Status of Bangalore Wetlands: Strategies for Restoration, Conservation and Management.

Kiran, R. & Ramachandra, T. V.

Wetlands play a pivotal role in the maintaining the ecological balance of the local system by its functions as sources, sinks, and transformers of a multitude of chemical, biological, and genetic materials. The interaction of human society with wetlands to obtain multiple benefits- natural resources, amenities and environmental services such as ground water, fisheries, migratory birds habitat, etc.

Wetlands occupy about 4.8% of Bangalore City's geographical area. Anthropogenic stress due to unplanned developmental activities and population growth has severely affected these fragile ecosystems sustainability. This has led to the decline in the number of waterbodies, spread area changes, interconnectivity breakage and decreased water quality. Spatial and temporal changes were analysed through tools such as GIS and remote sensing, etc. Waterbodies characterisation is done through physico-chemical and biological monitoring of monthly water samples from selected waterbodies, spread across the city.

Research results reveal about 35% decline in number of waterbodies between 1973-1996. Drainage network analyses highlights the loss in interconnectivity affecting the local hydrology, ground water table and other benefits of the ecosystem. Point and non- point source pollution has contributed to the decline in the health, affecting the beneficial utilities. Strategies involving local people, non-governmental organisations and educational institutions are proposed to restore, conserve and manage wetlands.

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INTRODUCTION

Wetlands are the areas inundated with water, where the water table is close to the land. They constitute a vital ecosystem, which helps in maintaining the ecological balance, serving the various needs of the society by recycling nutrients, purifying water, attenuating floods, maintaining stream flow, recharging ground water, etc., making it one of the most productive ecosystems.

Societies depend on aquatic ecosystems for food, and for domestic, agricultural and industrial purposes. The economic benefits from wetlands to the society are in the form of water supply, commercial fisheries, agriculture, energy resource, wildlife resource, recreation, tourism, cultural heritage, biodiversity, etc.

The myriad ways, in which wetlands are used, along with the numerous anthropocentric activities, have stressed wetlands in diverse ways. This is causing impairment of wetlands quality and disrupting its natural functions, which have led to direct physical destruction (drained for agricultural and developmental activities), siltation (soil erosion and removal of vegetative cover) and pollution from both point sources (municipal sewage and industrial effluents) and non-point source degradation (urban and agricultural runoffs) within the watershed and from more insidious long-range atmospheric transport of contaminants. Pressures from burgeoning population and unplanned urbanisation have subjected these ecosystems to tremendous stress threatening their very existence. In Bangalore, as elsewhere, wetlands are being lost due to,

i. Population pressures and growing economies leading to unplanned urbanisation and expansion, exerting greater pressures on land resources.
ii. Lack of governmental commitment in understanding the importance and essence of conservation and management of wetlands.
iii. Lack of cohesive academic research centered on wetland per se for its protection, management owing to financial constraints and lack of infrastructure and required expertise.
iv. Lack of proper stormwater management (source of non point sources) and unregulated land use management have also led to the persisting problems of pollution, eutrophication, invasion of exotic species, toxic contamination by heavy metals, pesticides and organic compounds.

Excessive nutrients and organic matters have led to eutrophication, siltation from erosion due to agricultural, construction, logging and mining activities, introduction of exotic species, acidification from atmospheric sources and contamination by toxic metals such as mercury and organic compounds (such as PCBs), and pesticides. In addition to physical alteration at the land-lake interface (e.g. draining) and hydrologic manipulations also (such as, damming outlets to stabilise water levels) affects the structure and functioning of the ecosystem.

The loss of wetlands has led to increased flooding in low lying areas, while degradation has resulted in decline in both surface and ground water quality, decrease in biological diversity, altered productivity of these ecosystems and its beneficial uses. Studies also show that about 40% of all waterbodies in Bangalore are mainly sewage fed [Krishna et al, 1996]. A broader definition of "urban wetland" is used to highlight aquatic systems predominantly affected by urban population and their drainage basin dominated by urbanisation, rather than the geology, soils or plants.

Realizing the importance of wetlands and its role to the society, a study was undertaken to assess the spatial and temporal changes, and the present status of wetlands to identify the major problems and threats encountered by wetlands, and formulate suitable strategies for their restoration, conservation and management.

