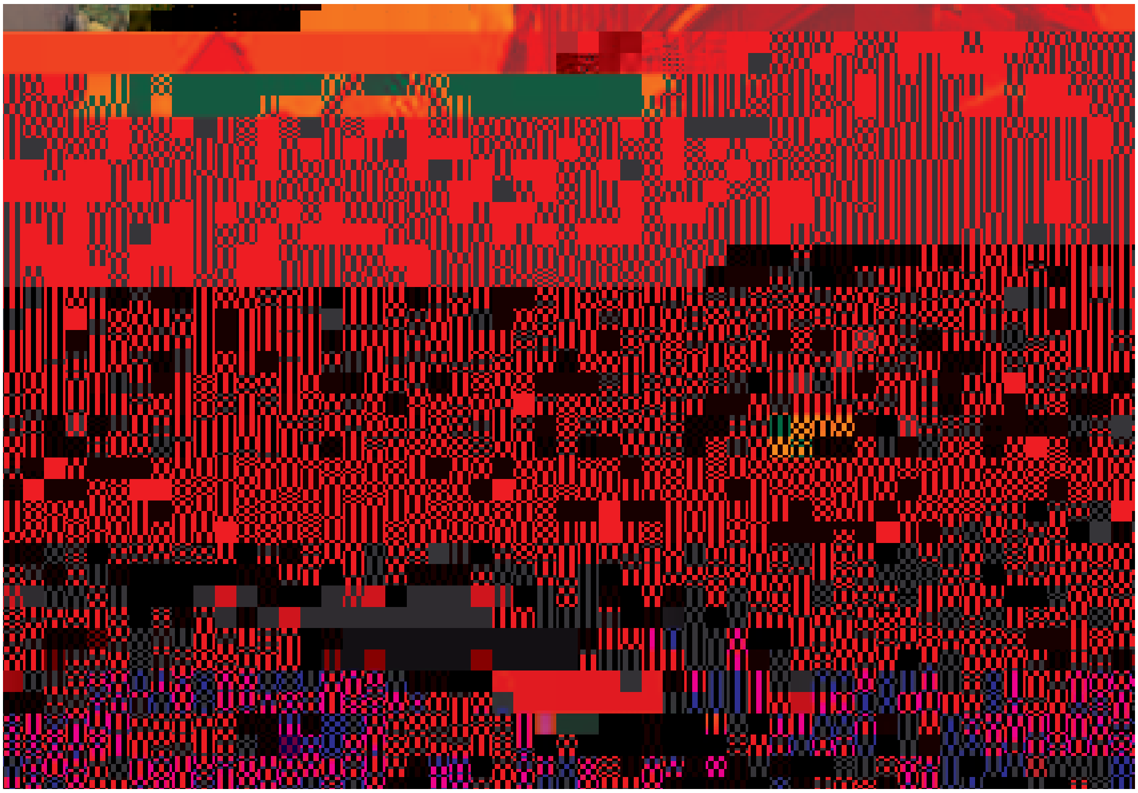
Ca e 19: I c a i g ec e c a d be efi i ec ic a ai al f a da c c i jec he Ta a Ri e , Ke a[58]

The Tana River is one of Kenya's most important river systems. With a total length of some 1,000

Ca e 20: C -Be efi A al i f he Skje Ri e P jec , De a k[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



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

Multi-criteria analysis is usually clustered into three dimensions: the ecological, the economic 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.

Ca e 22: U i g ec ic a al i j if e a i f he Wa a L g e Fl d lai , Ca e[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

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

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 10 0plion. At the t Ande a INCEg-024rc2 pto 0e pime of-. At C75lhe (7or)91.5s wirgcro(9o 0 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.

Ca e 24: A e i g he ec ic i ac f al e a i e la d e ec e eigh ec i , ai able e a d de el e f he Ba ela d Fl d lai , Za bia[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.

