ENVIRONMENTAL AUDITING OF BANGALORE WETLANDS

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ENVIS Technical Report 72

January 2015

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Environmental Auditing of Bangalore Wetlands

I. Wetlands of Bangalore: Recommendations for conservation and sustainable management

[Note: Sections (Section I & II) are identical in our recent reports focusing on Bangalore lakes – ETR73, ETR93 and ETR95

- **ETR95**: Ramachandra T V, Vinay S and Bharath H.Aithal, 2015. Detrimental land use changes in Agara-Belllandur wetland, ENVIS Technical Report 95, CES, IISc, Bangalore, India
- **ETR93**: Ramachandra T V, Asulabha K S, Sincy V, Vinay S, Bharath H.Aithal, Sudarshan P. Bhat, and Durga M. Mahapatra, 2015. Pathetic status of wetlands in Bangalore: Epitome of inefficient and uncoordinated Governance, ENVIS Technical Report 93, CES, Indian Institute of Science, Bangalore 560012
- **ETR74:** Ramachandra T V, Asulabha K S, Sincy V, Vinay S, Sudarshan P. Bhat and Bharath H.Aithal, 2015. Sankey Lake: Waiting for an immediate sensible action, ENVIS Technical Report 74, CES, Indian Institute of Science, Bangalore 560012
- **ETR73:** Ramachandra T V, Asulabha K S, Sincy V, Vinay S, Sudarshan P. Bhat and Bharath H.Aithal, 2015. Sankey Lake: Waiting for an immediate sensible action, ENVIS Technical Report 74, CES, Indian Institute of Science, Bangalore 560012]

Wetlands (and lakes) constitute the most productive ecosystems with a wide array of goods and services. These ecosystems serve as life support systems; serve as habitat for a variety of organisms including migratory birds for food and shelter. They aid in bioremediation and hence aptly known as 'kidneys of the landscape'. Major services include flood control, wastewater treatment, arresting sediment load, drinking water, protein production, and more importantly recharging of aquifers apart from aiding as sinks and climate stabilizers. The wetlands provide a low cost way to treat the community's wastewater, while simultaneously functioning as wild fauna sanctuary, with public access. These ecosystems are valuable for education and scientific endeavours due to rich biodiversity.

Bangalore city (Karnataka State, India) has been experiencing unprecedented urbanisation and sprawl due to concentrated developmental activities in recent times with impetus on industrialisation for the economic development of the region. This concentrated growth has resulted in the increase in population and consequent pressure on infrastructure, natural resources and ultimately giving rise to a plethora of serious challenges such as climate change, enhanced green-house gases emissions, lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc. Temporal data analysis reveals that that there has been a growth of 925% in urban areas of Bangalore across four decades (1973 to 2013). Sharp decline in natural resources – 78% decline in trees and 79% decline in water bodies highlight unplanned urbanisation process in the city. Urban heat island phenomenon is evident from large number of localities with higher local temperatures. The city once enjoyed salubrious climate (about 14-16 °C during peak summer – May month in early 18th century), now has been experiencing higher temperatures (34 to 37° C) with altered micro climate and frequent flooding during rainy days. The study reveals the pattern of growth in Bangalore and its implication on local climate (an increase of ~2 to 2.5 ºC during the last decade) and also on the natural resources, necessitating appropriate strategies for the sustainable management of natural resources (water bodies, tree cover, etc.). The frequent flooding (since 2000, even during normal rainfall) in Bangalore is a consequence of the increase in impervious area with the high-density urban development in the catchment and loss of wetlands and vegetation.

