

# Management of Upper Lake Watershed

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## Abstract

The Upper Lake of Bhopal (Latitude 23°12' to 23°16' N and Longitude 77°18' to 77°23' E), constructed in the 11<sup>th</sup> century AD, is rich in biodiversity and is a major source of potable water for the people of Bhopal having a population of 1.6 million. The lake is also a lifeline for farmers of the fringe area and for about 500 fishermen families. Hence protecting this valuable resource from pollution for sustainable water use is of great importance as a matter of policy. However, in practice management of this resource had hardly been a top priority, which has resulted in the deterioration of lake water quality consequent to rapid urban development in the watershed during later part of the last century. The infamous Bhopal gas tragedy in 1984, however, generated considerable environmental consciousness among the people and protection of this vital but vulnerable resource for sustainable use was started in 1995. The major objective of this conservation effort, being improvement of water quality, involved prevention of inflow of wastes and anthropogenic activities within and outside the lake area, offloading of accumulated nutrients through desilting, weed removal and aquaculture and promotion of wise use of water resource through mass awareness campaign. Integrated shoreline management thus involved providing a sewerage system in the urban watershed, creating a buffer zone between human settlement and the lake in the form of a road and a promenade in the urban fringe and a green belt of local species all along the lake periphery. There is a legal framework in place to control anthropogenic activity up to 50 meters of shoreline of the lake. Regular water quality monitoring revealed a positive impact of the conservation efforts. However, to sustain the efforts made so far a long-term management plan with active participation of all stakeholders are required.

**Keywords:** Upper Lake, urban development, pollution, water quality, management plan

## Introduction

The construction of storage reservoirs is an age old practice in India. Former rulers have contributed significantly by constructing large number of impoundments for providing drinking water to the people in their capitals and elsewhere. This was particularly necessary in arid, semi arid and other regions with highly erratic rainfall. Upper Lake of Bhopal, arguably the oldest among the large man-made lakes in central part of India, falls under this category. This Lake was created in the early 11th century AD by obstructing the natural flow of the Kolans, a rainfed tributary of Betwa river by constructing an earthen dam across the valley between the two hills now known as Idgah and Shamla hills.

With the passage of time, the administration of Bhopal City changed hands several times, and in the year 1956 it became the capital of State of Madhya Pradesh, the then largest state of India. Since then it noticed tremendous influx of people and consequent urban development especially on the northeast fringe of the Upper Lake. This caused increase in demand for potable water and thus pressure on the lake. Consequently the storage capacity of the Upper Lake had to be increased through raising the height of spillway. Though this had helped in easing the water supply, the increased anthropogenic activities in the watershed caused increased inflow of silt, untreated sewage, nutrients and pesticides from urban and rural areas and thus deterioration of water quality of the lakes. However, in view of its ecological importance, the Ministry of Environment and Forests, Government of India has recognized this lake along with another lake (Lower lake) located downstream of Upper Lake as wetland of national importance and designated them as Bhoj Wetland in 1998, and action for the conservation of Upper Lake was started in 1989 with emphasis on creation of a buffer zone of plantations between the lake and the human settlements. Later an integrated plan for the conservation and management of the lakes was

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conceived, and implementation of the same was started in 1995 through financial assistance of Japan Bank for International Corporation of Japan. Though the implementation of the project is still underway, its positive impacts are perceptible. This lake was declared as a Ramsar site in the year 2002.

### Location of the Lake

The Upper Lake is located between latitude 23°12' - 23°16' N and longitude 77°18' - 77°23' E. It is a shallow tropical lake. It has a watershed area of 361 km<sup>2</sup> and a maximum submergence area of about 37 km<sup>2</sup>. The attainment of maximum water level (508.04 meters above sea level) of the lake depends on the magnitude of monsoon rainfall (average being around 1150 mm) in the watershed area. The water level in the lake is maintained by discharging excess water through a spillway provided on the southern bank of the lake.

### Watershed Area

The watershed area of the lake displays a complete range of urban and rural activity with varying intensities. The land use pattern of the Upper Lake watershed area is shown in Table 1. The soil of major part of lakebed and the watershed of Upper Lake is loamy. The soil is black in color and is derived from trap by the process of weathering.

