

URBAN LAKES OF INDIA : AN OVER-VIEW OF THE PRESENT STATUS AND PROJECTIONS FOR THE FUTURE

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ABSTRACTS

The urbanization has been taking place in the world for more than 6000 years. In the developed countries about 75% of the population is concentrated in the urban areas. The rate of urban growth is especially high in developing countries like India. India has witnessed rapid urbanization since independence. The urban population in India was 62 millions (17.3 %) of total population in 1951 which increased to 218 millions (25.7 % of total population) in 1991. It is expected that by 2025 India's urban population will reach 50% of the total population of 1.2 billions. The population of India is expected to reach 1.64 billion by 2050. It is difficult to overstate the urgency of the problems confronting the urban lakes, which hold complete requirement of freshwater of urban area. A lake is a sort of catalyst in the development of the city, region and the country as a whole. In India most of the urban lakes are in crisis, beset by a myriad of problems that affect the quantity and quality of the water they contain, the organisms they support, and their ability to meet the water requirement. Some suffer from excessive water withdrawals and diversions, while others have witnessed deteriorating water quality because of polluting human activities on the surrounding land as well as in catchment area of the lake. This paper takes a candid look at what is happening today to urban lakes in India whether natural or artificial, freshwater or saline, and what is likely to happen to them if present trends continue into the future.

INTRODUCTION

Humanity faces the challenge of developing a civilization fit for a finite planet and one equipped to deal with a mounting scarcity of essential resources such as freshwater. It is difficult to overstate the urgency of the problems confronting the world's lakes, which hold more than 90 percent of all the liquid freshwater on our planet's surface. Many of the world's most important lakes are in crisis, beset by a myriad of problems that affect the quantity and quality of the water they contain, the organisms they support, and their ability to meet the water needs of the surrounding human population. Following the world trend, Indian Lakes area also suffering from excessive water withdrawals and diversions, witnessing deteriorating water quality because of polluting human activities on the surrounding land as well as in catchment area of the lakes. In recent decades, problems originating even beyond the immediate lake basin-- notably acid rain (at least for the lakes in the urban area) and climate change-- have added additional burdens to already stressed lake ecosystems. Indian Lakes, which are a primary source and storehouse of the country's easily-accessible freshwater, has now become a critical arena in this great transition of Indian society which degrades and depletes its own natural foundation. Many of these Indian Lakes are already in jeopardy.

STATUS AND PROJECTED FUTUTRE FOR URBAN LAKES OF INDIA

Sr.	Name of the water body and its location	Present Morphometric details of the lake	Studies Undertaken	Projection for the future
LAKES OF WESTERN INDIA				
1.	PICHOLA LAKE in RAJASTHAN Situating in the heart of city of Udaipur at 5 Km from Udaipur City Railway Station at an altitude of 587 m above mean sea level. Man Made Fresh Water Lake. Constructed about 600 years ago.	Lake Area- About 3.0 Sq. Km Max. Depth- About 4.0 m Min Depth- Around 1.0 m. Present status of Pichola Lake is such that the lake gets completely dried up before onset of the monsoon.	Limnological studies by Sukhadia Univerist at Udaipur. National Institute of Hydrology, Roorkee, India has taken studies for detailed hydrological investigations of Pichola Lake and development of model for hydrological processes for the lake and its catchment.	The lake used to be 10.5 Sq. km in area, 8.0m in max. depth 5.0 m in min. depth The lake thus created has been filled by sediment deposits to its present level and ceased to function as a source of water resources. Future of this lake is quite bleak due to continued reducing input to the lake, domestic sewage and other source of pollution finding its way into the lake throughout the year.
LAKES OF NORTHERN INDIA				
2.	RENUKA LAKE IN HIMACHAL PRADESH Natural, high altitude fresh water lake in sub-tropical monsoon climate. A long, narrow, oblong shaped lake situated near the town of Solan in Himanchal Pradesh. The lake situated at an altitude of about 700 meter above mean sea level is high altitude fresh water lake in sub-tropical monsoon climate, flanked by two parallel steep hills running east-west.	Length - 1.5 Km Breath - 0.3 km Max Depth - 10 m. Mean Depth - 5.66 m Average annual rainfall in catchment area is about 1500 mm. Catchment area - 254.3 ha in hilly forested terrain. One fourth of the lake area is covered by marshes.	Limnological and ecological studies with special reference to its flora and fauna by Himachal Pradesh State Government.	Shrinking at fast pace. Maximum depth is presently 10 m. only which was up to 25 m. in the last decade. Fresh water fish habitat, used to be in abundance, is now decreasing. The lake is facing serious threat of extinction due to its shrinkage.
3.	DAL LAKE IN SRINAGAR Situating at an altitude of 1587	Lake area is about 1760 ha.	Limnological & ecological,	The lake has been extensively