OBJECTIVES

The objectives of wetlands research are to,

i. Investigate levels and source of anthropogenic stress.
ii. Analyse the spatial and temporal changes of water bodies.
iii. Interconnectivity analysis of drainage network to assess the extent of loss in Bangalore urban district, due to anthropogenic stresses and its impacts.
iv. Assess the status of waterbodies in Bangalore by analysing the physico-chemical characterisation of selected waterbodies of Bangalore.
v. Identify major pollution problems of wetlands in Bangalore.
vi. Suggest suitable measures for restoration, conservation and management.

STUDY AREA

Bangalore district is located in the southern part of Karnataka state (Figure 1), stretched between latitudes 12° 39' - 13° 18' N and 77° 22' - 77° 52' E longitudes covering an area of about 2,191 sq. km. and supporting about 27.41 %, (5 million) of the total urban population [Census, 1991] of the state. The district has a mean maximum temperature of 36.2°C in April and a mean minimum temperature of 11.4°C in January and an average rainfall of 860 mm. This district is divided into rural and urban, with Bangalore urban consisting of North, South and Anekal taluks. The Bangalore City area is spread between Bangalore North and South taluks (at the center) covering an area of about 151 sq. km. at an average elevation of 900m. The current study is carried out in Bangalore city limits [as defined by Bangalore City Corporation (BCC) in Bangalore urban district].

Bangalore rural is located between Latitudes 12° 15' to 13° 35' N and 77° 05' to 78° E longitudes at an elevation ranging between 600-900 above MSL and spanning an area of 5814 sq. km. The district with head quarters at Bangalore, consists of eight taluks, namely, Channapatana, Ramanagaram, Kanakapura, Dodaballapur, Hoskote, Magadi, Devanahalli and Nelamangala.

METHODOLOGY

Spatial- Temporal, drainage network and interconnectivity analyses:

Integrated approach involving remote sensing data, spatial and temporal analyses tools [Geographical Information System (GIS)], collateral data and conventional field survey were adopted for this purpose. The base maps and the drainage maps were prepared using 1:50,000 scale Survey of India (SOI, 1973) toposheets. The thematic maps were prepared based on the visual interpretation of IRS-1C satellite imagery, using the visual interpretation keys such as tone, colour, texture, pattern, association, size shape, topography and drainage.

The 1:50,000 Survey of India (SOI, 1973) toposheets were used for the preparation of base maps and drainage maps giving a detailed drainage information of the area, showing the streams and the drainage channels. Ground verification and field validation of the thematic maps were done by selecting the training sites consisting of prominent features like water bodies, road and railway network and major settlements as ground control points, and field visits were made to check the interpretation accuracy.

Wetland Map

Wetland map of 1973 was prepared using 1:50,000 Survey of India (SOI) toposheets. IRS-1C imagery of 1996 was used for 1996 wetlands map. This was done by visually interpreting tools as tone, colour, texture, pattern, association, size, shape, topography, drainage and analysed using Image processing software (IDRISI) and GIS. The temporal changes in the number of water bodies over two decades was detected by overlaying maps of 1973 and 1996.

Water Quality Assessment

Exploratory field surveys and extensive literature review were carried out to find the present status of wetlands in Bangalore and the associated problems. This has helped in selecting the waterbodies (sample) for further study. [Detailed investigations were carried out in seven water bodies selected based on the type of pollution load and its location in order to get an overall picture. Water quality of these water bodies was assessed on monthly basis, by monitoring the physico-chemical and biological parameters following APHA [American Public Health Association, Standard Methods for Water and Wastewater Analysis, 1995], for about twelve months.

Tanks studied: Table 1

Sl. No	Tank	Location	Area (hectare)	Major source of pollution
1	Bannergatta	Lat. 12.890 - 12.911 Long. 77.630 - 77.632	5	None
2	Sankey	Lat. 13 006- 13.010 Long. 77.5727 - 77.5767	10	NPS, Vehicular pollution
3	Madivala	Lat. 12.896 - 12.914 Long. 77.610 - 77.622	115	Domestic, Industrial, NPS, Solid waste dumping
4	Hebbal	Lat. 13.040 - 13.050 Long. 77.579 - 77.591	75	Domestic, Industrial, NPS, Solid waste dumping
5	Ulsoor	Lat. 12.976 - 12.986 Long. 77.616 - 77.623	45	Domestic, Industrial, NPS, Solid waste dumping
6	Yediyur	Lat. 12.930 - 12.933 Long. 77.5762 - 77.578	4	Domestic, Industrial, NPS, Solid waste dumping
7	Kamakshipalya	Lat. 12.937 - 12.938 Long. 77.521 - 77.522	1	Domestic, Industrial, NPS, Solid waste dumping

RESULTS

Temporal change assessment done by overlaying Figure 2.2 (wetland map - 1996) over Figure 2.1 (wetland map-1973), showed a decrease of about 35% in the number of waterbodies over a period of two decades (23 years) as summarised in the table below. Region-wise spatial and temporal analyses is summarised in Table 2.

