Introduction

The Bhoj wetland, located in the heart of Bhopal city, is a prime example of a wetland ecosystem vulnerable to degradation due to multiple uses by a rapidly increasing urban population. The various benefits that accrue to multiple stakeholders from this wetland are either under priced or not priced at all. The existing management strategy of the wetland does not value these various environmental services.

Objectives

The objectives of the study are to:

- Value various wetland benefits / resources so that planners and policy makers can make appropriate allocation of wetland uses and services.
- Develop a socially acceptable, environmentally sound and economically feasible strategy for Bhoj wetland management.

Study Area

The Bhoj Wetland comprises of two lakes: the Upper Lake and the Lower Lake. In 1988 the Ministry of Environment & Forests (MoEF) of the Government of India declared the Upper and the Lower Lake to be a Wetland of National Importance. Bhoj Wetland is among the 16 wetlands in India to be included in the National Lake Conservation Plan (NCLP). In 2002, MoEF declared it as an internationally important wetland by including it in the Ramsar Convention list. The present Upper Lake is the highly diminished remains of a large lake constructed by Raja Bhoj in the 11th century. Its catchment area measures 361 km² and it has a water-spread area of 31 km². The Lower Lake also known as the Chota Talab or Small Lake is situated towards the east end of the Upper Lake and is almost fully surrounded by built-up areas. It has a small catchment area of 9.60 km² and a water spread area of 1.29 km². The Lower Lake receives its inflow in the form of seepage from the Upper Lake in addition to the drainage coming from 8 nallahs or drains. The water level is maintained at a constant point by regular outflow through a waste weir at Pul-Pukht into Patra Nallah.

Multiple Uses of the Bhoj Wetland

The Bhoj Wetland provides:

- Drinking Water: Nearly half the city’s drinking water supply comes from the Upper Lake, which provides 64.4 million litres of water per day. This is the most important use of the wetland, directly impacting the welfare of the citizens of Bhopal.
- Employment: The Wetland directly and indirectly provides employment to various communities like fishermen, washermen, boatmen, vendors and others. Approximately 300 families are engaged in fishing and trapa (water chestnut) cultivation while about 100 washermen make their living from the Wetland. There are approximately 50 boatmen whose livelihood depends on the Bhoj Wetland.
- Microclimate Stability: The microclimate of Bhopal is quite moderate as compared to the surrounding areas. According to its geographical location, the city should actually have an extreme type of climate. The Wetland’s moderating effect on temperature however, results in cool land breeze during the evenings which make the environment of the city enjoyable, even during the peak of summer. Vegetative cover adds to this effect.
Recreation Opportunities: The Wetland offers recreational activities to the people of Bhopal such as boating and other water sports, as well as scenic views.

Threats to the Wetland

The Bhoj Wetland faces major threats from siltation, solid waste pollutants, sewage, pollutants resulting from washing clothes, trapa cultivation, encroachment, increasing population, weeds and eutrophication, boating, agricultural waste, idol and tadjia immersion, and hospital waste on account of excessive use by large numbers of stakeholders.

Methodology

The study first identified the various stakeholders of the Bhoj Wetland through a pilot survey. Following this, a stakeholders’ workshop was conducted to identify the management issues of the Bhoj Wetland. The stakeholders’ workshop used the ‘Sticky Cloth and Paper’ method to facilitate discussion. The multiple stakeholders were identified as the entire population of Bhopal city, washermen, boatmen, water chestnut or trapa cultivators, fishermen, NGOs, various line departments, and corporators of different wards, among others.

Stakeholders of the Bhoj Wetland

- Entire Population of Bhopal city – for drinking water and recreation
- Lake front property owners - for aesthetic beauty
- Washermen - for washing clothes in the lake
- Fishermen - for fishing activities
- Trapa cultivators - for cultivating trapa
- Water supply agencies - for water purification and distribution
- Bhopal Municipal Corporation - for management of the Lake
- Department of Housing & Environment, Govt. of Madhya Pradesh - for decision making processes
- Madhya Pradesh Tourism Development Corporation (MPTDC) - for tourism development on the lake
- Vendors - for secondary benefits

Three major issues, viz. sewage and waste disposal, fishing and washing activities and recreational activities were recommended to be addressed for sustainable management of the wetland. This was followed by development of an ecosystem model using STELLA software based on water quality parameters. Various simulation runs were carried out by changing the parametric values. The results of the modelling exercise were used for scenario building to administer the valuation techniques such as Contingent Valuation Method (CVM) and Hedonic Pricing by conducting a sample survey of all the wards of the Bhopal City.

Results

Ecosystem Modelling of the Bhoj Wetland Using Water Quality Parameters

The main objective of the Ecosystem Modeling of the Bhoj Wetland was to understand its physical characteristics to enable stakeholders to have a better understanding of the resource which is to be valued.