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	<p>m above mean sea level in the flood plain of river Jhelum in eastern part of Srinagar city at the foot of Zabaravan mountains. It is a natural fresh water lake in arid cold climate. A small canal connects Dal Lake with the Anchor Lake and acts as an additional outflow channel.</p>	<p>Maximum depth is about 3.5 m. Shrinkage due to deposits of large quantities of silts being dumped into the lake by Telbal Nala. 80% of the inflow to the lake is supplied through the Telbal Nalla and 20% through direct precipitation.</p>	<p>studies have been carried out. Bathymetric survey was first introduced in 1976 in the lake study for Dal Lake. National Institute of Hydrology, Roorkee, India has conducted hydrological studies for the lake.</p>	<p>reclaimed to form man made islands separated by canals and areas of water covered by floating gardens. Total water spread area of the lake has shrunk to 12.4 sq. km from 23.4 sq. km in 118 years. The lake will shrink very fast due to heavy siltation and urbanization.</p>
4.	<p>MIRGUND LAKE IN JAMMU AND KASHMIR Situating at 15 km. north west of Srinagar between 34°08'E of latitude and 74°38'E of longitude at an elevation of 1580 m. above mean sea level on the flood plain of Jhelum. The climate of the lake area is warm, dry summer and cold & wet winter.</p>	<p>Highly eutrophic It is a shallow fresh water lake with reed beds. Present area of the lake basin is 300 ha and maximum depth of water in the lake is about 1.05 m.</p>	<p>Limnological and ecological studies have been undertaken by Jammu University.</p>	<p>Limnological and ecological studies have been undertaken for this lake. The study indicate that the lake is facing the problems of increasing siltation and eutrophication due to which the lake is bound to die.</p>
5.	<p>HOKARSAR LAKE IN JAMMU AND KASHMIR Situating at a distance of 10 km to the west of Srinagar at an altitude of 1580 m. above mean sea level, it is a fresh water lake. The lake is situated between 34° 05' N latitude and 74° 43' E longitude. Summer is warm & dry and winter is cold & wet.</p>	<p>It was once an ox-bow lake surrounded by fresh water marshes on the flood plain of Jhelum. Its a permanent eutrophic lake with very turbid water. Water spread area of the lake is 1300 ha. The maximum depth of water in the lake is 2.5 m.</p>	<p>Limnological and ecological studies have been undertaken by Jammu University.</p>	<p>Limnological studies have been conducted for this lake. The lake is suffering from heavy siltation.</p>
6.	<p>SHALLABUGH LAKE IN JAMMU AND KASHMIR Situating at 16 km. north west of Srinagar at an altitude of 1580 m. above mean sea level, it is a fresh water lake. The latitude is 34° 01' N and longitude is 74° 42' E.</p>	<p>Water spread area of the lake is 750 ha.</p>	<p>Limnological and ecological studies have been conducted for this lake.</p>	<p>The main threats to the lake are siltation, eutrophication and encroachment of the agricultural production.</p>

