Themes: Lakes, Water and Sanitation

ABSTRACT
Case Title: Conservation and management of Bhoj Wetlands, India #329

Sub Title: Describes the implementation of various conservation programmes for the conservation and management of the Bhoj Wetlands, a Ramsar site.

Description
Bhopal city, the capital of the state of Madhya Pradesh, is endowed with several man-made lakes created through the centuries. The Upper Lake, created in 11th century AD, and Lower Lake, created in the late 18th century AD, are by far the most important. The Upper Lake has special significance since it has been a source of piped water supply to the city of Bhopal for over 75 years. Even now, the lake accounts for some 40% of the city's water supply. Until 1947 the water quality of Upper Lake so good that it required no treatment before being supplied to the public. However, tremendous population growth of the city (about 70,000 in 1951 to about 1.4 million in 2001) and rapid urban development around Lower Lake and on the eastern and northern fringes of Upper Lake (especially during second half of the last century) subjected both the lakes to various environmental problems resulting in deterioration of their water quality mainly due to inflow of untreated sewage. The Bhoj Wetlands of Bhopal comprises of the Upper Lake and the Lower Lake. These lakes are of immense importance since they are inseparably linked with the socio, economical and cultural aspects of the people of Bhopal and are referred as lifelines of the city.

The Government of Madhya Pradesh implemented an integrated lake conservation programme during 1995-2004 through a Project Directorate directly controlled by Housing & Environment Department with the financial assistance of JBIC (Japan Bank of International Cooperation). The growing establishment of the settlements and consequent anthropogenic activities has resulted in various environmental problems like excessive growth of weed and algal mass, loss of water-spread area, deterioration of water quality and loss of bio-diversity, thereby inviting immediate attention for their conservation and management.

The basic objective of the project was to improve the water quality as well as to increase the storage capacity of these lakes.

The project activities involved both preventive and curative measures like increasing the storage capacity of the lake through de-silting, control of weed through de-weeding, prevention of pollution in the lake through diversion and treatment of sewage, catchment area protection through creation of buffer zone etc. The implementation of these activities resulted in increasing the water holding capacity of Upper Lake by four percent. Post project water quality monitoring confirms improvement in water quality of the lake when compared with the data of the pre-project implementation stage.

During implementation of conservation measures various types of administrative, social and legal issues have been encountered. The case study discusses how these issues have been addressed while implementing the conservation measures.

Lessons learned and replicability

A. A Lake and Its Catchment Must be Managed as a Composite Whole
Management of lakes and reservoirs for their sustainable use is directly linked to their catchment. In other words, a lake is a reflection of its catchment, and a number of measures must be taken to protect the catchment, including:

- Developmental activity that affects its green cover and landscape should be prohibited, and developmental activities associated with human settlements in the catchment should be restricted;
- Nonpoint source runoff (i.e., from the drains) must be trapped; and,
- Agriculture activities in the catchment require an awareness generation, conducted via the government extension services machinery, especially to facilitate a change in fertilizer consumption patterns, from

chemical to organic fertilizers.

B) Awareness Raising, Education and Stakeholder Participation are Essential

Stakeholder involvement, including lake-dependent communities and common people, should be an integral part of any management program. Their interest in the lake needs to be sustained through awareness campaigns and other eco-friendly activities.

C) Lakefront Protection is a Must

The lakefront is always prone to encroachments and pollution, thereby requiring protection as a major management action. This could be achieved by declaring a buffer zone from the full tank level of the lakes as a "No Construction Zone," by developing and demarcating the area as a biophysical zone. Nevertheless, protecting the lakefront and water-spread area from abusers is a continuing battle.

D) Administrative and Financial Mechanisms for Expeditious Decision-Making are needed

Project implementation in a government mechanism is usually handicapped because of a maze of red tape and delays in the decision-making process. For special projects, however, there is a need for administrative and financial innovations in project execution, as has been demonstrated by various state government decisions, which helped expedite the decision-making process.

E) Continuity of Project Staff is Essential

This lesson is of utmost importance when executing a time-bound conservation project. In the project, the technical staff involved in project preparation and execution remained with the project for long periods of time, thereby facilitating project continuity. However, frequent changes of the project head during the period when its execution was in full swing affected the project implementation progress.

F) Need to Sustain Measures

By their very nature, conservation measures are never one- time activities. The sustainability of the measures must be ensured for a long period, in order to achieve fruitful results.

Importance of case

This case provides insight regarding the issues involved in the implementation of an integrated urban lake conservation and management project.