An ecosystem model using the water quality parameters was developed to study the current status of the lake, followed by changes in these parameters over the last few years. The model was also used to project the status of the Upper and Lower Lakes in the future, based on past data and information from the restoration activities currently being carried out. A base scenario was developed and then by changing the value of various parameters, simulation runs were carried out.

The basic ecological parameters brought under the purview of the conceptual model for the Bhoj Wetland are sewage and proliferation of weeds. The other water quality related parameters like Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), pH, Total Hardness, Total Alkalinity, phosphate, Turbidity, Total Dissolved Solids (TDS) and Bacterial Count are correlated with these variables and with each other. Their dynamics in the lake’s ecosystem is studied. Data from seven out of 32 Quality Monitoring Stations were used for water quality parameters representing different kinds of pressures on the Upper and Lower Lake.
An advanced ecological model was developed using a system’s dynamics software package STELLA. A model was developed representing the base scenario and simulation runs were carried using data of 1991-92 and 1999. The scenarios so obtained actually represent the health of the lake ecosystem and stress the need to value the impact of the changing health of the lake on an economic system. They further throw light on prioritization of future policy interventions, which shall be required if the lake is to be sustainably managed.

Economic Valuation of Wetland Benefits

The scenarios so obtained through ecosystem modeling exercise were represented through various visual presentations and figures. These graphs were then converted into picture cards for easier explanation of status of the lake to the respondents in the survey. Having attempted the ecosystem modeling and knowing the extent of degradation and threats, valuation was undertaken so as to cover the extent of monetary benefits or losses to various stakeholders where benefits are directly or indirectly marketed. As the benefits as well as the users are multiple, a spectrum of valuation techniques have been used to capture the economic value of various uses.

The valuation exercise included: calculating the benefits of supplying drinking water to the city; the value of benefits accruing to various people whose livelihoods depended on the wetland; the value of preventive measures that people used to avoid water borne diseases, and the willingness of the people of Bhopal to pay for enjoying better recreational facilities from the Bhoj Wetland. In addition to this, the effect of the presence of the Upper Lake on the value of property prices was also studied and estimated.

Valuation of Recreation

To estimate the recreational value of the Bhoj Wetland, all 66 wards of the city covering 1500 households were surveyed, as this value accrues to all the residents of Bhopal. The technique of CVM was employed to obtain the willingness to pay by people (WTP) for improved recreational facilities at the Bhoj Wetland. The CVM was administered through a questionnaire-based survey with an initial open ended, followed by closed ended bidding model. The questionnaire comprised of attitudinal questions and scenario building. Two types of payment vehicles were proposed - one in the form of a voluntary payment to the body that would undertake the management of the Bhoj Wetland in the future; and the second, a compulsory tax imposed on the people of the city, the collections of which would go to this maintenance society.

The following were expressed by the people in terms of the WTP in terms of the voluntary payment and tax (Table 1). The values so obtained were then extrapolated for the entire city to estimate the value of the lake in terms of recreation (Table 2).

Table 1. Mean and median willingness to pay voluntarily (FINVOL) and in the form of tax (FINTAX)

<table>
<thead>
<tr>
<th></th>
<th>FINVOL</th>
<th>FINTAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>537.85</td>
<td>219.17</td>
</tr>
<tr>
<td>Median</td>
<td>241.00</td>
<td>29.50</td>
</tr>
</tbody>
</table>

Table 2: Estimated WTP For Entire City

| Median FINVOL per household per annum = Rs 241/- | Total Number of households in City = 2,01,116 | Total Voluntary WTP per annum = Rs 48.4 million |
| Median FINTAX per household per annum = Rs 29.50/- | Total WTP as tax per annum = Rs 5.9 million |

Valuation of Property Prices

This valuation exercise attempted to calculate the proportion by which the closeness to the Upper Lake affects property prices. For this exercise, people’s attitudes and the importance they give to particular factors while buying a piece of property, were studied. In the second step property prices in particular areas of the city were obtained, and these areas were then
ranked against parameters of neighborhood, proximity to markets, ease of access, environment, housing density and presence and absence of the lake. A regression model was created for this equation and from that, the effect of the presence of the lake on property prices was gauged. The analysis found that the price of a site near the lakes, similar in all other respects to a site away from the lakes, would be nearly 50 percent higher.

**Comparative analysis of Various Values**

Various other values generated incomes to stakeholders from activities like fish production, boating, Trapa cultivation, washing of clothes, and secondary selling activities, among others. Then the values were measured in terms of cost incurred by the population for treatment of water borne diseases, as well as the cost of getting high-quality water. Agencies incurred supply costs to purify and distribute water. The values so estimated using various valuation techniques are summarized in Table 3.