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7.	<p>NAINITAL LAKE IN UTTARANCHAL Situated in the heart of city of Nainital at an altitude of 1937 m. above mean sea level. It Is a fresh water lake. There is a submerged island running across center of the lake dividing it into two basins.</p>	<p>Lake area – 5.85 sq. km. The lake is surrounded by high hills. Deforestation of the surrounding hills is causing land slide due to which heavy load of boulders and sediment get dumped in the lake from time to time</p>	<p>National Institute of Hydrology, Roorkee, India has conducted studies on water balance, sedimentation, hydrodynamics, pollution aspects, thermal behaviour, and groundwater-lake interaction of Nainital Lake.</p>	<p>Lake capacity is reducing The areal extent of the lake is also reducing. Maximum depth of lake has reduced from 27.45 m in 1950 to about 24 m. in 1980. Life of the lake has been found to be around 200 years.</p>
8.	<p>SULTANPUR JHEELS IN HARYANA These are a group of shallow fresh water lakes having total area of 13,727 ha located at 15 km west of Gurgaon. The latitude and the longitude the lakes is 28°28' N and 76° 55' E respectively. The altitude of the lake varies from 220 - 230 m. The climate of the region is monsoon climate with very scanty rainfall. The lakes flood during monsoon and heavy rainfall. The siltation in the lakes is on the increasing scale.</p>	<p>The water body is eutrophic due to organic pollution and urban pollution. There is an excavation of sand from bed of the lake for lime industry. It was declared as Bird Sanctuary in 1971.</p>	<p>Water foul census had been carried out and abifauna has been well documented.</p>	<p>The siltation in the lakes is on the increasing scale. Planting of the salt tolerant species in surrounding area and restoration has been proposed to reduce erosion.</p>
LAKES OF SOUTHERN INDIA				
9.	<p>PULLICAT LAKE IN ANDHRA PRADESH AND TAMILNADU Situated at 45 Km north of Chennai. Natural lake in temperate humid climate</p>	<p>Lake Area - 72,000 ha (including swamps of 20,000 ha). 46,000 ha in Andhra Pradesh and 26,000 ha in Tamilnadu. About 60 Km long, 5 to 15 km wide. Average depth is about 2m</p>	<p>The lake is separated from the sea by a shoal or sediment bar. During monsoon season Pelar river and the shoal gets over flooded and lake and sea becomes one body.</p>	<p>Sedimentation from catchment area in Andhra Pradesh. as well as Tamil Nadu. is reducing the lake capacity</p>
10.	<p>LAL BAGH IN KARNATAKA Situated in the heart of City of</p>	<p>Presently water spread area of the lake is about 0.5 Sq. Km</p>	<p>Maysoore University has undertaken Ecological and</p>	<p>Lake area of about 2 Sq. Km in 1950 has reduced to about 0.5 Sq. Km as on date.</p>

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	Banglore. Manmade. Constructed in 1740 by Hyder Ali, King of Mysore	Maximum depth in the lake about 4 to 5 m. Sprawling colonies have come up in the fringe area of the lake.	biological studies.	Maximum depth of about 10 m. has reduced to 4 to 5 m. Due to encroachment by the developers, fish has disappeared. The lake is dying slow death.
11.	KRISHNARAJA SAGARA IN KARNATAKA Situating in the heart of city of Mysore, Krishnaraja Sagara is a man made fresh water lake in tropical monsoon climate. The lake was constructed during 1895-1940 by Krishnaraja Wodeyar IV, King of Mysore. The massive dam was conceived as a multi purpose project, for satisfying the water needs of the agricultural lands in Mandya, Mysore and ensuring power output of Sivasamudram project.	Famous Dusshera Mela is organized around the lake. Famous Brindavan Gardens were built by Krishnaraja Wodeyar IV, King of Mysore in 1932 when Sir Mirza Ismail was Dewan. Unique natural beauty of the lake and the garden on side of the lake. Different types of migratory birds visit the lake during different season of the year.	Maysore University has undertaken Ecological and biological studies.	The lake area of about 75 km ² . Maximum depth of water is approximately 100 m., and the mean depth of water in the lake is about 30m. Used for drinking, irrigation, recreation, fishing and power generation. The lake is epi-center of film shooting by Bombay, Madaras and Hyderabad film industries due to which its future is bright.
12.	Kollaru Lake in Andhra Pradesh Situating at 50 Km east of Vijawada at 0-5 m above mean sea level. Natural fresh water lake with associated marshes between Krishna and Godavari rivers in tropical monsoon climate.	109,000 ha at the time of maximum flooding. Maximum depth of the lake is around 3 m.	Ecological and biological studies have been undertaken.	Sedimentation in the lake is high. The lake bed is rising at 2.5 cm/year. Encroachment for agricultural is major threat to the lake. At the time of flooding in river Krishna and Godavari, sea water gets trapped in middle of the lake which makes the lake water saline.
13.	VEMBANAD LAKE IN KERALA Situating in the higher reaches of the coastal backwaters of Cochin at an altitude of 0-5 m above mean sea level. Natural fresh water lake which gets saline due to intrusion from sea	Lake area is about 8000 ha Maximum depth is about 4m.	Biological, limnological, and ecological studies have been undertaken for this lake.	The lake area was originally 70,000 ha which has now reduced to only 8,000 ha due to reclamation for agriculture. The future is bleak for this lake.

