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Valuing ecosystem services of wetlands—a tool for effective policy formulation and poverty alleviation

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Abstract Wetlands are highly productive ecosystems that provide a number of "life-supporting" services of significant value to mankind. Flood control, groundwater replenishment, sediment retention, water purification, recreation, as well as climate change mitigation and adaptation, are just a few of the many valuable ecosystem services that wetlands provide. Despite these benefits, owing to the poorly understood economic value of these services, policy decisions are taken without considering them in the planning process. As a result wetlands are not only used but overused, misused and abused. This paper demonstrates the relevance of adopting an integrated approach, comprising wetland modelling based on water-quality parameters, to understand the dynamics of the ecosystem, followed by the estimation of economic benefits among various stakeholders and the exploration of incentive-based mechanisms and their role in the alleviation of poverty. These elements of a toolkit for wetland management will help planners and policy makers to make informed decisions for the sustainable management of Bhoj Wetland.

Key words urban wetland; economic value; ecosystem services; ecological modelling; incentive based mechanisms; poverty alleviation

L'évaluation des services écosystémiques dans les zones humides, un outil pour la formulation de politiques efficaces et la réduction de la pauvreté

Résumé Les zones humides sont des écosystèmes très productifs qui offrent un certain nombre de services de préservation de la vie dont la valeur est significative pour l'humanité. Lutte contre les inondations, réalimentation des eaux souterraines, rétention des sédiments, purification de l'eau, loisirs, ainsi qu'atténuation et adaptation au changement climatique, sont quelques uns des nombreux services écosystémiques que fournissent les zones humides. Malgré ces avantages, en raison de la valeur économique mal comprise de ces services, les décideurs politiques ne les considèrent pas dans le processus de planification, à la suite de quoi les zones humides ne sont pas seulement utilisées, mais excessivement, mal et abusivement utilisées. L'article tente de démontrer la pertinence qu'il y aurait à adopter une approche intégrée, comprenant la modélisation des milieux humides sur la base de variables de qualité de l'eau, et de comprendre la dynamique de l'écosystème. Cette approche serait suivie par l'estimation des avantages économiques pour les divers acteurs, et par l'exploration de mécanismes incitatifs et de leur rôle dans la réduction de la pauvreté. Dans la boîte à outils de gestion des zones humides, ces instruments aideront les planificateurs et les décideurs à faire des choix éclairés pour la gestion durable de la zone humide de Bhoj.

Mots clefs zones humides en milieu urbain; valeur économiques; services écosystémiques; modélisation écologique; mécanismes incitatifs; réduction de la pauvreté

1 INTRODUCTION

1.1 Functions of urban wetlands and their linkages with poverty

Wetlands play a vital role in maintaining the overall cultural, economic and ecological health of all major ecosystems. Being one of the most productive ecosystems, wetlands carry out critical regulatory functions of hydrological processes within watersheds such as regulating water quality, water levels, flooding regimes, and nutrient and sedimentation levels (Banner *et al*. 1988, Gregory *et al.* 1991, Bullock

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and Acreman 2003). Popularly known as the "kidneys of the Earth", wetlands perform a wide array of functions ranging from reducing soil erosion to acting as natural water purifiers and from conserving migratory birds' habitats to mitigating extreme climate change (Schweiger *et al.* 2002, Rubec and Hanson 2009). Wetlands also have special attributes as part of the cultural heritage of humanity, as they are related to religious and cosmological beliefs, constitute a source of aesthetic inspiration, provide wildlife sanctuaries and form the basis of important local traditions. Further they are the direct source of livelihood for various communities.

Wetlands may be found in many urban areas in India, as they are the lifeline of many cities and have been preserved and looked after by the people as their main source of water for drinking and irrigation. These urban wetlands have been utilized as natural cleansing agents to mitigate the additional pollutant levels introduced within the urban landscape. They absorb large quantities of point-source pollutants, such as sewage, solid waste and industrial waste from washing of vehicles and also those which occur in runoff from agricultural land and open garbage dumps or discharged from hospitals. Typical runoff from cities carries iron, lead, copper, and heavy metals, as well as toxins, phosphorus, nitrogen and hydrocarbons, and acids (Verma 2008). However, over the years, these urban wetlands have gradually been depleted, as their open access has made them easily accessible sources of various resources and turned them into "wastelands" as the most convenient and low cost waste disposal sites. Various uses of these wetlands have been extracted without any investment having been made for their maintenance and restoration (Verma *et al.* 2001). Their fast pace of disappearance from the landscape is of great concern. Although India's Wildlife Protection Act, 1972 protects some ecologically sensitive regions, several wetlands are still an easy target for human over-exploitation (Verma *et al.* 2009a).

A healthy wetland ecosystem has a strong bearing on the functioning of an economic system and its population. The degradation of ecosystems services is seen by many as major a barrier to the achievement of the United Nations' Millennium Development Goals (MDGs) (Johnson 2005, Sachs and Reid 2006, Eriksen and O'Brien 2007, CBD 2008). As wetland ecosystems degrade, productivity may fall, resulting in lower incomes, producing greater poverty, and therefore, accelerated pressure on these ecosystems (Johnson *et al.* 2006). The overexploitation of provisioning services from these wetlands is likely to influence the ecosystem's ability to generate regulating ecosystem services that maintain air, soil, or water quality (Martinez-Alier 2002). This not only decreases the future yield of provisioning services, but also increases the vulnerability of people to environmental variability thereby exacerbating their impoverishment.

1.2 Economic value of wetlands

Although it is acknowledged that wetlands contribute to human well-being and support ecosystems essential for the survival of mankind, the protection of these wetlands is often considered to be in conflict with what appears to be more profitable economic uses of the land over a short term. Viewing through the lenses of hard-core economics and considering the fact that governments need to show tangible development achievements, it is often difficult to persuade politicians to protect wetlands against unsustainable development activities (Stuip *et al.* 2002). Policy and decision makers that do aim to design solutions for the wise-use of wetlands often lack access to reliable information that can be used to confront the arguments for over-exploitation or conversion. We argue that economic valuation of wetlands can help in better demonstrating the real benefits of wetlands, which can then stimulate informed decision making.

Although several studies are available on the economic value of wetlands in general (e.g. Barbier *et al.* 1997), not much work has been done on urban wetlands. A multi-level model recommended by Turner *et al.* (1998) for the economic valuation of urban wetlands is particularly relevant in this regard. The model links economic and ecological systems comprehensively and can be used to develop further an institutional and policy mechanism for payment of ecosystem services (PES) (Springate-Baginski and Wollenberg 2010). This is particularly important because PES for wetlands has to be intrinsically linked to the hydrological processes that underlie the functions of wetlands. The hydrological processes are, in turn, a function of several characteristics of wetlands, such as size, shape, species present, extent of vegetation, vegetation structure and distribution, soils, nature and location of water entry and exit, climate, location in respect of human settlement and activities, among other factors (Claridge 1991). While research in the past has focused on deriving the ecological value of a wetland based on some of the characteristics listed above, the diversity of these characteristics in terms of how each characteristic is measured makes the process of deriving any comprehensive assessment system more difficult. Such systems, if developed, can form the basis for valuation of and payment for certain services from wetlands. As the values have been developed from a very fundamental characteristic of the wetland, they are more convincing and reliable.

A basic problem faced while undertaking the valuation of wetlands is the high degree of interconnectedness within and between ecosystems. Gilbert and Janssen (1998) used the concept of "environmental function" in combination with system diagrams to address this problem. Their approach aims to demonstrate that linking environmental functions (mainly hydrological functions for an ecosystem such as a wetland) through systems diagrams with goods and services makes it possible to integrate the physical performance of wetlands with the economic efficiency of the system. This methodology can then be developed further to link ecological processes, ecological functions, goods/services derived from that particular ecological function and the ultimate user of that good/service. Another advantage of using this approach is that it gives an opportunity to link the economic benefits and costs derived by each user from the functions of wetlands with the basic characteristic of any wetland (Allen *et al.* 2008). This approach not only enables one to value ecosystems, but also assists in developing mechanisms for internalizing these values in decision-making because of its analysis at the hydro-geomorphic level.