Table 1. Upper Lake watershed land use.

Built Up Area	20.855 km <sup>2</sup>
Crop Land	219.050 km <sup>2</sup>
Plantation	9.600 km <sup>2</sup>
Open Forest	5.225 km <sup>2</sup>
Land with Scrub or Without Scrub	90.292 km <sup>2</sup>
Barren Rocky/Stony	8.465 km <sup>2</sup>
Other Lakes/Ponds	16.175 km <sup>2</sup>
Total Watershed Area	361.000 km <sup>2</sup>

### Importance of the Lake

The lake is the principal source of potable water to the city of 1.4 million people. In case of normal rainfall the water supply from the lake is 29 million gallons per day (MGD). Otherwise, off take may be much less (i.e. 12 to 15 MGD) depending upon the initial water level after the monsoon.

The lake is also rich in bio-diversity, principal components being phytoplankton, zooplankton, macrophytes, aquatic insects and avifauna (both resident and migratory). The details of biodiversity of the lake is as follows:

- Macrophytes - 106 species belonging to 87 genera of 46 families, including 14 rare species.
- Phytoplankton - 208 species comprised of 106 species of Chlorophyceae, 37 species of Cyanophyceae, 34 species of Euglenophyceae, 27 species of Bacillariophyceae, and 4 species of Dinophyceae.
- Zooplankton - 105 species ( 41 Rotifera, 10 Protozoa, 14 Cladocera, 5 Copepoda, 9 Ostracoda, 11 Coleoptera, and 25 Diptera).
- Fish fauna - 43 species of natural and cultured species.
- Avifauna - 179 species (52 migratory, 28 local migratory, and 99 local).
- Insects - 98 species of 10 families.
- Reptiles and Amphibians - >10 species, including 5 species of tortoise.

Furthermore, a buffer zone along the fringe of the wetland has been created through plantation of 51 species of angiosperms with adequate representation of medicinal plants.

### Problems

Due to tremendous population growth of the city (from just over 0.1 million in 1951 to about 1.6 million in 2001) and rapid urban development on the eastern and northern fringes of Upper Lake especially during the second half of the 20<sup>th</sup> century subjected the lake to various environmental problems resulting in deterioration of its water quality. The major causes of environmental problems of the lake are listed in Table 2.

Table 2. Environmental concerns affecting Upper Lake.

Problem	Causes
Reduction of storage capacity of the lake	Inflow of monsoon runoff and dry weather flow carrying silt and organic materials from urban and rural watershed.  Addition of clay and bio and non-biodegradable materials through Idol immersion.
Obstruction to smooth flow through the spill channel of the lake	Deposition of silt.
Flourishing growth of invasive aquatic plants	Nutrient enrichment of lakes due to inflow of sewage and agricultural wastes.
Deterioration of water quality	Inflow of untreated sewage from the urban watershed.  Dumping of municipal wastes not collected by the municipal corporation.  Addition of organic and inorganic materials through Idol and Tazia immersion (due to religious activity of Hindu and Muslim communities).  Direct human intervention and encroachment of fringe areas.  Addition of detergents used for washing clothes.

### Interventions in the Watershed for the Conservation of the Lake and to Improve its Water Quality

Interventions in the watershed are mainly preventive in nature and include the following:

- 1) **Demarcation of no construction zone:** The Bhopal Development Plan 2005 prohibits construction within 50 m of the Full Tank Level (FTL) of Upper Lake. Accordingly, a 50 m wide strip of land all along the FTL of the lake was demarcated and the document was provided to the concerned authorities (Bhopal Municipal Corporation and

Directorate of Town & Country Planning) to take appropriate action against encroachment.