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14.	<p>POOKOT LAKE IN KERALA Situated in the Western Ghats, Pookot Lake is a natural fresh water body. Water spread area of the lake is about 7.5 ha. The slopes of the northern and eastern sides of the catchment are 80 and 56 m/km. The elongation and circulatory ratios are 0.4 and 0.2 respectively. The average annual rainfall in the catchment is 4433 mm and the number of rainy days is 140.</p>	<p>About 60% of the rainy days are in the southwest monsoon and 30% of the rainy days in the north east monsoon. Water spread area of the lake is about 7.5 ha. The catchment of the lake is 40 ha in area and is separated from adjoining catchment by a chain of hills rising to the order of 800 m above mean sea level.</p>	<p>Limnological and hydrological studies have been undertaken for this lake. Maximum flow is during southwest monsoon period. There after sudden reduction in flow is observed in September. The runoff coefficient reaches the maximum value during the month of August (ranging from 0.91 to 0.98).</p>	<p>Due to heavy rainfall in catchment area, there is no threat to the lake.</p>
LAKES IN CENTRAL INDIA				
15.	<p>UPPER BHOPAL LAKE IN MADHYA PRADESH Situated in the City of Bhopal at an altitude of 508 m. above mean sea level. 1100 Years old man made lake in semi arid climate. Annual average rainfall in catchment ara of the lake is 1100 mm. This is a wetland of International Importance, included in RAMASAR Convention.</p>	<p>Post monsoon lake area is about 36 Sq. Km. Pre monsoon lake area is about 18 Sq. km. Max. depth of the lake is about 10 m Min Depth of the lake is about 3 m.</p>	<p>Limnological and ecological studies National Institute of Hydrology, Roorkee, India has under taken study for water balance, sedimentation, thermal behaviour and water quality aspects of the lake.</p>	<p>Fast shrinking. It had vast area of 1800 Sq. Km spread up to Bhojpur at the time of construction 1100 years ago. Mughal emperors reclaimed most parts of the lake for agriculture by putting earthen dam at Kamla Park. Lake area of about 195 Sq. Km in 1671 has got reduced to just about 30 Sq. Km by the year 2000. In dry season the lake water surface area even reduces to 5 sq. km. Encroachment is for reclamation of land for agriculture, socio-economic activity, urban development, Major</p>