With regards to valuation techniques, there is a wide array of methods:

(a) cardinal: monetary valuation techniques (market-based) comprising revealed preference approaches:

  (i) conventional market (direct market) such as effect on production, effect on health, defensive or preventive cost, replacement cost and shadow project,
  (ii) implicit market (indirect/hidden market) approaches such as travel cost, wage differences, property values, surrogate goods / proxy market goods and stated preference, and
  (iii) constructed market (direct) approaches such as artificial market and contingent valuation;

(b) ordinal-non monetary techniques such as contingent ranking multi-criteria analysis (MCA), conjoint analysis and participatory economic valuation.

In some cases, where budget and time are constraints, the benefit transfer technique is used to transfer the value of a project site (where the valuation exercise has already been done) to the policy site (for which the study is to be conducted) after due adjustments.

Estimates and measures of economic value are based on people's preferences. It is generally assumed that individuals, and not the government, are the best judges of what they want. People express their preferences through the choices and trade-offs they make (Kumar *et al.* 2010). Service users actually know how much a unit of ecosystem service is worth to them and do not require an economist to inform them. In fact, economists would be asking these users to value that service. What is needed is to make the service users understand how many more units of ecosystem service they will receive if conservation takes place. Analysing the distribution of costs and benefits of ecosystem change is as important as valuing the change in benefits in the first place. This can also help in identifying potential financing sources of conservation (Verma 2008). It is important to mention here that valuation of ecosystem services is not an end in itself, but a means to achieve the larger goal of sound policy and decision making. Although valuation cannot by itself overcome the omission of wetland concerns from decision making, it provides the evidence to make strong arguments and present convincing data to decision-makers that underline their economic importance (Emerton and Kekulandala 2003).

Because of the many services and multiple values of wetlands, many different stakeholders are involved in wetland use, often leading to conflicting interests and the over-exploitation of some services (e.g. fisheries or waste disposal) at the expense of others (e.g. biodiversity conservation and flood control). It thus becomes essential to understand the ecological health of the wetland and the value of ecosystem services from the wetland across a range of stakeholders, such that an integrated ecosystem-economic approach can be developed for the sustainable management of such wetlands (De Groot *et al.* 2006). Such an approach would also help in factoring in so-called "intangible" values of the wetland for which currently no markets exist.

2 STUDY AREA AND ASSOCIATED ISSUES

2.1 Location of the study site

The Bhoj Wetland (BWL), which consists of two lakes (Upper Lake and Lower Lake), is located in the city of Bhopal, the capital of Madhya Pradesh state, India. The city occupies an area of approximately 286 km^2 and is divided into 66 administrative wards of which 22 surround the BWL. In 1988, the Government of India's Ministry of Environment and Forests (MoEF) declared the Upper and Lower lakes as a wetland of national importance and in 2002, the wetland was declared as a Ramsar site. The Upper Lake is the highly diminished remains of a large lake constructed by the then ruler, Raja Bhoj, in the 11th century. The seasonal River Kolans, originating in Sehore District, some 48 km from Bhopal, and several small feeder streams at the western side of the lake, form the source. It has a catchment area of 361 km^2 and water surface area of 31 km^2. The Lower Lake, also known as *Chotta Talab* or Small Lake, is situated towards the east end of the Upper Lake and is almost fully surrounded by built-up areas, as shown in Fig. 1. It has a small catchment area of 9.60 km^2 and a water surface area of 1.29 km^2. Bhopal has a large number of water bodies of which the Upper Lake is the most magnificent. Bhopal as a city has been growing rapidly, particularly in the last few decades. According to the 1981 census, it grew at the decadal rate of 125%; in 1991, 58%; and in 2001, 41%. Due to the increasing population demands, there have also been significant changes in the land-use patterns of the city which has put immense pressure on the ecology of Upper Lake (Verma 2008). The Upper and Lower lakes are rich in micro as well as macro flora and fauna. Aquatic macrophytes are widely distributed in Bhoj Wetland; thus both lakes are rich in planktonic biodiversity (Verma *et al*. 2009b). The land use of the Upper Lake comprises urban catchment (20%), semi-urban catchment (10%) and rural catchment (70%).

2.2 Stakeholders of the BWL

The stakeholders of the BWL can be categorized as:

(a) Primary—compromising the entire population of Bhopal city, municipal wards around the lake, farmers in the catchment, lake-front property owners, washermen, fishermen, water chestnut (*trapa*) cultivators, vendors, visitors;

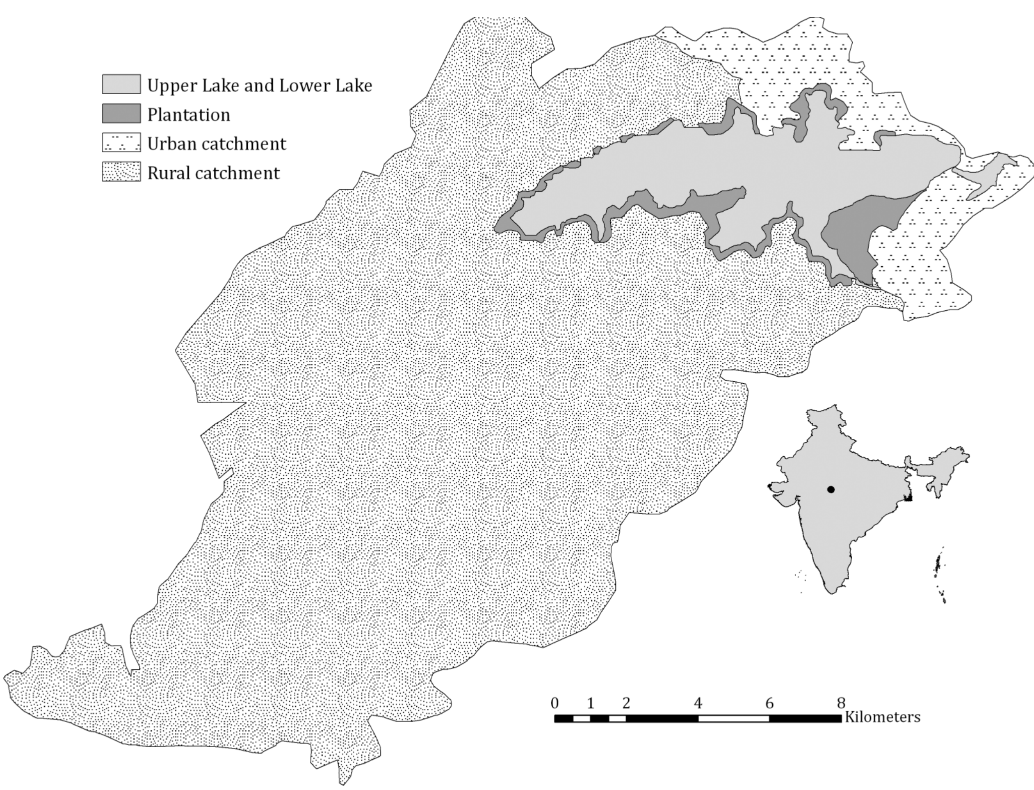

Fig. 1 Location of Bhoj Wetlands (Source: adapted from Verma *et al*. 2006).