Tools Used:

C4.2 Basin Management Plans

***Key Words*:** Integrated approach, stakeholder, involvement, lake catchment.

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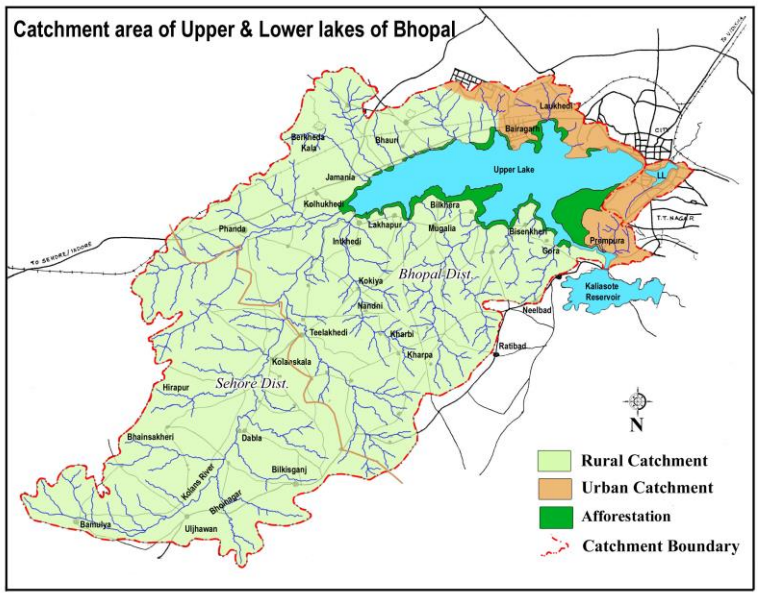
MAIN TEXT

1. Background and problems

Big and small water bodies, in the form of lakes and reservoirs, dot the landscape of South Asia. Unfortunately, the last half of the 20th century has witnessed large-scale degradation of the environment in general, and water resources in particular, due to multiple anthropogenic factors such as unprecedented population growth, and consequent urbanization, industrialization and chemical intensive agriculture. Among the first victims of this degradation process were the lakes and reservoirs in the vicinity of urban areas that underwent large-scale pollution due to sewage and industrial effluents and toxic chemicals. In most cases, nutrient enrichment led to eutrophication of water bodies, exhibiting negative manifestations such as :



- ✓ Loss of water-spread area because of siltation and construction activities;
- ✓ Continuous algal blooms;
- ✓ Excessive growth of macro phytes (e.g., water hyacinth) and loss of biodiversity; and,
- ✓ Water quality degradation.

The Upper and Lower Lakes of Bhopal, together called the Bhoj Wetlands fall in this category. King Bhoj created the Upper Lake in the early-11th century by construction of an earthen dam across the Kolans River, a rain-fed tributary of the Betwa River. In the late-18th century, Lower Lake was constructed by Nawab Chhote Khan (a Minister of Nawab Hayat Mohammed Khan's regime) to enhance the beauty of the city in the downstream of the earthen dam of the Upper Lake. However in the course of time, increased anthropogenic activities in the catchment have resulted an increased inflow of silt, untreated sewage, nutrients and pesticides from urban and rural areas, and an overall deterioration of the lakes' water quality. The Upper Lake is a source of potable water and meets 40% of the drinking water demand (29 million gallons per day) for the city's growing population. It is also an important water body for biodiversity and fish production. Fishing rights have been allocated on a long-term lease by the Bhopal Municipal Corporation (BMC) to a fishermen's cooperative, consisting of some 500 fishermen families. Lower Lake is mainly a recreational site. The livelihood of 250 washer-men families belonging to socio-economically weaker sections of the society is dependent on the Lower Lake. The BMC is the custodian of the lakes, and also has

the authority to control the land use in the fringe area of the lakes since it issues building permission sanctions.

The Bhopal Development Plan 2005, prepared by the Directorate of Town and Country of Madhya Pradesh, provides for the following regulatory measures for the protection and management of lakes:

- Fringe areas of the lakes have been declared as sensitive zones. No construction and development activities in 50 m space from the Full Tank Level (FTL) of the Upper Lake and 33 m space from the edge of the Lower Lake is allowed. The space is to be kept open. The lake fringe of the Upper Lake is to be kept free from any further construction except passive recreation;
- The areas of the Upper Lake, including slopes, are to be planted to the extent of 50-100 m from the maximum tank level with appropriate indigenous trees and shrubs to arrest the pollution and silt entering into the lake;
- The Upper Lake water, which is basically used for drinking purposes, shall not be allowed to be used for such water-based recreational activities that adversely affect the water quality; and
- The practice of agriculture right along the lake fringe areas is to be discouraged so that water is not polluted due to the addition of chemical fertilizer, pesticide and insecticides.

The Upper Lake has both rural and urban catchments. With a well-protected catchment, its water quality was of potable standard until recently. In the last few decades of the 20th century, however, many sections of the lake became surrounded by habitations as the city grew. These developments have generated anthropogenic pressures on the lake, thus accelerating its eutrophication and microbial contamination, and making the water unfit for human consumption without proper treatment.

Because the Lower Lake is located within a completely urban catchment, it has been subjected to many negative anthropogenic stresses, its water quality degradation has been much more pronounced than for the Upper Lake.