Table 2: Region-wise spatial and temporal analyses

Region	Area in sq. km	No. tanks (1973)	No. tanks(1996)	Percentage loss, (no. of tanks)
North	506.87	138	96	30.43
South	594.96	241	150	37.75
Total	**1101. 8**	**379**	**246**	**34.09**

The results showed about 4.5% (49.56 sq. km.) of the total area studied (1102 sq. km.) was covered by the waterbodies. Further analysis showed a decrease of 133 waterbodies (North - 42, South - 91) over a period of twenty three years, owing to pressures from public spirited endeavors, projects/undertakings such as the public utility bus stand (e.g., Kampamudhi, Doddamudhi tanks), residential layouts, commercial establishments, stadium, recreation, etc.

These human induced stresses, mainly urbanization and unplanned growth, have led to the physical alterations some beyond redemption leading to decrease in both the spread area and water quality, and loss in drainage interconnectivity. A detailed drainage analyses was undertaken in Bangalore rural and urban districts, to assess the implications of urbanisation. Talukwise drainage network for urban district is given in Figure 3 while Figure 4 provides for Bangalore rural district.

The comparative analysis of drainage network between Bangalore urban and rural showed that wetlands in Bangalore urban district were subjected to intense pressure due to the process of urbanisation and increasing population, resulting in loss of interconnectivity, in contrast to waterbodies in Bangalore rural where less pressures from direct human activities were noticed as shown in Figure 3. In order to identify the type of anthropogenic activities that has resulted in the loss in interconnectivity, Belandur and Madivala lake drainage network was studied in detail to assess the extent of loss and its implications.

In order to assess the impact of developmental activities, the wetland map of 1996 (generated with the help of IRS-1C data) was overlaid on the base map. This brings out the loss in connectivity between wetlands. Figures 5.1 and 5.2 shows the interconnectivity of lakes at Madivala and Bellandur with the adjacent lakes respectively. Due to conversion and encroachment of two water bodies, connectivity between Yelchenahalli kere and Madivala is lost as in the case of Bellandur and Ulsoor lakes with the conversion of Challegatta tank into a golf course. The GIS analyses revealed that due to developmental activities in the catchment area the drainage connectivity between the wetlands have been lost. This has resulted in the loss of wetlands, decreases in catchment yield, loss of water storage capacity (due to sedimentation etc.), and shrinkage in the wetland area, which has further led to depletion in the ground water table.

One of the significant functions of water bodies are, they act as recharge zones for groundwater. Reduction in water bodies has a serious impact on ground water level (bore wells) as is evident from the recent study that due to disappearance of lakes the ground water table has decreased from 35-40 feet to 250-300 feet in 20 years [Deepa et al, 1997]. The results from various studies support that decrease in the wetlands has also led to decrease in the habitat flora, fauna and migratory birds. This clearly indicates that apart from the decline in number and quality, there is a loss in terms of functions and values, to the ecosystem.

Status of water bodies: Physico, Chemical and Biological characterisation

The colour of the polluted waterbodies were mostly greenish, due to algal blooms and effluents from domestic and industrial sources. Turbidity in the waterbodies ranged from 1.0-25.0 NTU (Nephlometeric Turbidity Units) in cleaner waterbodies and 70.0-362.0 NTU in polluted waterbodies, mainly due to silt, organic matter and autochthonous sources (mainly planktons) from both point source (industries and domestic) and non-point source pollution (stormwater runoff), directly influencing the light penetration and affecting the production efficiencies in lakes.

The pH values of most water samples analysed showed to range from alkaline 7.6 - 9.3 to acidic. Kamakshipalya recorded 6.0 - 6.6 during the entire study period. Higher alkaline values were noticed at Yediur and Ulsoor tanks. At a given temperature, pH is controlled by the dissolved chemical compounds and the biological processes in the solution [Chapman, 1996]. The dissolved solids mainly consist of carbonates, sulphates, chlorides, nitrates and possibly phosphates of calcium, magnesium, sodium and potassium. High dissolved solids were noticed in all the studied lakes except Bannergatta and Sankey lakes ranging from 30.0-301.0 mg/L and 430.0-1024.0 mg/L in the polluted lakes such as Kamakshipalya and Yediur respectively. The suspended solids ranged from 52.2 mg/L to a high of 288.3 mg/L as a result of silt and matter in suspension.