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				encroachment in the water surface area of the lake is by the State government for creating transport facilities for VIP, recreational activities etc.
16.	<p>CHANDPATTA LAKE IN MADHYA PRADESH</p> <p>Situated at 5 km. east of Shivpuri in Madhav National Park of Madhya Pradesh at an altitude of 450 m. above mean sea level, Chandpatta lake is a man made lake. The latitude and longitude of the lake is 25° 26' N and 77° 42'E respectively. The climate of the lake is dry tropical monsoon climate.</p>	<p>Home of wild animals.</p> <p>Water spread area of the lake is 200 ha and its maximum depth is 12 m.</p> <p>Water level in the lake fluctuates in dry and wet season by about 2 m.</p> <p>The lake supplies water for irrigation.</p>	<p>Ecological studies have been undertaken for this lake.</p>	<p>The lake is eutrophic due to organic pollution and sedimentation from the catchment area.</p> <p>The lake is facing dark future.</p>
17.	<p>SAGAR LAKE IN MADHYA PRADESH</p> <p>Situated in the heart of City of Sagar of Madhya Pradesh at an altitude of 517 m. above mean sea level, latitude of 23°50' N and longitude of 78°45' E, Sagar Lake is a man-made fresh water lake. The lake constructed in 1912, is divided into two parts, the main lake with water spread area of 107.7 ha at full tank level and the small lake with water spread area of 37.03 ha. The volume of the lake is 389 ha-m at full level. The mean depth of water in the lake is 2.48 m with maximum depth of 5.3 m at full tank level. The</p>	<p>There is high level of organic pollution in the lake. The lake is eutrophic.</p> <p>Fringe area of the lake has been encroached for urban development.</p> <p>The lake has a periphery of 5.23 km with maximum length of 1.247 km and width of 1.207 km. The water level drops in the summer season and the lakes</p>	<p>Biological and ecological studies have been conducted. National Institute of Hydrology, Roorkee (NIH) has conducted hydrological studies for water balance and sedimentation of the lake. NIH has also conducted studies for chemical analysis of</p>	<p>Till half a century ago the lake used to be a continuous source of water supply to the city of Sagar. Over the last decades the lake has shrunk to its present status due to heavy siltation in the due to deforestation in the near by area. Forest Department, Sagar, M.P. has estimated the total annual quantity of silt deposition to be 0.45 ha-m in which 55% is contributed from</p>

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	climate of the area is arid tropical climate.	may become totally dry in draught years. Catchment area of the lake is 1817 ha, out of which the total water spread area is 1435 ha, at full tank level.	lake water	the built-up free catchment area of 4.08 sq. mile and the rest is contributed from the built-up free catchment area of 3.22 sq. miles of the feeder Kanera Canal.
LAKES OF NORTH-EAST INDIA				
18.	LOKTAK LAKE IN MANIPUR Situating in the city of Imphal at an altitude of 770 m. above mean sea level . Natural lake in Tropical Monsoon Climate. There is a hydropower plant of 10 mw being operated by lake water	Lake area of the lake is about 26,000 ha. Max. depth of the lake is about 20 m. Min depth in some part of the lake is about 5 m.	Limnological studies by Manipur University. Preliminary field investigation for hydrological study by National Institute of Hydrology, Roorkee	Fast shrinking. Maximum depth of lake has reduced from 29 m. in 1950 to about 20 m. in 1980. Due to eutrophication and siltation, vast portion of the lake has been covered by thick algae locally called phumdi due to which power production from the lake is suffering.
19.	RUDRA SAGAR (LAKE) IN TRIPURA, INDIA Situating in the City of Agratala. Natural lake in humid tropical humid climate	Lake area is about 6 Sq. Km Water spread area of the lake has reduced to about 6 sq. km from 12 Sq. Km in 1950. Maximum depth of water has reduced to 6 m. from 20 m in 1950.	Limnological, ecological and biological studies have been undertaken for this lake by Tripura University.	Catchment area of the lake has been encroached by planners and developers. Input to the lake is monsoon runoff from the catchment area bringing debris from the urban land and sediment from agricultural field.
20.	DEEPAR BEEL IN ASSAM Situating at a distance of 10 km south west to Guwahati	Lake area is about 4000 ha. Depth at	Limnological and ecological studies have	Half of the lake dries in winter and the shore line is converted to

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	at an altitude of 53 m above mean sea level. Natural fresh water lake in tropical humid monsoon climate	maximum flooding is about 4 m which drops down to 1 m in dry season.	been undertaken for this lake. National Institute of Hydrology, Roorkee, India has undertaken for hydrological studies of this lake such as water balance, sedimentation etc.	rice fields. Due to this there is continuous encroachment by the farmers resulting in shrinkage of the lake. Forest to south of the lake are being felled due to which heavy sediment load is coming into the lake resulting in its shrinkage.
LAKES OF NORTH-WEST INDIA				
21.	LONAR LAKE IN MAHARASTRA Situating at 140 Km. from Aurangabad. Largest and oldest natural lake of meteor origin in the world in semi-arid climate. Around 50,000 years old.	Mean Depth of About 100 m., is left only to about 50 m due to bottom being of highly weathered trap	Limnological studies have been undertaken for this lake by Pune University.	Though, there is underground feeding of the lake, mean depth of about 100 m has reduced to about 50 m. due to continued siltation in the lake.