Table: Water quality of Upper & Lower Lakes of the Bhoj Wetland (1991-92)

Parameter	Range	
	Upper Lake	Lower Lake
pH	8.8-9.2	7.15-9.7
Transparency (cm)	NA	14-98
Conductivity (µS/cm@ 25°C)	213-228	259-374
Total dissolved solids (TDS; mg/l)	121-252	86-169
Hardness (mg/l)	60-146	68-154
Chloride (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)	1.8-6	2.2-11.5
Chemical oxygen demand (COD; mg/l)	8.8-26.4	8-112
Class	B	D

The major issues concerning the environment of the lakes are described below:

Problems	Causes
Reduction of water storage capacity of the lakes	Inflow of silt and organic materials from urban and rural catchments, along with monsoon runoff and dry weather flows; Addition of clay and non-biodegradable materials through immersion of idols
Obstructions to smooth flow of water through the Upper Lake's spill channel, resulting in a threat to the stability of the earthen dam	Constriction of the spill channel, due to deposition of silt
Deterioration of water quality	Inflow of untreated sewage from habitations; Dumping of municipal wastes not collected by the Municipal Corporation; Dissolving of paints in water during immersion of idols; Chemical fertilizer runoff from the catchment; Activity of washing of clothes by washermen, resulting in release of detergents; Leakage of oil during motor boating
Flourishing growth of invasive aquatic plants	High nutrient load to lakes from inflow of sewage and agricultural wastes
Reduction of water spread area	Encroachment on the lake fringe area, which becomes exposed when the lake water level drops after rains end

Considering the ecological importance of these lakes, the Government of India declared the twin lakes as lakes of national importance, and efforts to improve their environmental status began in 1989. In recognition of its rich biodiversity (especially avifauna), and for adopting an integrated management plan, this wetland was declared a Ramsar site (a wetland of international importance) in 2002.

2. Decision & Action taken

A. Planning Stage

Efforts to manage the lakes had been implemented in a piecemeal manner since 1988. The State Government initiated a public awareness generation program of manual weed removal called 'Sarovar Hamari Dharohar' (Lakes are Our Heritage) in 1989. Because of the degradation of water quality resulting from aggravated pollution loads and environmental degradation of the lakes, the Government of Madhya Pradesh prepared an integrated plan for the Conservation and Management of both lakes, and requested financial assistance from the Government of India (GOI) in 1989. The GOI provided grants-in-aid of Rs. 16.5 million for conservation works during 1989-1992. Because of the high costs of conservation works, the GOI proposed the plan for external financial assistance to the Government of Japan in 1991.

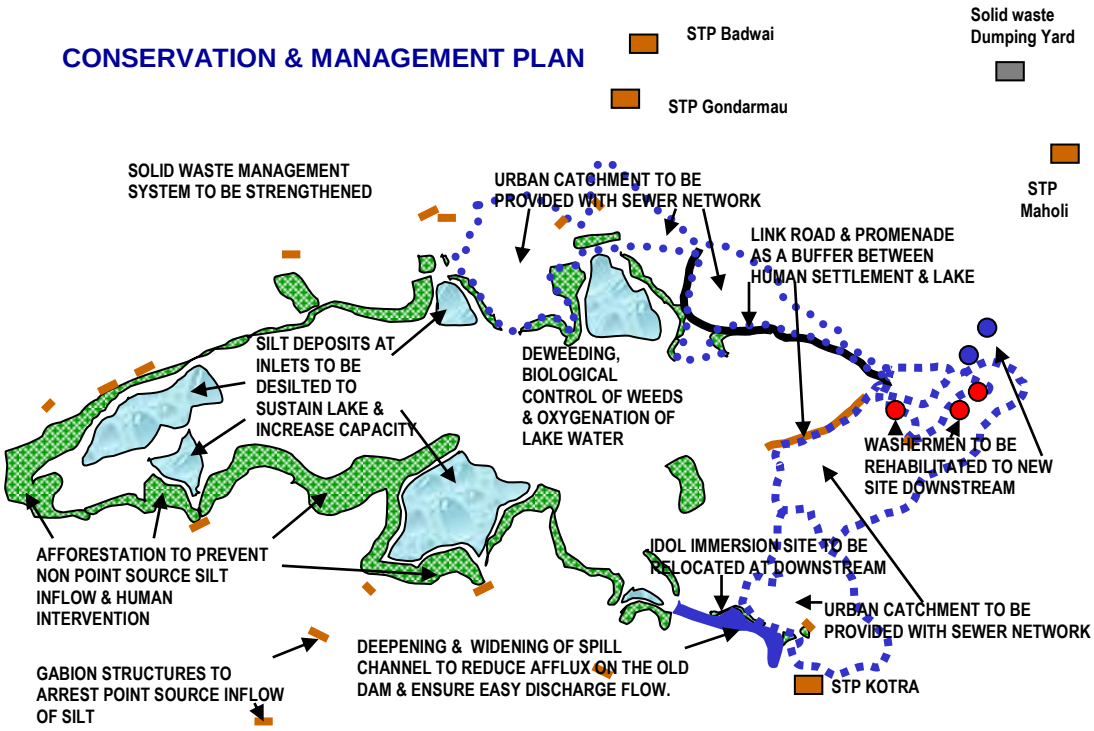
The Japan Bank for International Cooperation (JBIC) dispatched a study team, under Special Assistance for Project Formation (SAPROF), to India in 1993 to assess the project feasibility. Upon its recommendations, JBIC agreed to provide financial assistance, in the form of a soft loan of 7.055 billion yen out of the total project cost of 8.033 billion yen. It was decided that the balance 978 million yen would be shared equally by the GOI and the State Government. An agreement between the JBIC and the

Government of India (Ministry of Finance, Government of India being the signatory) was executed for implementation of the "Lake Bhopal Conservation and Management Project" (also known as Bhoj Wetland Project), to be executed over a period of 5 years, beginning in April 1995.