- 2) **Creation of buffer zones between the lake and the human settlements:** A 5.4 km Link road on the north-east and a 2.5 km long Lake View Promenade on the south east fringe of the lake were constructed which served the dual purpose of prevention of encroachment of lake fringes, being a physical barrier as well as reduction of traffic pressure through the city. The promenade became a recreational and relaxing site for the city dwellers.
- 3) **Buffer zone plantations:** In order to prevent encroachment for human settlements and cultivation and grazing within the lake area, buffer zones have been created particularly in the Western, Southern and Northern fringe of Upper Lake. Besides this, intensive plantation has been carried out in the watershed area of the lake to control soil erosion. The species selected are either biomass producing or having medicinal properties and are tolerant to both flooding and drought conditions. About 1.7 million plants have been planted in over 10 km<sup>2</sup> land for over a period of 12 years. In the program under social forestry, farmers were encouraged to raise fruit yielding trees along their crop fields and marginal lands. The results were quite encouraging.
- 4) **Watershed treatment:** In order to mitigate inflow of silt, agricultural residues and other wastes into the lakes, 73 check dams made of loose boulder/Gabion structures having a cumulative silt trapping capacity of about 0.35 million cum have been constructed across 28 inlet channels.
- 5) **Sewerage system:** Infrastructure (laying of 86.7 km pipeline through congested human settlements and construction of 8 sewage pump houses and 4 treatment plants) for diversion and treatment of 35 MLD domestic sewage from the lake is being developed.
- 6) **Solid waste management:** Infrastructure of Bhopal Municipal Corporation was strengthened through providing additional equipment and vehicles. Outcome being

additional collection and disposal of 70 MT of solid waste from the 18 municipal wards located in the urban watershed of the lake.

- 7) **Promotion of organic farming:** Intensive cropping with use of inorganic fertilizers is being done in the rural watershed. Through monsoon runoff, a significant part of these nutrients find their way into the lake, causing growth of aquatic vegetation in the lake. With a view to discourage the practice of inorganic fertilizers based intensive farming in the watershed, a promotion drive for the use of organic fertilizer produced by the farmers themselves using farm waste and cow dung was launched. These include hand-on training to the farmers for making high quality compost using bacterial inoculum. The farmers find the method quite acceptable since crop yield was high compared to the use of compost produced by them through conventional method and there was considerable saving.

### Stakeholder Participation

The participation of ordinary people in the project implementation is an essential and important feature. This has been achieved through a well-coordinated awareness program involving political and religious leaders, district/city administration, local people, NGOs, schools, etc. The important stakeholders' participation in watershed management activities is as follows:

- Reforestation of watershed area through participation of farmers.
- Promotion of organic farming in the watershed through participation of farmers.

### Impacts of Implemented Action

- Due to construction of silt traps across small feeding channels and creation of buffer zone plantation around the lake, sedimentation of the lake was considerably reduced. The silt traps were also found to be very effective in trapping the organic debris from the rural watershed.
- Before creation of buffer zone plantation, land was either used for agriculture or infested with shoreline weeds. Either of the situations was not desirable. After plantation and protection, not only the general ambience of

the area improved but due to appearance of ground flora soil erosion from the area became negligible. The area also became a major attraction for the avifauna. An avifauna census completed in the year 2001 has revealed 179 species, which include 52 migratory, 28 local migratory and 99 local avifauna species. Some of them are also arboreal reflecting positive impact of plantation on biodiversity. Increase in population of *Grus antigone*, a vulnerable species, has also been reported.

- In the plantation area the understory grass species become a regular source of cattle feed for the nearby villages. The plantation and protection activities also provided ample job opportunities for the villagers, of whom a significant number were women. For the development of nurseries local women were involved wherever necessary.
- The Link road not only becomes a barrier against encroachment of Lake Area, but it helped in easing traffic pressure through the city.
- The project implementation has provided many job opportunities for the local people.
- Due to reduction of inflow of solid waste and silt and reduction of direct intervention of the people, no significant deterioration of water quality was observed. After the commissioning of sewerage system, further improvement in water quality of the lake is expected.

### Lessons Learned

The people's participation for the success of Lake Conservation program is a must.

### Future Action Plan

These include the following:

- Constitution of Lake Conservation Authority to sustain the conservation efforts made under the project.
- Declaration of buffer zone plantation area as well as the southern transitional zone of the Upper Lake as a bird sanctuary, a first in state of Madhya Pradesh, to provide long-term protection to the plantations raised and to promote eco-tourism.