The dissolved oxygen levels of the analysed waterbodies ranged from 1.2 mg/L in Kamakshipalya lake to 11.1 mg/L in Ulsoor and Yediur lakes largely due to photosynthetic activity. The recommended dissolved oxygen concentration for a healthy and ideally productive lake waterbody is 8 mg/L [Wetzel, 1973].

The contents of phosphates were found to be low, ranging from 0.06 mg/L to a high of 4.2 mg/L in Kamakshipalya lake. The standard is 0.2 mg/L for surface inland water [Chakarapani et al, 1996]. This parameter is very crucial and ecologically elusive, as it has the tendency to be precipitated by the many cations and accumulates at the bottom of the lake. The nitrate values ranged from 0.1mg/L to 2.7 mg/L. The standard for inland surface water is 0.1 mg/L [NEERI, 1988]. This parameter is very significant from the point of view of productivity in lakes.

The Chemical Oxygen Demand (COD), measures the oxygen equivalent of the organic and inorganic matter in a water sample that is susceptible to oxidation. COD as a result of pollution is largely determined by the various organic and inorganic materials (calcium, magnesium, potassium, sodium etc). The COD values ranged from 27mg/L in unpolluted waters to a high of 621 mg/L in Kamakshipalya.

Among the analysed heavy metals Iron and lead were shown to be present in greater concentrations than zinc and chromium.

Results of the present study showed that for most of the analysed parameters for five lakes (Ulsoor, Hebbal, Yediur, Kamakshipalya and Madivala) of the seven analysed exceeded the limits set by Indian Standard for Industrial and sewage effluents discharge [IS: 2490 -1982].

WETLAND MANAGEMENT

Management is the manipulation of an ecosystem to ensure maintenance of all functions and characteristics of the specific wetland type. The loss or impairment of wetland ecosystem is usually accompanied by irreversible loss in both the valuable environmental functions and amenities important to the society [Zentner, J. 1988]. Appropriate management and restoration mechanisms need to be implemented in order to regain and protect the physical, chemical and biological integrity of wetland ecosystems. In this context a detailed study of wetland management and its implications on the socio-economic aspects is required from biological and hydrological perspective.

In Bangalore as in most urban centers environmental pressures on wetlands are created by human activities, by changing land use in the watershed area, pollution from point and non-point sources, soil compaction, loss in interconnectivity and solid waste dumping, etc., all affecting the natural functioning of wetlands. Protecting these wetlands existing functions proves to be incredibly complex as it involves building a partnership among the various agencies, working in a co-ordinated effort in addressing the common goal of minimizing the human-induced changes that affect the hydrology, biogeochemical fluxes and the quality of wetlands. The problems of wetlands in Bangalore can be broadly summarized as,

- Hydrologic alterations, includes changes in the hydrologic structure and functioning of wetland by direct surface drainage, de-watering by consumptive use of surface water inflows, unregulated draw down of unconfined aquifer from either groundwater withdrawal or by stream channelisation for various human activities.
- Increased sedimentation, nutrient, organic matter, metals, pathogen and other water pollutant loadings from both storm water runoff (non point source) and wastewater discharges (point source).
- More insidious atmospheric deposition of pollutants into these waterbodies mainly by the vehicular and industrial pollution both from within and towards the sub-urban industrial complexes.
- Introduction or change in characteristic wetland flora and fauna (exotic) as a result of change in the adjacent land uses deliberately or naturally, changing water quality, etc.

Wetlands are an integral part of watershed; their position, natural and anthropogenic activities, hydrology, climate, geology of the region and site-specific factors influence their natural functioning. The over exploitation of wetlands in Bangalore in using them as receptacles of untreated sewage, runoff from developed urban and agricultural areas, changing land use within the watershed etc., have resulted in rendering the ecosystem in peril. This deteriorating water quality due to pollution has led to spawning of mosquitoes, due to absence of predators such as *Gambusia affinis*, killifishes (*Fundulus spp.*), etc., which preys on mosquito larvae[Buchsbaum, R. 1994]. An Integrated Pest Management (IPM) involving bio-regulation approach could possibly control mosquitoes rather than draining wetlands.