Urban ecosystems are the consequence of the intrinsic nature of humans as social beings to live together (Ramachandra *et al.*, 2012; Ramachandra and Kumar, 2008). The process of urbanisation contributed by infrastructure initiatives, consequent population growth and migration results in the growth of villages into towns, towns into cities and cities into metros. Urbanisation and urban sprawl have posed serious challenges to the decision makers in the city planning and management process involving plethora of issues like infrastructure development, traffic congestion, and basic amenities (electricity, water, and sanitation), etc. (Kulkarni and Ramachandra, 2006). Apart from this, major implications of urbanisation are:

- **Loss of wetlands and green spaces:** Urbanisation (925% concretisation or paved surface increase) has telling influences on the natural resources such as decline in green spaces (78% decline in vegetation) including wetlands (79% decline) and / or depleting groundwater table. Quantification of number of trees in the region using remote sensing data with field census reveal 1.5 million trees and human population is 9.5 million, indicating one tree for seven persons in the city. This is insufficient even to sequester respiratory carbon (due to breathing which ranges from 540 -900 g per person per day).
- **Floods:** Conversion of wetlands to residential and commercial layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetative cover, reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000.
- **Decline in groundwater table:** Studies reveal the removal of wetlands has led to the decline in water table. Water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of lake with its catchment for commercial activities. In addition, groundwater table in intensely urbanized area such as Whitefield, etc. has now dropped to 400 to 500m.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water pervious surfaces, which reduce surface temperature through evapotranspiration.
- **Increased carbon footprint**: Due to the adoption of inappropriate building architecture, the consumption of electricity has increased in certain corporation wards drastically. The building design conducive to tropical climate would have reduced the dependence on electricity. Adoption of building architecture unsuitable for Bangalore

climate has contributed to higher electricity consumption and hence higher GHG (Greenhouse gases). Per capita electricity consumption in the zones dominated by high rise building with glass facades require 14000-17000 units (kWh) per year compared to the zones with eco-friendly buildings (1300-1500 units/person/year)Higher energy consumption, enhanced pollution levels due to the increase of private vehicles, traffic bottlenecks have contributed to carbon emissions significantly. Apart from these, mismanagement of solid and liquid wastes has aggravated the situation.

Unplanned urbanisation has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface runoff. Drainage systems are unable to cope with the increased volume of water, and are often blocked due to indiscriminate disposal of solid wastes. Encroachment of wetlands, floodplains, etc. obstructs flood-ways causing loss of natural flood storage.

THREATS FACED BY WETLANDS IN BANGALORE: The rapid development of urban sprawl has many potentially detrimental effects including the loss of valuable agricultural and eco-sensitive (e.g. wetlands, forests) lands, enhanced energy consumption and greenhouse gas emissions from increasing private vehicle use (Ramachandra and Shwetmala, 2009). Vegetation has decreased by 32% (during 1973 to 1992), 38% (1992 to 2002) and 63% (2002 to 2010).