<table>
<thead>
<tr>
<th>Uses / Impacts</th>
<th>Stakeholders</th>
<th>Valuation Techniques</th>
<th>Value (in Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Drinking Water</td>
<td>Water supplying agencies</td>
<td>Supply Cost</td>
<td>9,54,13,962</td>
</tr>
<tr>
<td>B. Fish Production</td>
<td>Fishermen</td>
<td>Market Price of Existing Production</td>
<td>80,00,000</td>
</tr>
<tr>
<td>C. Boating</td>
<td>Boatmen</td>
<td>Income Estimation</td>
<td>24,37,880</td>
</tr>
<tr>
<td>D. Trapa cultivation</td>
<td>Trapa (water chest) Cultivators</td>
<td>Market Price of Existing Production</td>
<td>50,00,000</td>
</tr>
<tr>
<td>E. Washing of clothes</td>
<td>Washermen</td>
<td>Income Estimation</td>
<td>36,00,000</td>
</tr>
<tr>
<td>F. Secondary Activities</td>
<td>Maize Cobb sellers</td>
<td>Income Estimation</td>
<td>1,44,00,000</td>
</tr>
<tr>
<td></td>
<td>Sugar cane juice sellers</td>
<td></td>
<td>2,73,60,000</td>
</tr>
<tr>
<td></td>
<td>Snacks &amp; cold drink stalls</td>
<td></td>
<td>2,06,40,000</td>
</tr>
<tr>
<td></td>
<td>Horse rides</td>
<td></td>
<td>7,92,000</td>
</tr>
<tr>
<td></td>
<td>MPTDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Cafeteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Boating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Water borne Diseases</td>
<td>Population using lake’s water</td>
<td>Cost of Illness</td>
<td>12,00,254</td>
</tr>
<tr>
<td>H. Quality water</td>
<td>Population using lake’s water</td>
<td>Purification Costs</td>
<td>1,24,35,876</td>
</tr>
<tr>
<td>I. Recreation</td>
<td>Entire population of the city</td>
<td>CVM</td>
<td>4,84,68,956</td>
</tr>
<tr>
<td></td>
<td>(i) As Voluntary Payment</td>
<td></td>
<td>59,32,922</td>
</tr>
<tr>
<td></td>
<td>(ii) As Compulsory tax</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. Increase in property prices</td>
<td>Lake front property owners</td>
<td>Hedonic pricing</td>
<td>50% higher property prices</td>
</tr>
</tbody>
</table>

**Conclusion**

It is evident from the Table 3 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 the people. All the values so estimated have not been aggregated, as some stakeholders use the lake for multiple values and such overlapping could not be avoided. Other important values like biodiversity and microclimatic effects have not been estimated due to lack of availability of data. The undertaken exercise however, does give a good insight of the multiple values that have not been considered to the extent possible in the current management activities.

Further, even if one is able to collect the revenue through what people were willing to pay in the from of voluntary payment to the society (Rs. 4,84,68,956 per annum), or in the from of tax to the government (Rs. 59,32,922/- per annum), the amount so collected would be much more than the existent estimated cost of maintenance of various subprojects of the Bhoj Wetland agency (Rs. 80,70,00/- per annum), if the collected revenue is from voluntary payment and reasonably collects 74% of the amount through taxes. With this, it is hoped that the authorities would keep the following recommendations in mind while implementing the current work and also before taking up fresh activities in the Wetland.

**Technical Recommendations**

The following suggestions are proposed to effectively implement the restoration sub-projects:

a. **Preventive measures:** Floating fountains have been put up in the Lower Lake at huge costs without completing the garland drain project, responsible for stopping sewage from entering the Lower Lake. As a result, on the one hand, sewage continues to flow unabated into the Lower Lake, while the floating fountains are supposed to aerate the Lake. The effect of the fountains is thus negated, and cannot be observed unless the flow of sewage is stopped.
b. **Problems with the road:** The Retghat–Lalghati Road has been constructed on the left bank of the Upper Lake, and is supposed to act as barrier to prevent encroachment. However, sewage through neighbouring colonies continues to flow underneath.

**Policy Related recommendations**

The critical need today is to recognize 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 challenging task and requires action at many levels as well as delicate integrity of diversity of issues and management institutions. Such an approach must begin with involving all stakeholders in the Wetland in the form of a local area institution. This would be helpful in eliciting their views for the use and future management of the Bhoj Wetland. The Institution so formed could frame an action plan to cover all ecological, economic, social and institutional issues. To cover the above issues, the following set of policy recommendation is proposed:

- People’s Participation
- Effective co-ordination
- Transparency in the System
- Setting up of a Bhoj Wetland Management Committee
- Economic Valuation
- Setting up of a Management Fund
- Cost Benefit Analysis
- Promotion of Eco-tourism
- Development of View Points
- Prioritisation of Activities Using Simulation Runs of the Proposed Ecological Model.