(b) Secondary—water supplying agencies, Bhopal Municipal Corporation, the Department of Housing and Environment, the Sports Authority of India, Van Vihar National Park, Madhya Pradesh Tourism Development Corporation, the Ministry of Environment and Forest, photographers, film makers, bird watchers, student population, researchers; and
(c) Tertiary—funding agencies such as the World Bank, the Japanese Bank for International Cooperation (JBIC), and the State Government; international agencies of wetland conservation such as the Ramsar Bureau, the International Union for the Conservation of Nature (IUCN); organizations in India, e.g. the Central Statistical Organisation (CSO), the Ministry of Statistics and Program Implementation (MOSPI), the Centre for Science and Environment (CSE), The Energy Research Institute (TERI); international organizations, e.g. the International Institute of Environment and Development (IIED), Wetlands International (WI), the World Wide Fund for Nature India (WWF), Resources for the Future (RFF), the Centre for Social and Economic Research for Global Environment (CSERGE), the International Lake Environment Committee (ILEC); and various universities, international societies on ecological economics and ecosystem health and associations for common property resources, etc.

2.3 Benefits from the wetland

The wetland provides multiple benefits to a wide array of stakeholders and the local population, including:

(a) Drinking water: nearly 40% of the drinking water supply for the city of Bhopal comes from the Upper Lake and this is the most important use of the wetland as far as the welfare of the citizens is concerned. Altogether some 1.227 m^3 s^{-1} of water is provided to the city from the Upper Lake.
(b) Employment: to various communities of fishermen, washermen, boatmen and vendors, among others Approximately 300 families are engaged in fishing and *trapa* cultivation, while some 100 washermen make their living from the wetland and there are some 50 boatmen whose livelihood is dependent upon the wetland. Because of many visitors to the lake, a number of roadside vendors selling maize cobs, and other food and snack items, have their stalls next to the lakes and earn incomes.
(c) Microclimate stability: in terms of moderating effects on temperature and humidity.
(d) Recreation: people enjoy the aesthetic beauty of the wetland.

2.4 Threats to the wetland

Being an urban wetland, the Bhoj Wetland is very fragile due to high levels of human interference. It faces various threats, such as siltation on average in the range of 1.00–2.58 cm annually; the sedimentation rate from the catchment area is about 367 m^3 per km^2 annually. The flow of pollutants from the adjoining 17 municipal wards that directly drain into the lake is nearly 7500 m^3 d^{-1} of sewage water and 360 m^3 d^{-1} of slurry. In addition, a high quantity of detergents, chemicals and furnace ashes also flow into the lake on a daily basis. *Trapa* (water chestnut) also adds to dead organic matter when this seasonal floating plant dies. Further encroachment by urban slum dwellers and agricultural invasions is rampant along the fringe areas of the wetland, which is also infested by weeds; eutrophication occurs in almost the entire fringe area of around 33.78 km^2. The weeds found are mainly of four types:

– Shoreline (rooted): *Trapa bispinosa, Nelumbium* sp.;
– Emergent *Ipomoea aquatica, Polygonum glabrum*;
– Floating: *Eichhornia crassipes, Lemna minor*; and
– Submerged–*Potamogeton* sp., *Chara* sp. *Hydrilla verticillata*, etc.

Fuel waste from motorboats—and the flow of agricultural waste from the rural catchment also impact on the wetland's water quality. The immersion of a large number of idols and tadjia during the Hindu and Muslim religious festivals also leads to siltation on quite a large scale, besides releasing heavy metals such as cadmium, chromium, lead, zinc and other extremely harmful chemicals. The dumping of hospital waste from the adjoining hospitals is also resulting in the harbouring of bacteria in the biodegradable matter (Verma *et al.* 2001). As a result of such harmful activities, owing to increased human activities in the urban catchment and intensification of inorganic agricultural practices in the rural catchment, the drinking water quality has been deteriorating steadily over the years and falling below the permissible level, as can be seen in Table 1.

Table 1 Water quality of Upper and Lower lakes in Bhopal in 1991/92 (source: Kodarker and Mukerjee 2005).

Parameter	Range	
	Upper Lake	Lower Lake
pH	8.8–9.2	7.15–9.7
Transparency (cm)	NA	14–98
Conductivity (μS/cm at 25°C)	213–228	259–374
Total dissolved solids (TDS; mg/L)	121–252	86–169
Hardness (mg/L)	60–146	68–154
Chlorine (mg/L)	16–30	14.9–88.9
Total phosphorus (mg/L)	0.003–0.07	0.106–1.02
Total nitrogen (mg/L)	0.1–0.9	1.08–1.46
Biochemical oxygen demand (BOD; mg/L)	18–6	2.2–11.5
Chemical oxygen demand (COD; mg/L)	8.8–26.4	8–112
Class	B	D

A large phytoplankton population is found in the Upper and Lower lakes, e.g. Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae. In the Upper Lake, Bacillariophyceae spp. was found dominant while in Lower Lake Chlorophyceae spp. was found dominant in almost all seasons (Bajpai *et al.* 2001).These factors are largely responsible for the eutrophication and deterioration of water quality. Above all, the ever-increasing population of the city aggravates the above threats further. The impact has been on both water quality and quantity as well as on the biodiversity and aesthetic beauty of the lake.

2.5 Interventions by the BWL agency since 1995

The Japan Bank for International Co-operation (JBIC) provided US$ 45.5 million as a loan for the implementation of the BWL restoration project. The objectives were to conserve and manage the Bhoj Wetland (which was subjected to severe environmental degradation due to pollution) and to ensure availability of water from the Upper Lake (which was one of the major sources of water supply to the city of Bhopal) with an increased quantity and satisfactory quality. The total project cost is US$ 53.5 million in which the State Government's contribution was US$ 8 million. The restoration activities comprised desilting and dredging works, catchment area treatment, shoreline and fringe area management, water quality management and aeration through floating fountains and ozonisers.

2.6 Objectives of undertaken research

Although the government's BWL restoration project commenced in 1995, until 1999 the focus was primarily on defensive intervention, such as installation of floating fountains, ozonisers, de-weeding and dredging. These measures targeted the symptoms rather than undertaking preventive measures to address the main problem of flow of sewage to the lake. Hence, the net effect of all other interventions seemed to be either nil or negative. Above all, the various stakeholders were not involved in the planning and implementation process of restoration activity; consequently the citizens of Bhopal did not develop any sense of responsibility for and belongingness to the project, although they were target recipients. Furthermore, by the year 2000, when the first study by the author was proposed, no future planning was done by the management agency to generate finance for the maintenance of various engineering structures, established as part of BWL restoration activity.

This status of citizens' awareness and overall management of the BWL motivated the author to undertake the study "Economic Valuation of Bhoj Wetland for Sustainable Use" (1998–2000) under the World Bank's Environmental Management Capacity Building Programme (EMCaB) with the Ministry of Environment and Forests, Government of India. The main objectives of this valuation study were: to analyse factors that were causing BWL degradation, to estimate the nature and extent of damage to the wetland, to quantify impacts of degradation on wetland benefits, to quantify the costs born by various stakeholders, to generate values of various services extracted from the wetland, to define the willingness of people to conserve the BWL, to envisage participation of stakeholders in the planning process, and provide feedback to the BWL management agency for appropriate interventions for its sustainable use. Using the BWL valuation study's recommendations for desired interventions in a rural catchment, which had identified greater damage due to intensive inorganic cultivation in two thirds of the catchment area of the BWL, an action learning project on "Developing Incentive Based Mechanism (IBMs) for Watershed Protection Services and Improved Livelihoods" (2005–2006) was undertaken in the rural BWL catchment by the International Institute for Environment and Development (IIED) and the UK Department for International Development (DFID), with the principal author of this paper engaged in the livelihoods economics component. The outcome of this study is summarized in Section 5.1.

Further, the lessons learned are included in the recently concluded UK Natural and Environment Research Council (NERC) and DFID-supported multi-institutional project “Strengthening Capacity for Alleviation of Poverty through Ecosystem Services (SCAPES)” (2009–2010), wherein the dynamics of poverty and ecosystem services have been reviewed. The authors were engaged to provide evidence of potential use of valuation of ecosystem services as a knowledge-base in poverty reduction studies using South Asian case studies.