The project was to be coordinated with JBIC by a government- controlled society, called the Environmental Planning and Coordination Organization (EPCO), the executive and advisory arm of the Environment Department on statewide environmental issues. It would be implemented by the Bhopal Municipal Corporation (BMC), State Public Health Engineering Department (PHED), Capital Project Administration (CPA) and MP Fisheries Development Corporation (MPFDC).

The project envisaged tackling various conservation and management issues of the Upper and Lower Lakes of Bhopal in an integrated manner. Although the issues are interrelated and interlinked, for ease of operation and management, these issues were divided into various sub-projects, albeit with the understanding of the related issues and their interconnectivity with each other. The project initially envisaged 14 sub-projects under the major topics of:

- ✓ Desilting and Dredging (desilting and dredging of the lakes; deepening and widening of the spill channel, and restoration of the island);
- ✓ Catchment Area Treatment (afforestation, creation of buffer zones, construction of check dams, silt traps, toe walls and cascading and garland drains);
- ✓ Prevention of Pollution (Sewerage schemes);
- ✓ Shoreline and Fringe Area Management (construction of link road from Retghat to Lalghati, solid waste management, prevention of pollution from Dhobighats); and
- ✓ Improvement and Management of Water Quality (deweeding, biological control of weeds through aquaculture, installation of floating fountains, water quality monitoring).
- ✓ Considering the importance of public awareness in successful project implementation, public participation and environmental awareness activities were added as the 15th sub-project. Additional works, including a lake view promenade and protection of lake fringes (both for shoreline management), a bridge across the Bhadbada spill channel, establishing an Interpretation Center for increasing environmental awareness, and control of seepage from the earthen dam of the Upper Lake, were subsequently included as additional sub-projects during 2002-2004.



B. Implementation Stage

Implementation of the projects began in April 1995. Being a large investment project, sanction of the major works fell under the purview of the State Cabinet. To ensure speedy disposal, the State Cabinet delegated its financial powers to an Empowered Committee under the chairmanship of the Chief Secretary of the State Government, which was constituted in February 1996. The Committee had the secretaries of all concerned state government departments with a stake in the project implementation, as well as a representative from Ministry of Environment & Forests, GOI, as members. A Japanese-Indian joint venture firm formed for this project was appointed as Project Management Consultant (PMC) in May 1996, with a mandate to advise the project during project implementation.

A project cell was set up within EPCO, with the role of coordinating the activities of various implementing agencies (IA) and the PMC. At times, the IA showed an indifferent attitude toward completing the project on schedule. The project progress was tardy for the first two-and-a-half years because of a lack of coordination between the implementing and coordinating agencies, as well as the PMC. None of the Detailed Project Reports (DPRs) of the various sub-projects were cleared for implementation during this period, with the three parties blaming each other for the delay. Two of the DPRs ultimately had to be given to private consultants for preparation. The project remained headless for a period of 6 months (March - September, 1997).

However, upon a Project Officer joining the project in September 1997, the activities began taking shape, with many DPRs cleared between then and mid-1998. The speed of project execution further improved in May 1998, when the state government decided to bring most of the sub-projects (except for the ones being executed by the Bhopal Municipal Corporation and the CPA) under a single umbrella called the Bhoj Wetland