Guidelines for wetland management

The wetland management program generally involves activities to protect, restore, manipulate, and provide for the functions and values emphasizing both quality and acreage by still advocating sustainable usage of them [Walters, C. 1986.]. Management of wetland ecosystems requires an intense monitoring, increased interaction and co-operation among the various agencies (state departments concerned with environment, soil, natural resource management, public interest groups, citizen groups, agriculture, forestry, urban planning and development, research institutions, government, policy makers, etc). Such management goals should not only involve buffering wetlands from any direct human pressures that could affect the wetlands normal functions, but also in maintaining important natural processes that operate on them that may be altered by human activities. Wetland management has to be an integrated approach in terms of planning, execution and monitoring requiring effective knowledge on a range of subjects from ecology, economics, watershed management, and planners and decision makers, etc. All this would help in understanding wetlands better and evolving a more comprehensive solution for long-term conservation and management strategies.

1. The management strategies should involve protection of wetlands by regulating inputs using water quality standards (WQS) promulgated for wetlands and such inland surface waters to promote their normal functioning from the ecosystem perspective, still deriving economic benefits by sustainable usage.
2. Urban wetlands provide multiple values for suburban and city dwellers [Castelle, et al., 1994]. The capacity of a functional urban wetland in flood control, aquatic life support and as pollution sink implies a greater degree of protection. It provides a resource base for people dependent on them. When dealing with such common resources, some of the important factors to be considered for developing a management strategy for wetlands are,

    i. Data relating to the current ecological condition of the lakes in Bangalore is inadequate. This necessitates an immediate need to create a database on the wetland types, morphological, hydrological and biodiversity data, surrounding land use, hydrogeology, surface water quality, and socio-economic dependence, and highlight the stress these systems are subjected to in the given context.

    ii. Conduct regular water quality monitoring by involving institution, colleges and regulating bodies of surface water, groundwater and biological samples. Such programs helps in providing technical, hydrologic support and information which aid in better understanding of these systems and formulating a comprehensive restoration, conservation and management programs.

    iii. Development of water quality database, data analysis and disseminating information by involving local institutions and accessibility to all users. This can be achieved through,

        1. Exchange of data across departments involved in the program, easy accessibility to regularly and continuously monitored data;
        2. Update technical guidance and water quality maps at regular intervals and indicate quality determinant parameters;
        3. Analyse and discuss case studies of water quality issues;
        4. Provide spatial, temporal and non-spatial water quality database systems.

    iv. Correct non-point source pollution problem and administer the Pollution Prevention Program through the environmental awareness programs.

3. Creation of Buffers zones for Wetlands protection: Creating buffer zones limiting anthropogenic activities around the demarcated corridor of the wetland could revive its natural functioning. The criteria for determining adequate buffer size to protect wetlands and other aquatic resources depend on [Castelle et al. 1994].

i. Identifying the functional values by evaluating resources generated by wetlands in terms of the economic costs, etc.
ii. Identify the magnitude and the source of disturbance, adjacent land use and project the possible impact of such stress in the long term, etc.

iii. Buffer characteristics - vegetation density and structural complexity, soil condition and factors.

A fully formed functional *In-buffer* must consider the magnitude of the identified problems, resource to be protected, and the function it has to perform. Such a buffer zone could be consisting of diverse vegetation along the perimeter of waterbody, preferably an indigenous one serving as trap for sediments, nutrients, metals and other pollutants, reducing human impacts by limiting easy access and acting as a barrier to invasion of weeds and other stress inducing activities [Stockdale, 1991].

4. Community support: Wetland management, restoration or conservation of wetland ecosystem requires an integrated, broad-based inter-agency partnership all working towards a common goals involving the educational institutions, forest department, Bangalore Development Authority (BDA), City Corporation, Irrigation department, Public Works Department (PWD) and Pollution Control Board for a successful conservation and management of wetlands. Also active participation of local community, conservation organisations, NGO's, and citizens' groups with active support from the media at all levels of planning, executing and monitoring is required for implementation of measures to meet the set goals.

5. Schools and colleges: Wetlands requires a collaborated research involving natural, social and inter-disciplinarian study aimed at understanding the various components, such as, monitoring of water quality, socio-economic dependency, biodiversity and other activities as an indispensable tool for formulating long term conservation strategies [Kiran et al., 1999]. This needs multidisciplinary-trained professionals in educating the essence of wetland importance involving the local school, colleges and research institutions. Initiate educational programs aimed at rising the levels of public awareness and comprehension of aquatic ecosystem restoration goals, and methods.

The active participation from the schools and colleges in the vicinity of the waterbodies may value the opportunity for hands-on environmental education further entailing setting up of laboratory facilities at site. Regular monitoring of waterbodies (with permanent laboratory facilities) provides a vital inputs for conservation and management.