The learning outcomes from three different studies conducted by the author have been internalized in this paper. We underline the need for recognition and valuation of essential ecosystem services provided by the BWL and their role in the alleviation of poverty. We demonstrate the requirement of understanding the ecological health of the BWL with the help of a simple ecosystem model based on water quality, giving it scenario runs based on the interventions made by the BWL management agency. A modelling exercise linked to economic valuation techniques is used to estimate the value of various ecosystem services provided by the BWL. The valuation exercise was conducted with various stakeholders, especially those from marginalized communities who draw many livelihood benefits from the wetland. The modelling and valuation outcomes have been used to provide a set of policy and technical recommendations including the need for development of IBMs for ensuring the sustainable use of the BWL.

3 METHDOLOGY

3.1 Execution of the modelling-valuation-IBMs exercise

In this section, we mainly discuss the methodology used in the first study (Verma 2008) on the economic value of ecosystem services of BWL. The modelling-valuation study uses the integrated ecosystem–economy linkage approach of wetland functions, services and values, as illustrated in Turner *et al.* (1997). The ecosystem model was developed to understand the dynamics of the lake, using water-quality parameters. Data were collected from eight representative quality monitoring stations to establish the impact of ongoing interventions, which helped in building scenarios for the valuation exercise. Various direct and indirect market-based techniques were then employed to generate various wetland values across a range of stakeholders. The economic values were obtained through expert consultations, site visits, focus-group discussions, secondary data collection, workshops involving various stakeholders across expert discussions, and a detailed primary survey across sampled households of various municipal wards. The process began with stakeholder-wise identification of values and management issues, for which a pilot survey was done, wherein it was found that three major issues, viz. sewage and waste disposal, fishing and washing activities, and recreational activities, need to be addressed and understood in terms of the perception of the stakeholders. This was followed by a multi-stakeholder workshop to identify the problems, alternatives and information gaps, and to elicit the response of departments responsible for such issues. All concerned stakeholders (as classified above) were invited and were initially informed about the objectives and methodology of the project and then divided into three heterogeneous groups. The “sticky cloth and paper” method, which comprises sticking paper notes on a cloth sprayed with glue, was used to facilitate the discussion. The workshop culminated in all three groups presenting their findings; then, through open discussion, recommendations were formulated for a follow-up strategy for sustainable management of the wetland. Consultations were made with a number of international and national experts to assess and confirm the appropriateness of the methodology followed.

A major valuation exercise was conducted through detailed surveys of about 1500 households covering all 66 wards. The survey was undertaken to seek their willingness to contribute to conservation of the wetland for maintenance of the aesthetic waterscape value and water quality of the BWL. Data were analysed using various economic and statistical tools and, eventually, technical and policy recommendations were made for sustainable management of the BWL. The second study on livelihood issues was executed in eight villages within the rural catchment, as shown in Fig. 2, to analyse comparatively the livelihoods of the sampled populace in the upper catchment before and after implementation of incentive mechanisms. A combination of qualitative and quantitative techniques, such as in-depth interviews with sampled populations in selected villages, participatory rural appraisal (PRA) and focus-group discussions (FGDs), plus an intensive household survey, were used to acquire information.

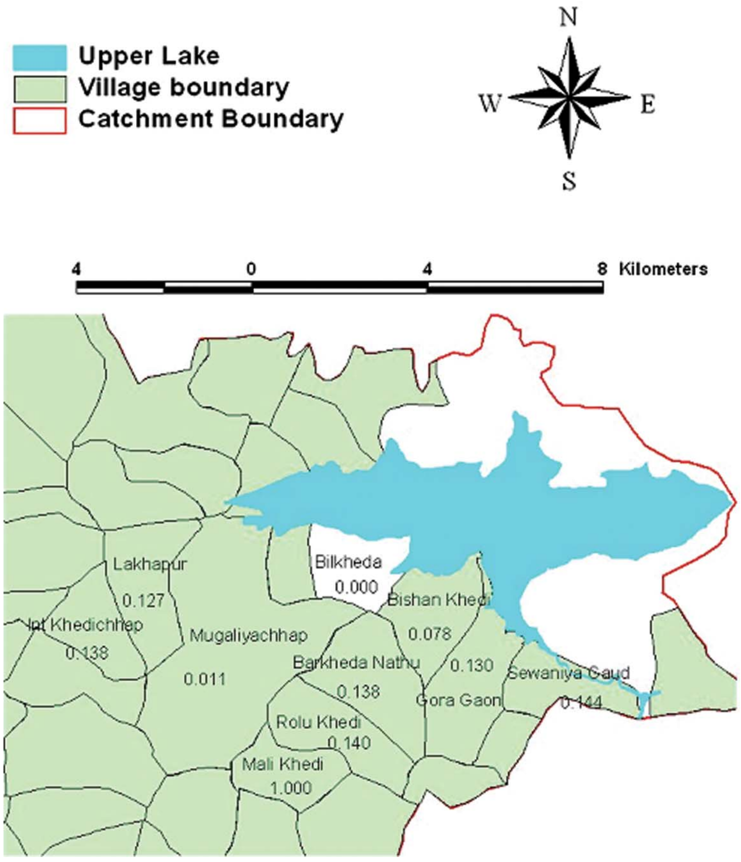

Fig. 2 Location of villages in the rural catchment (source: adapted from Verma *et al*. 2006).

3.2 Bhoj wetland ecosystem model

3.2.1 Description of model Ecosystem modelling involves the description of ecosystem functions and their changes over time or space (or both) in measurable quantities. It allows some test of the set of process hypotheses at the ecosystem level. It helps to identify the stress areas in a system and supports development of appropriate management strategies to counter such pressures on the ecosystem. To develop a model for a wetland ecosystem it is essential to understand the hydrological processes that underpin the ecosystem, such as precipitation, surface water flow, groundwater flow and evapotranspiration that influence the water quality functions and the overall water budget of the wetland. These are the roles that wetlands play in modifying or controlling the quantity and quality of water moving through the wetland. An understanding of such functions facilitates management and protection of wetlands and their catchments. Whist the knowledge of hydrological processes of wetlands is growing, there are still many gaps in understanding exactly how best to restore the wetness of the wetlands (Acreman *et al*. 2007, Acreman and Mountford 2009).

A detailed conceptual model that incorporates causes, impact and feedback control strategies, including restoration and pollution prevention activities, was developed in the study using Oakerson's basic interaction model for the management of common property resources. In addition, the BWL is classified as an anthropogenic-naturalized urban wetland in the model following the method described by Wang *et al.* (2010). The model assesses the impact of economic, ecological, social and technological factors on the lake's ecosystem and suggests control strategies through the feedback mechanism; it thus follows a holistic approach for the sustainable management of Bhoj Wetland. However, due to lack of data availability the model considered only basic water quality parameters; the pressure of economic, social and technological factors are demonstrated through changing values of these parameters indirectly via valuation techniques across various stakeholders.

3.2.2 Description and significance of model variables A detailed ecological model linking basic parameters and their impact on water quality was developed. Although it is clear that the linkages are very complex, to be consistent with the extent and availability of data and information, and to achieve parametric specifications that produces stable relationships, the model focuses on ecosystem dynamics. The model is not intended to be a complete description of the ecology of Bhoj Wetland. The key model variables selected are drinking water quality parameters.

The main ecological parameters included within the conceptual model for the BWL are sewage and weeds resulting from increasing population. So the initial parameter is taken as population, and its impact on sewage outflow and subsequent impact on weeds were studied. Other water quality parameters including dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, total hardness, total alkalinity, phosphate, turbidity, total dissolved solids (TDS) and bacterial count are linked with these primary variables and with each other, such that their dynamics in the lake's ecosystem can be studied. Using the data on water quality parameters at seven quality monitoring stations, representing different kinds of pressures on the Upper and Lower lakes, an advanced ecological model, as shown in Fig. 3, was developed using the system dynamics software package STELLA (5.2).