Project Directorate, by upgrading the project cell within EPCO. Being under the same administrative department, the CPA was left independent. Thus, two executive divisions were formed as the IA under the Project Director (new designation of the Project Officer). To assist the IAs in preparing the DPRs of each sub-project, and for monitoring their implementation, a Project Coordination and Monitoring cell within the project was created, reporting to the Project Director, with the induction of experts of various disciplines (environmental engineering, urban planning, geo-hydrology, limnology, ecology, etc.) from various government departments. Since EPCO was going to execute such major works for the first time, an operational system that delineated the responsibilities of the executing and monitoring divisions was prepared and implemented.
In May 1998, another major decision was taken to accelerate the tendering and sanctioning of the project works. In the government system, authority for sanctioning works depends on the magnitude of the estimated costs. The time required for such sanctions are often long, having to pass through several levels and thereby creating a bottleneck constraining smooth progress for time-bound projects. It was necessary that such departmental delays be avoided if the project was to be completed within the remaining 2 years. A project Technical Evaluation and Tender Approval Committee (TE and TAC) was constituted in May 1998, under the chairmanship of the Secretary of the Environment Department, including Chief Engineers of the Public Health Engineering, Water Resources, and Public Works, as well as a representative of the Finance departments, as members. It was the competent authority for according approval to the Detailed Project Reports of the various works under the project, evaluating tenders and technical matters, and sanctioning works up to Rs. 15 million for all IAs.
Regarding financial issues, as per the loan agreement with the JBIC, the release of funds to the State Government was done via a reimbursement process (i.e., the JBIC would reimburse the expenditure made by the IAs). The Project Authority previously got the funds from the government in the form of budgetary allocations in its annual budget, with its release from the Finance Department having to be periodically obtained. There often was a delay in getting the budget released from the Finance Department, thereby also delaying payments to contractors. This problem was ultimately overcome with the EC giving the go-ahead in 2000, with the concurrence of JBIC, to shift from a reimbursement mode to a transfer mode of payment. Under this new system, the bills were passed by the IAs, and payment to contractors made directly by the JBIC to their account, thereby bypassing the state budgetary system.
This change both accelerated project execution and made the payment system completely transparent. In addition, to prevent the transfer of IA or EPCO personnel involved in project execution, the Empowered Committee decided that nobody would be transferred or relieved from his duty without the concurrence of the Empowered Committee.
With this new system in place, the project implementation became much smoother, with the TE and TAC regularly convening to make necessary technical decisions. Further, the time for sanctioning DPRs, calling tenders and tenders evaluation, was considerably shortened. In July 2000, however, the Project Director was transferred, with the next director lasting only 4 months, followed by a short period in which the project was headless, resulting in delaying the progress at a crucial implementation stage. However, from December 2000, till the project end in May 2004, the project run by two Project Directors, both having reasonable terms.

The following sub-projects were executed:

Fringe area protection
The Bhopal Development Plan 2005 prohibits construction within 50 m of the Full Tank Level (FTL) of the Upper Lake and within 33 m of the Lower Lake. Accordingly, a "No Construction Zone," located up to 50 m from the FTL of the Upper Lake, has been demarcated with boundary stones. A physical barrier, in the form of arches along the Lower Lake, has been constructed to prevent direct access to the lake.

Creation of buffer zones between the lake and the human settlements
A 5.4 km Link Road on the northeast and a 2.5 km long Lake View Promenade on the southeast fringe of the lake, were constructed, to serve the dual purpose of preventing encroachment of the lake fringe area and reducing the traffic pressure throughout the city. The promenade also has become a recreational site for city dwellers. In order to prevent encroachment by human settlements, cultivation and grazing within the lake area, and siltation, plantation buffer zones have been created, particularly in the western, southern and northern fringes of the Upper Lake. In addition, intensive planting activities have been carried out in the lake's watershed area to control soil erosion. About 1.7 million plants have been planted in over 10 km2 of land over a period of 12 years. In the social forestry program, farmers were encouraged to raise fruit yielding trees along their crop fields and marginal lands, with the results being encouraging to date.

Catchment area treatment
The catchment area of the Upper Lake covers about 361 km^2, with agricultural practices being undertaken in most of the area. During the rainy season, runoff from the catchment carries much silt and organic debris to the lake. The urban catchment runoff and sewage enters the lakes through various drains, causing both siltation and water pollution. To mitigate the inflow of silt, agricultural residues and other wastes into the lakes check dams of loose boulder/gabion structures, and silt traps having a cumulative silt trapping capacity have been constructed across the inlet channels.

Interception and treatment of Sewage
Sewage is a major cause of pollution and water quality deterioration of both lakes with 14 drains carrying 15 million liters/day of sewage entering the Upper Lake and 28 drains carrying 50 million liters/day entering the Lower Lake. An 86.7 km sewerage pipeline sewage pump houses and 4 treatment plants have been constructed for diversion and treatment of domestic sewage.

Solid waste management
Due to limited infrastructure before project implementation, the municipal corporation could only collect 96 tons of garbage daily, compared to the generation of 131 tons of garbage from the project area (18 city wards). The infrastructure of the Bhopal Municipal Corporation was strengthened from project funds, by providing dumper placers; refuse compactors, a sewer-cleaning machine and containers. An electronic weighbridge also was installed at the dumpsite to monitor the efficiency of each vehicle. These measures resulted in the additional collection and disposal of 70 metric ton of solid waste from the

18 municipal wards located in the urban watershed.

Prevention of pollution due to washing activities

There are informal settlements of washer men along the Lower Lake, with the sewage from these settlements previously flowing directly into the lake. Their cloth-washing activities also resulted in discharges directly into the Lower Lake. These sewage inflow and washing activities caused drastic deterioration in the lake's water quality.

To ameliorate the situation, the washer men have been shifted outside the catchment of the Lower Lake, with rehabilitation sites for 250 washer men families having all facilities for living and washing, being constructed.

Resettlement of the washer men families has been completed with the vacated land being developed as a buffer zone with gardens and parks.

Dredging and de-silting of lakes

Due to silt deposition from the various drains, mass land formation was occurring at the confluence points, resulting in decreased water storage capacity and spread area. About 85,000m^3 silt was removed from the Lower Lake via the dredging operation.