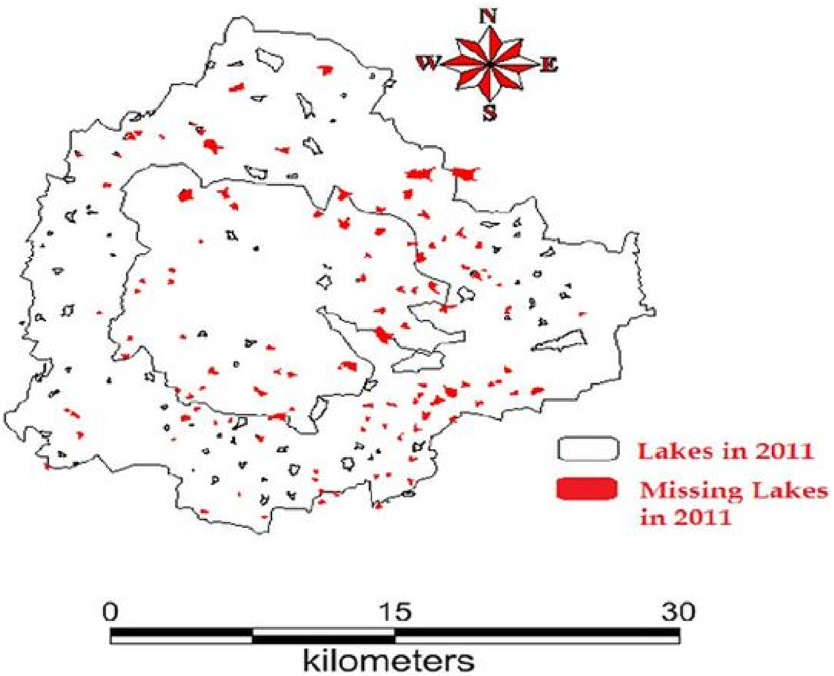

Figure 1: Lakes encroached by land mafia

Disappearance of water bodies or sharp decline in the number of water bodies in Bangalore is mainly due to intense urbanisation and urban sprawl. Many lakes (54%) were encroached for illegal buildings. Field survey of all lakes (in 2007) shows that nearly 66% of lakes are sewage fed, 14% surrounded by slums and 72% showed loss of catchment area. Also, lake catchments were used as dumping yards for either municipal solid waste or building debris (Ramachandra, 2009a; 2012a). The surrounding of these lakes have illegal constructions of buildings and most of the times, slum dwellers occupy the adjoining areas. At many sites, water is used for washing and household activities and even fishing was observed at one of these sites. Multi-storied buildings have come up on some lake beds that have totally intervene the natural catchment flow leading to sharp decline and deteriorating quality of water bodies. This is correlated with the increase in built up area from the concentrated growth model focusing on Bangalore, adopted by the state machinery, affecting severely open spaces and in particular water bodies. Some of the lakes have been restored by the city corporation and the concerned authorities in recent times. Threats faced by lakes and drainages of Bangalore:

1. Encroachment of lakebed, flood plains, and lake itself;
2. Encroachment of rajakaluves / storm water drains and loss of interconnectivity;
3. Lake reclamation for infrastructure activities;
4. Topography alterations in lake catchment;
5. Unauthorised dumping of municipal solid waste and building debris;
6. Sustained inflow of untreated or partially treated sewage and industrial effluents;
7. Removal of shoreline riparian vegetation;
8. Pollution due to enhanced vehicular traffic;
9. Too many para-state agencies and lack of co-ordination among them.
10. Different custodians for upstream and downstream lakes in the valley (Figure 2 and Table 1).