Based on data from 1985, 1991/92 and 1999, compound growth rates were determined and elasticity between various variables was calculated to establish quantified linkages between them. Next, a model was developed representing the baseline scenario and simulations were run, first by using 1985 and 1991/92 data to determine the status of the lakes if such trends were to continue (without restoration and prevention activities, i.e. pre-restoration management activities), and second these were compared with a further set of simulations run using 1991/92 and 1999 data (after the commencement of restoration activities).

3.3 Description of valuation methods used in the study

Having defined the extent of degradation and threats with the help of the model developed, an economic valuation exercise was undertaken to identify the extent of monetary benefit or loss to various stakeholders where benefits are directly or indirectly marketed. In the absence of any such markets, people's perceptions for conservation of wetland resource were employed. As the uses are multiple, it was difficult to capture one single value for all of them together; hence, a spectrum of valuation techniques was used to capture the economic value of various uses. The Direct Valuation, Cost of Illness Approach and Defensive or Preventive Costs, Contingent Valuation Method (CVM) and Hedonic Pricing techniques of valuation were all used to capture varied values to multiple stakeholders. The valuation exercise included calculation of the values of drinking water supply to the city; the value of benefits accruing to various people whose livelihoods depended upon the wetland; the value of preventive measures that people used to avoid water-borne diseases, and people's willingness to pay (WTP) for enjoying better recreational facilities from the Bhoj Wetland. In addition, the effect of the presence of the Upper Lake on the value of property prices was also studied and estimated. The two major techniques, which were based on household survey are explained in sections 3.3.1 and 3.3.2.

3.3.1 Contingent valuation method To estimate the recreational value of the Bhoj Wetland, all 66 municipal wards of the city covering 1500 households were surveyed, as this value accrues to all the residents of the city of Bhopal. The technique of CVM was employed to obtain the willingness of people to pay for improved recreational facilities from the Bhoj Wetland. The CVM was administered through a questionnaire-based survey with an initial open-ended followed by a closed-ended bidding model. The questionnaire was divided into two sections:

(a) *Attitudinal questions* These aimed to make the interviewee comfortable by asking some questions regarding their views and opinions on various problems plaguing the country. These questions were followed by a few queries, aimed at obtaining information regarding the water supply to their homes, and whether the people were aware of the various problems that pose a threat to the lake.
(b) *Scenario building* Here, information was given about Bhoj Wetland Management Society, proposed by the project team, and its action plans. This presented a scenario by considering benefits that people would gain from the activities of this society. They were told about the expected increases in recreational benefits and aesthetic beauty, and were shown photographs of the lakes

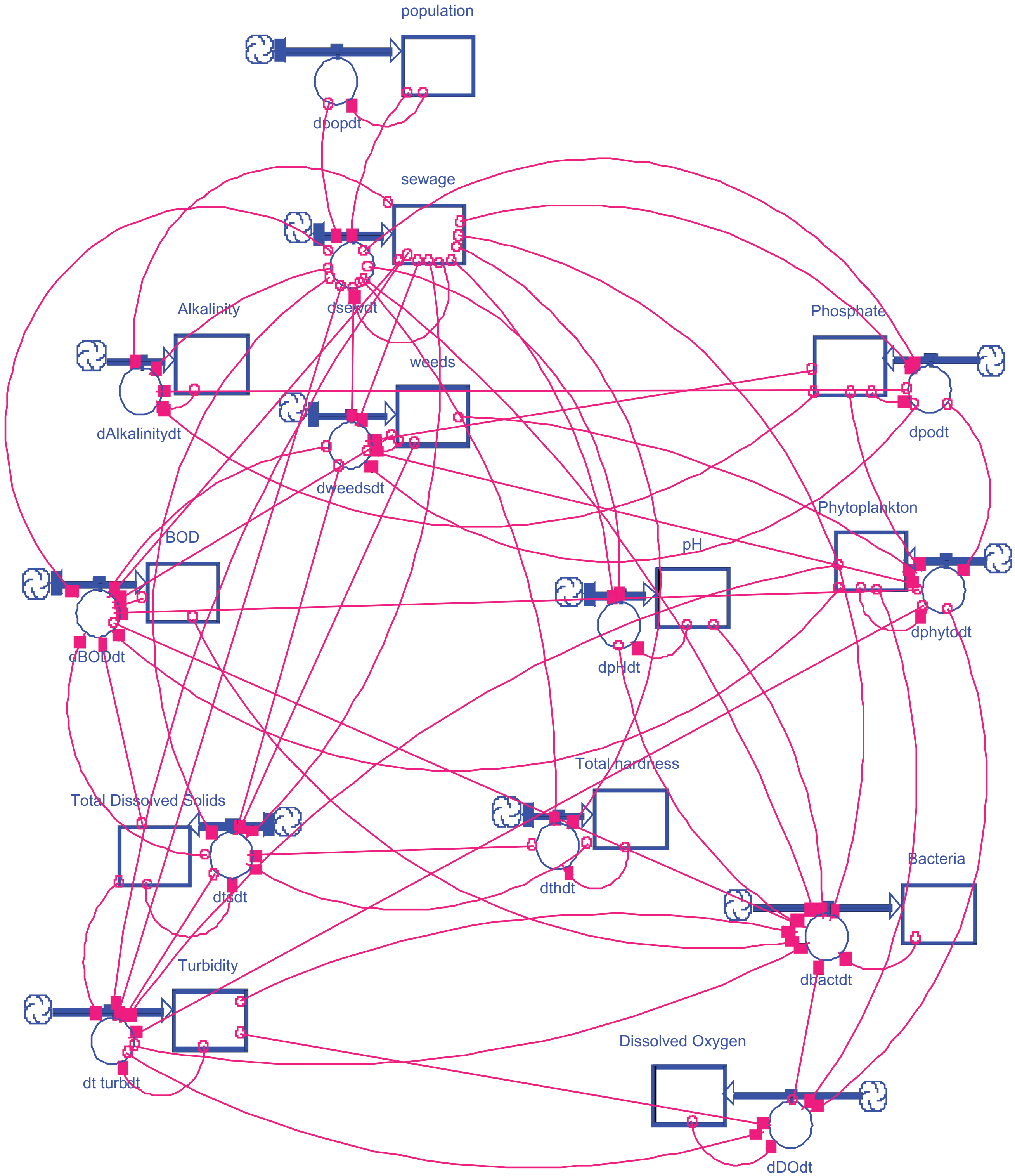

Fig. 3 Ecosystem model of Bhoj Wetland (source: adapted from Verma *et al*. 2001).

from different angles showing the degraded state of the lakes without any successful intervention, as well as views from a distance where the lakes look very beautiful and clean, the latter taken as a proxy for a successful water quality restoration regime. In addition, they were shown charts depicting the structure of the society and its role in the lakes management.

After the pre-test, two types of payment vehicle were considered: first, a voluntary payment to the body named as Bhoj Wetland Maintenance Society, which would take up the management of the Bhoj Wetland in the future; and second, a compulsory tax imposed by the Municipal Corporation, the governmental organization managing the lake currently. An open-ended bidding game was used to seek their willingness to pay for lake maintenance and the respondents were asked a follow-up question to their initial non-zero bid, which was a close-ended question. The respondents were also given a chance to change the initial value of WTP if they wished after going through the entire bidding process.

3.3.2 Hedonic pricing method This valuation exercise attempted to calculate the effect of the vicinity of the Upper Lake on neighbouring property prices and was studied in two steps. First, attitudes of the people were studied on the importance they give to various factors when buying a property. Second, some property prices in particular areas in the city were obtained and then these areas were ranked against parameters of neighbourhood, proximity to markets, ease of access, environment, housing density and presence and absence of lake. A regression model was created for this equation and, from that the effect of presence of lake on property prices was gauged. Values attached to different property factors by the buyers were analysed using multi criteria analysis (MCA) and the DEFINITE software, to produce appraisal scores for different characteristics of properties. The various factors included the existence of lake, the availability of drinking water, safety, the existence of school for children, and the nature of the property itself.