Silt removal in Upper Lake, however, was undertaken through dry excavation, after constructing earthen cofferdams and dewatering the area. The excavated materials were transported to wastelands transforming them into productive agricultural and plantation lands.

Deepening and widening of the spill channel

To maintain the Upper Lake's water level, it has a spillway and approach channel (4.41 km long) for the smooth discharge of excess water during the rainy season through gates. Continued silt deposition over the years within the existing narrow channel section, however, resulted in obstructions to the smooth flow of water through the channel. Silt accumulation near the gates also caused high pressure on the gates. As an insufficient spillway system discharge capacity could lead to the buildup of water pressure in the Upper Lake, causing a threat to the dam at Kamla Park therefore deepening and widening works were carried out in 2.6 km of the spill channel to accommodate a discharge of 566 m3/sec, with about 0.98 million m3 of silt being removed. The channel also was given a proper shape to attain the required discharge.

Restoration of Takia Island

Takia Island in the Upper Lake has a Mazar of Shah Ali Shah Rahmatullah Aliah, which is of religious importance. Because of wave action, its periphery has been getting eroded from the western side over the years, posing a threat to the existence of the Mazar, while it was being silted on the eastern side. Two rows of toe walls were constructed around the

island as a remedial measure and the area between the walls was filled in with soil excavated from the silted lakebed.

Weed removal

Nutrient enrichment of the lakes due to inflow of untreated sewage, organic waste-containing runoff from urban areas in both lakes, and agricultural residues from rural areas around the Upper Lake have caused excessive aquatic vegetation growth within the lake area. In order to reduce nutrient recycling and prevent accelerated evapotranspiration of lake water, controlled weed removal operations were carried out in about 90% of the submergence area of the Upper Lake, and almost the entire area of the Lower Lake. Removal of different types of weeds, including shoreline (*Ipomea fistulosa*), emergent (*Scirpus roylie*, *Cyprus rotandus*, *Polygonum glabrum* and *Ipomoea aquatica*), floating water hyacinth and an assemblage of submerged weeds, was started in a systematic manner since January 1999. Maintenance operations are still continuing, with the magnitude of weed growth having been considerably reduced.

Installation of water oxygenation systems

Injection of ozone to improve water quality of an urban lake was tried out for the first time in the world in the Lower Lake. For the Upper Lake (a potable water source), however, only fountains with the provision of exposing the hypolimnetic water to the atmosphere have been installed.

A total of 15 aeration units (1 ozonizer, 1 ozonizer cum fountain and 4 fountains in the Lower Lake; 9 fountains in the Upper Lake) have been installed to oxygenate the hypolimnetic water. This activity has not only improved the water quality, but has also become a tourist attraction.

Biological control of weed through aquaculture

Herbivore grass carp, along with Indian Major carp, were introduced in the lakes to control submerged weeds (e.g., *Hydrilla*, *Najas*, *Vallisnaria*), as well as to maintain ecological balance. This has resulted in an up to 50% reduction in the density of aquatic weeds, and an increase in fish production by 130%. Thus, this activity has both improved the lake water quality, and enhanced the economic conditions of fishermen.

High-level bridge across Bhadbhada spill channel

For containing the development on the southeastern part of Upper Lake, and to reduce traffic pressure over the old Bhadbhada Bridge (spillway), a 4-lane bridge across

Bhadbhada spill channel was constructed, and is expected to divert the development outside of the catchment of the Upper Lake.

Public awareness campaign

During the implementation of the project, it was realized that there was a need to educate the public of Bhopal about the need for the project and to make the public aware of the deteriorating lake environment. It was decided, therefore, to organize a well-coordinated public awareness program. As an initial activity, a survey was conducted to assess people's responses regarding the conservation and lake management efforts. Based on this initial study, people of all walks of life were involved through the awareness program. The cooperation of selected NGOs also was solicited for this activity, with various education awareness materials being developed including: gatherings at strategic locations; publication of special bulletin (Tal Sandesh) to create awareness regarding diversion of Idol immersion activities; advertisement in newspapers regarding project actions; communication through TV/radio; T-shirts/caps, showing the message of "Save Bhopal Lakes," used by students/volunteers involved in awareness campaign; and stickers with various lake conservation slogans, used to communicate the message. A major achievement of this awareness campaign was the complete cessation of idol immersions at the traditional site of the Upper Lake.

Interpretation Center

To create awareness among people of all walks of life, an Interpretation Center was developed on the shore of the Upper Lake, depicting the origin of the Bhoj Wetland, ecosystem structure and functions, conservation principles, project activities and the future course of action for the wise use of the lake ecosystem. This museum is expected to be a common meeting point for stakeholders, as well as a tourist attraction.