CONCLUSIONS

This paper presents a candid look at sordid affairs of urban lakes in India, whether natural or artificial, freshwater or saline, and what is likely to happen to them if present trends continue into the future. The Upper Bhopal Lake at Bhopal in Madhya Pradesh has shrunk from more than 100 sq. km. 500 years ago to about 19 sq. km. by the year 2002. Encroachment by the public as well as government agencies are rampant. If the present trend of encroachment and land use in the catchment continues, the Upper Bhopal Lake will meet its untimely death in just next 96 years, the magic figure arrived on the basis of sedimentation and water balance studies conducted for the Upper Bhopal lake. Pichola Lake at Udaipur in Rajasthan has completely dried up, though Pichola Lake used to be the main source of meeting water requirement of city of Udaipur and feeding source for other connected water bodies. This paper recognizes the critical state of many of these fragile, vulnerable, and often strikingly beautiful resources of India. It convinces people of the need to ensure healthy lakes as a primary source and storehouse of the easily-accessible water resources, as sources of food and economic livelihoods, utilizing them in a manner that maximizes their sustainable use, while also preserving their quality and ecosystem integrity for current and future generations.

REFERENCES

- Chow, V.T., (1964).** "Handbook of Applied Hydrology", McGraw Hill Publishing Company", New York. James H. Zumberge, section 23, Hydrology of Lakes and Swamps.
- Dooge, J., 1975,** "The water balance of bogs and fens", in Hydrology of marsh-ridden areas, Proc. Symp. Minsk, Intern. Assoc. Sci. Hydrol., UNESCO Press (Paris), pp. 207-271.
- Dwivedi, Vijay Kumar (1996),** "Status Report on Environmental Aspects of Lake Hydrology in India", UNDP Project Report No. IND/90/003 of National Institute of Hydrology, Roorkee, India.
- Ecology and pollution of Indian Lakes and Reservoirs, edited by P.C. Mishra and R.K. Trivedi.**
- Ground Water Survey Circle of Water Resources Department of Government of Madhya Pradesh, Bhopal, Report, 1978,** "Ground water observation in the wells in Bhopal District".
- McCaughey E. and Kalff, J. (1981),** "Empirical Relationships Between Phytoplankton and Zooplankton Biomass in Lakes", Canadian Journal of Fish & Aquatic Science, 38, pp. 458-463.
- NAEP, (1991),** "Nitrogen and Phosphorous in Fresh and Marine Waters", NPO-research report no. C. National Agency of Environment Protection, Danish Ministry of Environment.
- National Institute of Hydrology, Roorkee, India (1992),** "Hydrological Developments in India since Independence", A contribution to Hydrological Sciences.
- National Institute of Hydrology, Roorkee, India (2000),** Report No. TR/BR-12/1999-2000. "Water balance of Sagar Lake".
- Novitzki, R.P., 1978,** "Hydrologic characteristics of Wisconsin's lakes and their influence on floods, stream flow and sediment", in Lake functions and values: the state of our understanding, Proc. Nat. Symp. on Lakes, Am. Water Resour. Assoc./Nat. Lakes Tech. Coun., Lake Buena Vista, Florida, Nov 7-10, eds. Greason, P.E., Clark, J.R. & Clark, J.E., pp. 377-388.
- O'Brien, A.L., 1977,** "Hydrology of two small lake basins in eastern Massachusetts", Water Resour. Bull. 13(2), pp.325-340.
- OECD (1982),** "Eutrophication of Waters: Monitoring, Assessment and Control", OECD, Paris, pp. 210.
- UNESCO, 1974,** "Water balance of different lakes and reservoirs of the world".
- Winter, T.C., 1988,** "A conceptual framework for assessing cumulative impacts on the hydrology of nontidal lakes", Environ. Man. 12(5), pp. 605-620.
- Woo, M-K. & Valverde, J., 1981,** "Summer streamflow and water level in a mid-latitude forested swamp", Forest Sci. 27, pp. 177-189.