The second step also involved the definition of a regression equation to express the degree to which various factors affect the price of property in the city. The factors of Neighbourhood (N), Market (M), Access (A), Lake (L), Environment (E) and Housing Density (HD) were taken into consideration for this purpose. Through these regression equations, it was discovered that all of the coefficients taken in the equation are significant, i.e.:

$$\mathrm{P} = f(\text{constant}, \mathrm{N}, \mathrm{M}, \mathrm{A}, \mathrm{L}, \mathrm{E}, \mathrm{HD}) \quad (1)$$

where P is property price (in Rs per sq. ft) and the other factors as described above.

$$\mathrm{P} = \alpha + \beta_1\mathrm{N} + \beta_2\mathrm{M} + \beta_3\mathrm{A} + \beta_4\mathrm{L} + \beta_5\mathrm{E} + \beta_6\mathrm{HD} \quad (2)$$

where α is a constant and β are the coefficients to the variables.

4 RESULTS AND DISCUSSIONS

4.1 Results of simulation runs (model)

The simulations indicate a significant dependence of economic value in the form of direct and indirect income derived from the ecological health of the wetland. Simulation results from the STELLA model for previous and ongoing restoration projects of the Bhoj Wetland define likely changes in lake water quality conditions for the next 25 years. Most of the changes depend upon sewage coming into the lake. A small change in the sewage can make a remarkable difference to all parameters. The simulation run results of prior and ongoing restoration activities revealed the impacts of the ongoing restoration projects on the water quality parameters of the Bhoj Wetland. The restoration activities did not show perceptible changes in all the parameters selected in this model (Table 1). Most of the parameter growth rates are negligible for the coming 10 years. Parameters such as pH and DO improve in future years. Only bacterial counts showed a significant difference, with a sudden growth and maximization within 4–5 years. The diversion of sewage after completion of a sewerage sub-project can achieve better conditions as defined by all water quality parameters. A number of other ecological parameters, which are excluded here, could also be linked with the changes. Taking the above simulation outcome into consideration, better sustainable management policies can be adopted and the lakes' ecological health can be improved. To formulate a complete understanding of the lake ecosystem, a detailed, complex model that includes all ecological parameters needs to be developed. The outcome of the modelling exercise was internalized in the valuation process and accordingly responses of the stakeholders in terms of extent of intervention and associated economic costs were sought; these are described in the following section.

4.2 Results of valuation techniques

4.2.1.1 Valuing wetland ecosystem services using market price and cost-based preference approaches

4.2.1.1 Valuation of drinking water supply Full Supply Cost includes the costs associated with the supply of water to a consumer and is composed of two separate items: operation and maintenance (O&M) cost, and capital charges, both of which should be evaluated at the full economic cost of inputs. Since in this particular exercise only the cost of distribution of water in one particular year is actually taken into consideration, the capital charges have been ignored. There are three agencies that obtain water from the Upper Lake for drinking supply and they pay annual charges to the Bhopal Municipal Corporation for use of water from the Bhoj Wetland. The annual rental and other recurring expenses of these agencies for water supply over the year 1999–2000 totals US$ 2.12 million. The entire revenue that is collected from the city of Bhopal as water tax charges is US$ 0.47 million per annum. This tax includes the amounts paid by all the commercial organizations and people of the city. Thus, a large subsidy is being provided to the people as far as drinking water is concerned.

4.2.1.2 Valuation of fish production There are some 450 families who earn their living through fishing in the Upper Lake waters. These people usually employ gill nets to catch fish, the major fish species that are available being the major Indian carps, such as *Catla catla*, *Labeo rohita*, *Clarius* spp., *Cirrhimus mrigala, Ctenopharyngodon idella* and *Hypophthalmichthys molitrix*. The catch is extremely uncertain, but an average fisherman earns US$ 33 per month from this activity. Thus the annual total earnings of the entire fishing community are approximately US$ 0.18 million. The fishing community also pays around US$ 2222 for annual leases to the Bhopal Municipal Corporation. Thus, the total net earnings to the fishermen is estimated as US$ 177 778.

4.2.1.3 Valuation of boating activities Private boatmen operate in both the Upper and the Lower lakes, including 20 paddle and rowboats in the Upper Lake and seven in the Lower Lake. After paying the boating license fee, annual profits of around US$ 2264 are being earned through boating activities in the Lower Lake. Therefore, combining the figures for the Upper and Lower lakes, boating is estimated to yield an annual income of US$ 54 175 for private boatmen.

4.2.1.4 Valuation of *trapa* cultivation There are some 50 families involved in *trapa* (water chestnut) cultivation and, according to the cultivators, each family gets around US$ 222, on average per annum, which comes as a lump sum on the sale of the harvest, usually in September–October. Therefore, the total income generated through the cultivation and sale of *trapa* amounts to US$ 11 100.

4.2.1.5 Valuation of cloth washing activities There are around 100 washer families settled around the lake. On average, every household earns US$ 66 a month. At this rate, the annual income generated from all washing activities in the Lower Lake amounts to US$ 79 200.

4.2.1.6 Valuation of secondary activities Multiple secondary activities exist around the lakes. The annual income earned by them is estimated through personal interview, for example, a cafeteria and running of tourism boats by MPTDC—US$ 40 000 and 15 000, respectively; road-side vendors selling maize cob—US$ 3200; sugarcane juice sellers—US$ 6000; snacks and cold drink stalls—US$ 4600; and horse riding—US$ 17 600. Thus, the total income generated by these private individuals through their economic activities in the Upper and Lower lakes amounts to approximately US$ 86 400.

4.2.1.7 Valuation of water-borne diseases If a person falls ill on account of a water-borne disease, it may incur a major cost. The number of days lost as productive working days adds to this cost. The number of cases of water-borne diseases has been obtained from the Directorate of Health Services, for 1995–1999, and an approximate expenditure, based on a survey of local government hospital doctors and covering only common water-borne diseases such as gastroenteritis, diarrhoea, and jaundice, was calculated. These figures only give a partial view since most people do not visit government hospitals, but attend private practitioners. Even if we take the figures that have been obtained and examine the cases reported only in 1999, the amount that people have spent on medical care and the opportunity cost of time foregone either of the patient or his accompanying person amounts to US$ 60 000 annually. Assuming 45% of the population are dependent on the lakes, this figure reduces to US$ 27 000 as the annual cost of treatment for water-borne diseases for people using the lakes' water.

4.2.1.8 Valuation of quality of water As a result of the high risk of water-borne diseases and the large number of cases of such diseases every year (reported cases are definitely fewer than the actual number of cases), many people use preventive measures such as home water filtration devices (e.g. Aquaguard and

ZeroB) and Hepatitis B vaccinations. Data regarding the total number of water purifiers purchased in the last few years and the costs incurred in their installation werer obtained from various companies and their agents. The total purification costs incurred by people for April 1995–April 2000 amount to US$ 2.26 million. Taking the total number of households in Bhopal as 287 183, the cost of water purification per household reaches US$ 8 in the last five years. Again, by assuming 45% of the total purification cost incurred by individuals to reflect the population dependent upon water supply from the Upper Lake, we calculate a total of US$ 1.02 million as the economic value of the Bhoj Wetland that people would be willing to pay in order to obtain pure drinking water.