6. Regulatory bodies: An interagency regulatory body comprising personnel from departments involved in urban planning (Bangalore Development Agency, Bangalore City Corporation, etc.), resource management (Forest department, Fisheries, Horticulture, Agriculture, etc.), and regulatory bodies such as Pollution Control Board (PCB), local citizen groups, research organisations and NGOs would help in evolving effective wetland programs covering significant components of the watershed, that needs a co-ordinated effort from all agencies and organisations involved in programs affecting the health of wetland ecosystems directly or indirectly

RESTORATION

Restoration means reestablishment of predisturbance aquatic functions and the related physical, chemical and biological characteristics (Cairns, 1988; Lewis, 1989) with the objective of emulating natural and a self regulating/perpetuating system that is integrated ecologically with the landscape and the functions the wetlands perform. The goals for any restoration program should be realistic and tailored to individual regions, specific to the problems of degradation and based on the level of dependence. The restoration program should mandate all aspects of the ecosystems, including habitat restoration, elimination of undesirable species, and restoration of native species from the ecosystem perspective with holistic approach designed at watershed level, rather than isolated manipulation of individual elements. This often requires reconstruction of the physical conditions; chemical adjustment of both the soil and water; biological manipulation, reintroduction of native flora and fauna, etc.

Restoration goals, objectives, performance indicators (indicates the revival or success of restoration project), monitoring and assessment program should be viably planned, so that, project designers, planners, biologists and evaluators have a clear understanding. Monitoring of restoration endeavour should include both structural (state) and functional (process) attributes. Monitoring of attributes at population, community, ecosystem and landscape level is appropriate in this regard.

Restoration strategy developed in collaboration with the government, researchers, stakeholders at all level and the NGOs should address the following.

1. Set principles for priority setting and decision making,
2. Prioritising goals, assessment and monitoring strategies based on specific roles they perform, level of dependency and type of problems faced by wetlands.
3. Innovation in financing and use of land and water programs for better and sustainable usage of these resources.

It is deemed important to give priority to repair those systems that would have lost without any form of intervention. A framework is to be developed categorising by the level of interventions required for prioritisation. [Committee on Restoration of Aquatic Ecosystems et al, 1992]:

i. Those that recover without any intervention;
ii. One's that can be restored close to their former condition to serve their earlier functions consideration cost involved, technical review of the restoration plan etc based on the goals and objectives set.
iii. One’s that cannot be restored to any agreeable degree viably.

CONCLUSION

Wetland ecosystems are interconnected and interactive within a watershed. In Bangalore the environmental pressure of unplanned urbanisation and growing population has taken its toll of wetlands. The study revealed about 35% decline in the number and loss in the interconnectivity among wetlands disrupting the drainage network and the hydrological regime leading to irreversible (sometimes) changes in wetland quality.

The exploratory survey and physico-chemical and biological characterization of lakes located all over the city shows that lakes are polluted mainly due to sewage from domestic and industrial sectors. Detailed quantitative investigations of seven waterbodies (selected based on location and the type of input source) involving physical and chemical parameters and statistical analysis of selected parameters reveals that Kamakshipalya, Yediur, Hebbal and Ulsoor lakes have higher degree of pollution compared to the Sankey and Bannergatta tanks which has no major source of pollution.

The preliminary socio-economic survey carried out in the region surrounding Hebbal lake through Contingency Valuation Method showed high level of dependency on wetlands for ground water, food, fodder, fish, fuel, etc. The high level of dependency on wetlands and its poor quality calls for immediate restoration of degraded lakes and appropriate measures for conservation and management in order to maintain ecological balance in the region.

The restoration program with an ecosystem perspective through Best Management Practices (BMPs) helps in correcting point and non point sources of pollution wherever and whenever possible. This along with regulations and planning for wildlife habitat and fishes helps in arresting the declining water quality and the rate in loss of wetlands. These restoration goals require intensive planning, leadership and funding along with the financial resources and active involvement from all levels of organisation (governmental, NGOs, corporate conglomerates, citizen groups, research organisations, media, etc.) through interagency and intergovernmental processes all made instrumental in initiating and implementing the restoration programs. Various measures including the creation of a Regional Conservation Forum (RCF) represented by a network of educational institutions, researchers, NGO's and the local people are suggested to help restore the already degraded lakes, and conserve those at the brink of death. In order to restore, conserve and manage our fast perishing wetland ecosystem, the need of the hour is to formulate viable plans, policies and management strategies.

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