Control of seepage through earthen dam of Upper Lake

The earthen dam of the Upper Lake was constructed in the year 1005, reportedly being constructed between 2 dry masonry wall fields with moorum (small pebbles mixed with red soil) and boulders. A tunnel (gallery) subsequently was constructed to release water from the Upper Lake to the Lower Lake, and to supply potable water to the city. Lacking proper care over the years, the upstream retaining wall of the earthen dam, upstream toe, and the tunnel inside the earthen dam, were damaged. Consequently, water was seeping throughout the length of the body of the dam and through the tunnel. A proposal to stabilize the dam retaining wall, and to prevent water wastage, was included in the project at a later stage. The remedial measures included concrete construction of existing stone masonry walls, grouting of retaining walls, construction of bell-mouth inlet and outlet structures of the tunnel, and shot-creting in two layers on the tunnel's inner wall. A vertical shaft was provided to facilitate the future inspection and treatment of the tunnel. For inspection purposes, a pathway was laid on the upstream side of the dam. Area beautification also has been done through provision of planters and lighting, with the work being in its last stage of completion.

C. Project Innovations

In addition to what was conceptualized in the project, a number of other innovations also were done, including the following :

Promotion of organic farming

Intensive cropping with inorganic fertilizers is being done in the rural watershed. A significant part of these nutrients find their way into the lake via monsoon runoff, causing the growth of aquatic vegetation. With the intention of discouraging farming practices in the watershed based on inorganic fertilizers, a drive to promote the use of organic manure was launched in 15 villages of the catchment, comprising two districts of the State. The manure was produced by the farmers themselves, and was comprised of farm wastes and cow dung. Relevant activities included hands-on training to farmers for making high-quality compost using bacterial inoculums. The farmers found the method acceptable, since their crop yields were higher, compared to the conventional method, and there also was considerable savings because the need to purchase inorganic fertilizers was eliminated.

Control of idol immersion activities.

Religious activities have a deep relationship with water resources in India. At the end of religious festivals, the immersion of idols in water is practiced throughout the country. Idol immersion also was practiced in the Upper Lake, which is a potable water source for the people of Bhopal. Since the idols are made of wood, hay, bamboo, clay, and printed with bright (heavy metal laden) colors, the lake was receiving silt, as well as being polluted. Thus, an alternate idol immersion site on the spillway of the Upper Lake was developed, and through constant persuasion and intensive awareness campaigns, idol immersion ceased around the year 2002 at the traditional site, which was located near the potable water intake point. Because the new site was located on the spill channel of the Upper Lake, the impacts of idol immersion on the main water body were eliminated.

Control of motor boating.

Being a large, urban lake, boating activities, including motor boats, were popular in the Upper Lake, causing pollution problems related to oil and grease spillage. The project authorities were able to convince the BMC to ban motor boating because of the spillage, which was polluting the lake.

D. Future Action Plan for Sustainability

During the implementation of the Lake Bhopal Conservation and Management Project, it was realized that due to the multiplicity of agencies involved in the development, regulation and maintenance of the lakes and their catchment areas, and the issues thereof, the conservation and management efforts for these lakes were being diluted. Also, environmental conservation and management of lakes could be a one-time effort, and project activities must be continued as a catalyst to initiate further action and development activities. Additionally, the experiences gained and the human resources developed during the project implementation process should be meaningfully utilized for the purpose of conserving lakes and other water bodies of the entire state of Madhya Pradesh. Finally, although there were a number of laws related to water resources, there

was no single agency with responsibility for their conservation and management. Thus, there is a need for a specialized, legally-empowered agency for the integrated conservation and management of lakes and water bodies.

The Government of Madhya Pradesh decided to established an independent Lake Conservation Authority (LCA) for conservation and management of lakes for the entire state of Madhya Pradesh. In response to this initiative taken by the Government of Madhya Pradesh, JBIC funded a pre-investment study of the institutional and financial framework of such an agency. After discussion with various stakeholders, and several rounds of roundtable meetings with the stakeholders, the pre-investment study consultant recommended an institutional framework for the Lake Conservation Authority, and suggested a mechanism to make the Authority financially viable (there were no attempts during the project implementation to generate revenues except by the Water Quality Monitoring laboratory). It is proposed that the Authority function with two-tier administrative set-up (i.e., a State level Lake Conservation Authority), headquartered at Bhopal, with local Lake Management Committees constituted for each conservation area (constituting a specific lake, its catchment and command areas). The responsibilities of the LCA would include the following:

- Preparing an inventory of lakes and other water bodies in the state;
- Identifying critical water sources and formulating conservation and management plans to prevent anthropogenic activities;
- Regulating and controlling incompatible activities, which adversely affect the water sources;
- Formulating policy guidelines for managing water resources;
- Preparing basin management plans;
- Identifying and facilitating declaration of conservation areas; and,
- Preparing status reports of water resources.

The LCA was constituted in May 2004 with four functional divisions (Research, Development and Monitoring, Engineering, Outreach and Administration and Finance). While the Outreach Cell was responsible for implementation of awareness program involving NGOs, the Research, Development and Monitoring and Engineering divisions were to focus on development of conservation plans of the lakes of the state, and monitoring implementation of such plans by the Field level agencies in the Conservation Areas. The day-to-day function of the LCA was under the control of a Chief Executive Officer.