4.2.2 Valuation of recreation services using stated preference CVM approach Of the 1500 households surveyed, 1497 completed questionnaires were obtained. These were then screened to eliminate those that were either incompletely filled, or where it was believed that respondents' evaluation of the enumerators was not good, or they showed a lack of conviction in improvements that were proposed as part of the scenario, or where the enumerators mentioned lack of understanding or seriousness on the part of the respondents. Ultimately, the number of questionnaires was reduced to 804 (a reduction of 46%, done mainly to maintain the accuracy of the sample). The results of the CVM exercise for recreational value are depicted in Tables 2 and 3. Owing to large differences in the mean and median, the median values were used to extrapolate the value for the entire population of Bhopal city. The values of median voluntary payment and median tax were extrapolated for the total number of households of the city. Interestingly, people expressed high WTP for lakes management by the Lake Conservation Society (US$ 1 million annually), whereas collection through an environmental tax by the government would generate a small amount of revenue (US$ 0.13 million annually).

Table 2 Mean and median willingness to pay as Final Voluntary Payment (FINVOL) or Final Tax (FINTAX) (source: Verma *et al.* 2001).

	FINVOL	FINTAX
Mean	537.85	219.17
Median	241.00	29.50

Table 4 Estimation of hedonic pricing derived using SPSS 10.0. Dependent variable: price (in Rs per sq. ft); number of observations: 27; $R^2 = 0.781$ (source: Verma *et al.* 2001).

Variable	Coefficient	*t*-statistic
Constant	−607.596	−3.883
N	282.739	4.591
M	−112.570	−1.661
A	101.902	1.575
L	185.896	2.518
E	111.047	2.097
HD	−67.203	−1.379

N: neighbourhood; M: market; A: access; L: lake; E: environment; and HD: housing density.

4.2.3 Lake front property—valuation through indirect hedonic pricing method In Table 4, it can be seen that all the coefficients used in the equation for calculating property prices are statistically significant. For establishing the relationship between price in Rs per sq. ft and presence of the lake, a partial correlation test was run, the value of which came out as 0.495, adjusting for all the other parameters. Thus, it is estimated that a property sited near the lakes would be nearly 50% more expensive than a similar property sited away from the lakes.

4.2.4 Comparative analysis of various values It is evident from the above analysis that the drinking water, recreation and property attributes command high values from the lake, whereas other, income-based values are important to specific sections of

Table 3 Estimated willingness to pay (WTP) per household and for the whole of Bhopal City (total number of households: 201 116) (source: Verma *et al.* 2001).

Median FINVOL per household per annum: Rs 241.00 (US$ 5.43)*	Total voluntary WTP per annum: Rs 48 468 956.00 (US$ 1 091 643)
Median FINTAX per household per annum: Rs 29.50 (US$ 0.67)	Total WTP as tax per annum: Rs 932 922.00 (US$ 133 624.4/-)

* 1 US$ = Rs 44.40.

Table 5 Overview of economic value of ecosystem services of BWL.

Ecosystem service	Basis of estimation	Estimated annual value (US$ million)
Benefits from ecosystem services:		
Drinking water supply	Annual charges of water using agencies to Bhopal Municipal Corporation for supplying water	2.120
Fish production	Income of fishing community	0.178
Boating activities	Income of private boatmen	0.054
Trapa cultivation	Income of *trapa* cultivators	0.011
Cloth washing	Income of washers	0.079
Secondary activities such as cafeteria, snacks, horse riding, etc.	Income generated by private activities	0.086
Drinking water quality	Expenditure on effects of common water-borne diseases; damage cost avoided	0.027
Drinking water quality	Expenditure on preventive measures; replacement cost.	1.017
Recreation services	Contingent valuation method	0.13 (tax) to 1.00 (voluntary contributions)
Aesthetic beauty	Prices of lake-front properties–-hedonic pricing	Property rates expected to be 50% higher for properties near lake.
Cost of maintenance of various engineering structures:		
	Projected maintenance cost	0.18

the population (Table 5). All the values so estimated have not been aggregated, as some stakeholders gain multiple values from the lakes, and such overlapping could not be avoided. Further, other important values such as biodiversity and microclimatic effects were not estimated due to lack of available data. Nevertheless, this exercise provides an important insight into the multiple values of the wetlands that have not been considered in the current management activities. It should also be noted that if a management agency is able to collect the revenue through what people are willing to pay in the form of voluntary payment to the society, the revenues would far exceed the projected cost of maintenance of various sub-projects of the BWL agency. However, if the revenue is collected only through taxes, the amount would be only 74% of the projected cost of maintenance.

5 TECHNICAL AND POLICY RECOMMENDATIONS

The above exercise recognized the inter-linkages and benefits that could be obtained if the wetland is managed in an integrated manner and is sustainably used. It is a very challenging task and requires actions at many levels with diverse issues and management institutions. Such an approach must begin with the involvement of all stakeholders in the wetland in the form of a local area institution that can help in eliciting their views for use and future management of the Bhoj Wetland. This institution could produce an action plan to cover all ecological, economic, social and institutional issues. Finally, using the results that emerged from the modelling and valuing exercise, the study provided a set of technical recommendations ranging from the strengthening of preventive measures to check the flow of sewage to the wetlands, along with defensive measures including aeration, to cultural measures including aesthetic improvements e.g. stopping the dropping of litter and dumping of rubbish, and intensive measures in the rural catchment of BWL to transform the intensive inorganic cultivation into organic cultivation. Furthermore, the set of policy recommendations to develop different viewpoints and reduce the current pressure on the lakes included: people's participation, and effective co-ordination; transparency in the system; setting-up of a Bhoj Wetland Management Committee; setting-up of a management fund for maintenance of the BWL; cost–benefit analysis of individual interventions made under the JBIC Project; detailed ecosystem modelling with a wide range of parameters including water quality; and the promotion of eco-tourism.

5.1 Developing incentive-based mechanisms for improving livelihoods and ensuring sustainable use of the Bhoj Wetland

Important interventions were made in the rural catchment upstream of the wetland, for example, organic farming practices were introduced in the rural catchment of the upper lake as the 15th subproject to control the flow of inorganic input nutrients to the lake, beginning in 2002. This was further strengthened through the Madhya Pradesh Lake Conservation Authority (MPLCA), which was set up after the completion of the JBIC project in 2004, and a mechanism of incentives was also explored through the action learning project titled "Developing markets for watershed protection services and improved livelihoods" (IIED and DFID, 2005–2006) wherein the first author was involved in conducting livelihood baseline and impact study of interventions in the eight villages of the rural catchment (Verma *et al*. 2006). The overall objective of the IIED project was to promote wetland conservation and wise use through incentive-based mechanisms, with a particular focus on reducing agricultural runoff. The key challenge lay in orienting the upstream and downstream stakeholders to appreciate their respective roles in lake water quality management, especially in relation to the rural catchment.

A review of good management practices to control agricultural non-point source pollution concluded that organic farming was the most suitable option. Structured dialogues were conducted with farmers that confirmed the need for incentives to facilitate the shift towards organic farming to offset transition costs, such as sustained knowledge inputs on organic techniques. These included composting and bio-pesticides; reducing uncertainty of yields; offsetting the likely initial dip in outputs and the starting costs of certification (Senaratna Sellamuttu *et al.* 2008). However, the livelihoods impact study undertaken by the first author compared three cultivation scenarios of pure inorganic, transitional and pure organic farming of soybean and wheat crops, and found that net profit per acre (approx. 0.4 ha) of soybean increases with the shift to organic farming, although transition costs were not valued. As the cost of manure constitutes a major component in the total cost of cultivation, the shift in manure use from inorganic to organic has a perceptible influence on cost reduction. Through the PRA exercise, we found that while under organic farming the cost of agriculture inputs was less, the cost estimates may not reflect the additional labour required for preparing and applying organic inputs. The total input cost for soya, including labour, as obtained during the PRA exercise, was estimated to be US$ 106 per acre in chemical farming, which reduced to US$ 86 per acre for organic farming, resulting in net savings of US$ 20 per acre by practicing organic farming. In the case of wheat, the chemical farming input cost was US$ 129 per acre, whereas that for organic farming would be US$ 108 per acre—net savings of US$ 21 per acre (Verma *et al.* 2006). Most of farmers opined that, due to use of organic compost, there was an initial decline in yield as compared to chemical farming, but they observed that the use of organic compost has improved soil structure and retained moisture in the soil.