Cha e 5

Moving form case studies to standard practice

5.1 Diffe e die lead diffe e deci i

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.

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Sector	Management question	Valuation focus	Valuation method or decision-making tool	Decision-making message	Country/Region	Reference
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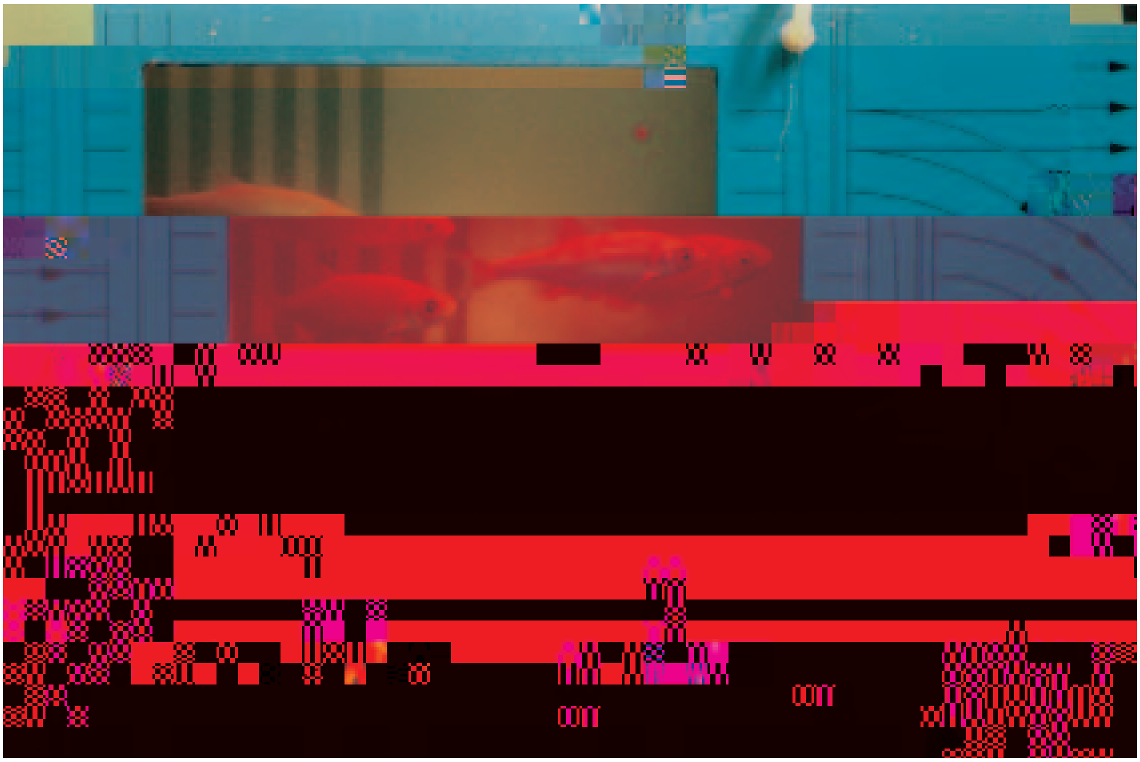

5.2.2 Cha ge a f hi ki g: b ild i l e e a d a a e e

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 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 S e g he ca aci : c ea e a l f k ledge a d abili ie

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.

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27 A public good is characterised by the non-excludability of its benefits – each unit can be consumed by everyone, and does not reduce the amount left for others. Many ecosystem services are pure or partial public goods – for example scenic beauty (a pure public good), or water quality (which has many of the characteristics of a public good). In contrast a private good is one from which others can be excluded, where each unit is consumed by only one individual. Most natural resources are private goods.

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.

29 A complementary good is one which is used in conjunction with another – for example between other products and fishing activities such as the collection of reeds for fishing baskets or firewood for fish smoking.

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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.

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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

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 val-

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

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Value – Counting ecosystems as water infrastructure

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