The State Government has been provided a core fund of Rs. 24 crore by JBIC for post project conservation works against a specifies time schedule for maintaining the status of the lakes. It was expected that the LCA would be self-sustaining through proper investment of the corpus, and generating resources through project grants and consultancy services to other agencies involved in lake management within and outside the state. However, time schedules for the post project conservation have not been followed.

3. *Outcomes*

The implementation of the conservation measures resulted in substantial improvement of water quality besides increasing the storage capacity of the water body. The outcome of the project is depicted in following table:

Activities	**Action Taken**	**Outcome**
Interception and treatment of Sewage	An infrastructure has been developed that comprises an 86.7 km pipeline with 8 sewage pump houses and 4 treatment plants	Diversion and treatment of 56 MLD domestic sewage has been developed.
Dredging and de-silting of lakes	About 85,000m^3 silt was removed from the Lower Lake via the dredging operation. A total of 2.70 million m^3 of silt was removed from 6 peripheral zones of Upper Lake,	Resulting in a 4% increase in lake storage capacity.
Weed removal	Removal of different types of weeds, including shoreline (*Ipomea fistulosa*), emergent (*Scirpus roylie*, *Cyprus rotandus*, *Polygonum glabrum* and *Ipomoea aquatica*), floating (water hyacinth) and an assemblage of submerged weeds, was started in a systematic manner since January 1999	A total of 1022 ha of shoreline and emergent weeds and 101351mt of submerged weeds were removed.
Catchment area treatment	To control the inflow of silt, agricultural residues and other wastes into the lakes,	75 check dams 2 silt traps having a cumulative silt trapping capacity of 0.36 million m3, have been constructed across 31 inlet channels
Deepening and widening of the spill channel	Deepening and widening works done in 2.6 km of the spill channel with the removal of about 0.98 million m3 of silt.	Resulted in increase in discharge of 566 m3/sec
Prevention of pollution due to washing activities	Washer men shifted outside the catchment of the Lower Lake, with rehabilitation sites for 250 washer men	Reduction in input of detergents, improvement in water quality.
Installation of water oxygenation systems	A total of 15 aeration units (1 ozonizer, 1 ozonizer cum fountain and 4 fountains in the Lower Lake; 9 fountains in the Upper Lake) have been installed to oxygenate the hypolimnetic water.	Increase in dissolved oxygen concentration and biodiversity in the lake
Biological control of weed through aquaculture	Herbivore grass carp, along with Indian Major Carps, were introduced in the lake to control submerged weeds (e.g., *Hydrilla*, *Najas*, *Vallisneria*), as well as to maintain ecological balance.	About 40% reduction in the density of aquatic weeds in the first year with an increase in fish production by 130% was achieved.
Solid waste management	The infrastructure of the Bhopal Municipal Corporation was strengthened from project funds, by providing dumper placers; refuse compactors, a sewer-cleaning machine and containers.	Infrastructure of municipal corporation was strengthened to enable additional collection and disposal of 70 metric ton of solid waste from the 18 municipal wards located in the urban watershed.

4. *Lessons Learned and replicability*

Followings are the lesson learned while implementing various conservation measures under the project

A. A Lake and Its Catchment Must be Managed as a Composite Whole

Management of lakes and reservoirs for their sustainable use is directly linked to their catchment. In other words, a lake is a reflection of its catchment, and a number of measures must be taken to protect the catchment, including:

- Developmental activity that affects its green cover and landscape should be prohibited, and developmental activities associated with human settlements in the catchment should be restricted;
- Nonpoint source runoff (i.e., from the drains) must be trapped; and,
- Agriculture activities in the catchment require an awareness generation, conducted via the government extension services machinery, especially to facilitate a change in fertilizer consumption patterns, from chemical to organic fertilizers.

B) Awareness Raising, Education and Stakeholder Participation are Essential

Stakeholder involvement, including lake-dependent communities and common people, should be an integral part of any management program. Their interest in the lake needs to be sustained through awareness campaigns and other eco-friendly activities.

C) Lakefront Protection is a Must

The lakefront is always prone to encroachments and pollution, thereby requiring protection as a major management action. This could be achieved by declaring a buffer zone from the full tank level of the lakes as a "No Construction Zone," by developing and demarcating the area as a biophysical zone. Nevertheless, protecting the lakefront and water-spread area from abusers is a continuing battle.

D) Administrative and Financial Mechanisms for Expeditious Decision-Making are needed

Project implementation in a government mechanism is usually handicapped because of a maze of red tape and delays in the decision-making process. For special projects, however, there is a need for administrative and financial innovations in project execution, as has been demonstrated by various state government decisions, which helped expedite the decision-making process.

E) Continuity of Project Staff is Essential

This lesson is of utmost importance when executing a time-bound conservation project. In the project, the technical staff involved in project preparation and execution remained with the project for long periods of time, thereby facilitating project continuity. However, frequent changes of the project head during the period when its execution was in full swing affected the project implementation progress.

F) Need to Sustain Measures

By their very nature, conservation measures are never one- time activities. The

sustainability of the measures must be ensured for a long period, in order to achieve fruitful results.

5 Contacts, references, Organization and People

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