Some bottlenecks were experienced in the process of adoption of organic farming. First, there was limited availability of organic manure as people had limited cattle numbers that could provide dung for organic manure. Second, organic farming was found to be labour-intensive compared to inorganic farming and there was a scarcity of labour and the labour was costly. Third, there was a decline in yield in organic cultivation initially compared to chemical farming. Another hurdle was the lack of a premium price for organic products and the lack of market assurance for organic products by implementing agencies. These problems need to be solved for the sustainable adoption of organic farming. The study found that willingness to shift to organic practices is greater if incentives, such as certification and market support through differential pricing systems, are set. Premium price payments would certainly help improve the livelihoods in farming communities. Further dialogues between downstream urban stakeholders were also initiated under IIED study for increased access to water services, which could be used for compensating and "incentivizing" farmers in the rural catchment. Introduction of an income tax rebate in the case of a voluntary payment scheme for wetland conservation, and environmental bonds, could be other incentives to motivate people to pay for wetland conservation finance. But despite intensive negotiations with varied stakeholders, up until now no payment mechanism could be initiated.

5.2 Institutional framework for wetlands

There is currently no specific national policy and legal framework for wetland conservation, management and their wise use in India. A draft regulatory framework for conservation and management of wetlands is being finalized and will be notified under the

Environment (Protection) Act, 1986. At present, conservation and wise use of wetlands is being ensured through the legal framework of:

(a) *Legislation* Indian Forest Act, 1927; Forest (Conservation) Act, 1980; Wildlife (Protection) Act, 1972; Air (Prevention and Control of Pollution) Act, 1974; Water (Prevention and Control of Pollution) Act, 1974; Water Access Act, 1977; Environment (Protection) Act, 1986; Biological Diversity Act, 2002; Coastal Regulation Zone Notification, 1991; and their respective amendments;
(b) *Policies* National Environment Policy, 2006; National Conservation Strategy and Policy Statement on Environment and Development, 1992; National Forest Policy, 1988; and
(c) *Plans* National Biodiversity Action Plan, 2008.

In 2006, the National Environmental Policy (NEP) first recognized the need for legal regulatory mechanisms for the protection of wetlands from degradation and to conserve the character of their ecosystems. After several meetings of an expert group from multi-disciplinary backgrounds, a draft was prepared. The law will be called the Wetlands (Conservation and Management) Rules, 2008. The Central, State or District authorities will assess the conservation procedure of the wetlands and monitor and review the implementation of the regulations by setting up committees such as the Central Wetland Conservation Committee (CWCC), the State Wetland Conservation Committee (SWCC) and District Wetland Conservation Committee (DWCC) depending on the category of the wetland. The committees consist of members who are expert in wetland-related disciplines. The committee will be constituted every three years. After elaborate discussions on this issue, the Ministry has come up with a draft regulatory framework for the conservation of wetlands. This framework lists some of the activities that are prohibited and others that need to be regulated. Categorization of wetlands has also been proposed on the basis of significance of the functions performed and for determining the extent and level of regulation. The draft regulation also considers central, state and district conservation committees, their functions and powers and enforcement of regulatory activities. The framework is currently being finalized.

At the state level in Madhya Pradesh, the MPLCA was constituted in 2004 under the Government Housing and Environment Department to facilitate the conservation and management of water resources of the state in an environmentally sustainable manner and to generate awareness among the people to conserve these precious water resources. The major functions and duties of MPLCA were given as:

1. Preparation of an inventory of lakes and other water bodies in the state.
2. Identification of critical water resources and formulation of conservation and management plans to prevent ruthless anthropogenic activities.
3. Regulation and control of incompatible activities that adversely affect the water resources.
4. Regulation of the use and prevent abuse of surface and sub surface water resources.
5. Acting to regulate exploitation of groundwater and prevent its misuse.
6. Formulation of policy guidelines for management of water resources.
7. Exercising supervision over functions of management bodies.
8. Acting as a clearing house for all technical matters.
9. Advising the state government, its agencies, local authorities and autonomous agencies on matters pertaining to conservation and management of lakes or similar surface water resources.
10. Preparation of a Basin Management (Catchment, Submergence and Command area) Plan.
11. Maintenance, monitoring and research.
12. Identifying and making recommendation to the State Government for the Declaration of Conservation areas.
13. Preparation of a status report of water resources.
14. Preparation of a Publication Ecological Conservation Plan for water resources.
15. Reviewing Ecological Conservation Plan on own motion or through State Government.
16. Prepare Environmental Management Projects, Conservation and Management Project, etc.
17. Formulation of Act for synchronization of development, management and conservation plans to facilitate improvement of water resources.
18. Resolving trans-boundary, trans-catchment and multi disciplinary conflicts.
19. Extending technical cooperation and advice in formulation of plan for local level Lake Management Committees.
20. Acting as a bridge between state level and local level Lake Management Committees in implementation and monitoring of conservation plans.

21. Approaching state government for enacting any regulation to fulfil above objectives.
22. Provide consultancy services to national and international institutions/ organizations for fund generation.
23. Any other functions which are incidental to or conducive to the fulfilment of above functions/ objectives.

Despite a plethora of guidelines and mechanisms of managing wetlands, the Bhoj Wetland is still in a poor, degraded state. Mere creation of an institution is not sufficient, it must be successfully implemented. Furthermore, the lack of a National Policy for wetlands means it is not easy to integrate several individual policies and guidelines, which seemed to be a major reason for degradation of such important resources in the country. Moreover, in the state of Madhya Pradesh, creation of the MPLCA also does not seem to have had the anticipated impact due to weak implementation of its objectives and the investment made on the Bhoj Wetland has not resulted in its conservation and wise use.

6 CONCLUSIONS AND WAY FORWARD

This paper highlights the need for conducting an integrated assessment of wetland ecosystem services across the wetland water body itself as well as its catchment and the set of stakeholders, so as to reflect the total wetland ecosystem value. It puts emphasis on understanding the health of the wetland ecosystem and its dynamics, which could be articulated in the form of a wetland ecosystem model. This exercise was combined with a review of influencing factors from the catchment and resultant impact on wetland benefits that were captured through appropriate valuation techniques. Estimation of the benefits reinforces the justification for investing in wetland conservation and support decision-making processes for the allocation of wetland resources; thus the goal of valuation was to improve decision-making processes by providing the kinds of information that can lead to sustainable outcomes. Valuation of ecosystem services was just a part of the whole exercise of developing a sustainable management model of the BWL. The paper also demonstrates the need for setting up an incentive-based mechanism for the upstream and downstream stakeholders for the sustainable management of the wetland. The core idea of the policies and strategies that support such mechanisms should always be poverty alleviation, and the role of valuing ecosystem services to bring the poor above poverty levels should always be kept in mind (Verma *et al*. 2009a).

This integrated approach relies upon adequate databases and information systems maintained for the wetland water and nutrient budget, the hydrological processes of wetlands, temporal data on water quality and other ecological parameters, the value of and green accounts of various wetland ecosystem services and transaction cost estimates for establishing PES or IBMs for wetlands to ensure their conservation. A sufficient budget is needed for R&D activities to generate data on the building blocks of wetland management. Recent appreciation of wetlands as sinks of climate change impacts needs to be internalized in various studies, and efforts need to be made to seek international payments. Further capacity building should be undertaken amongst an array of stakeholders to instil an appreciation for "Total Wetland Ecosystem Values". A lack of such initiatives and information systems is a major stumbling block in wise use and sustainable management of wetlands, which needs to be addressed on an urgent basis to check the depletion and degradation of immensely valuable wetland ecosystems.

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