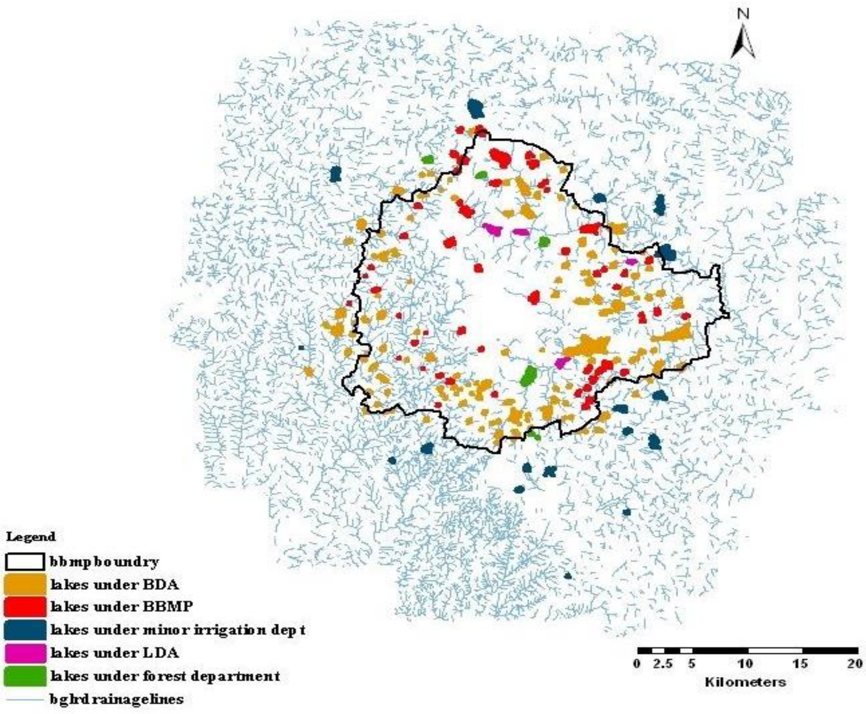

Figure 2: Spatial spread of lakes and custodians (too many – BBMP, BDA, LDA…. But too less effort to protect these lakes)

Table 1: Lakes with BBMP (A: Area in acres, G: Gunta, T: Total)

Sl.No	Name of the lake	Taluk	Hobli	Name of the village Survey No.	Extent (A-G) as per RTC
1	Agrahara Lake	B'lore North	Yelahanka	Agrahara -33	**15-34**
2	Allalasandra kere	B'lore North	Yalahanka	Allalsandra -15	**41-23**
3	Ambalipura Kelagina kere	B'lore East	Varthur	Ambalipura-40 & 41	3-0, 4-09 T-**7-09**
4	Amblipura Melinakere	B'lore East	Varthur	Ambalipura-36	**12-16**
5	Attur kere	B'lore North	Yalahanka	Attur kere-81 Ananthapura-92 Ramagondanahalli- 39 Kempanahalli-12	56-29 6-15 7-22 19-18 **T-90-04**
6	Avalahalli	B'lore North	Yalahanka	Avalahalli -10 & Singanayakanahalli 64	11-01 2-10 **T-13-11**
7	Bhimmana katte	B'lore South	Kengeri	Halagevaderahalli-138	1-23
8	Bayappanapalya Kunte (Munniyappana katte)	B'lore South	Uttarahalli	Vajarahalli -36	2-31
9	Challakere Lake	B'lore East	K.R. Puram	Challakere - 85	38-05
10	Chinnapanhalli kere	B'lore East	K.R. Puram	Chinnapanahalli 15 & 17	11-33 11-10
11	Chokkanahalli lake	B'lore North	Yelahanka	Chokkanahalli Sy-2	8-02
12	Dasarahalli kere (Chokkasandra)	B'lore North	Yeshwanthapura	Dasarahalli - 24 Chokkasandra - 5	3-29 24-04 **T-27-33**
13	Deepanjali kere	B'lore South	Kengeri	Devatige Ramanahalli-32	**7-22**
14	Devsandra kere	B'lore East	K.R. Puram	Devasandra 31	**16-08**
15	Doddabommasandra	B'lore North	Yelahanka	Dodda Bommasandra-56 Kodigehalli- 175 Thindlu - 53	39-10 49-21 35-28 **T-124-19**
16	Doddakanenahalli kere	B'lore East	Varthur	Doddakanenahalli - 109	**18-14**
17	Dore kere	B'lore South	Uttarahalli	Uttarahalli -22 Vasanthapura -06	19-11 '9-06 **T-28-17**
18	H Gollahalli Lake (Varahasandra Lake)	B'lore South	Kengeri	Kengeri Gollahalli-9 Varahasandra-9 Hemgepura-25	7-08 4-33 7-25 **T-19-26**
19	Halagevaderahalli Lake	B'lore South	Kengeri	Halagevaderahalli-1	**17-10**
20	Handrahalli	B'lore North	Yeshwanthapura	Handrahalli -8	**16-06**
21	Haraluru kere	B'lore East	Varthur	Haraluru-95	**34-70**
22	Herohalli	B'lore North	Yeshwanthapura	Herohalli-99	**34-33**
23	Harohalli lake	B'lore North	Yelahanka	Harohalli-91	**74-32**

24	Jogi kere	B'lore South	Uttarahalli	Mallasandra-30	**3-20**
25	J.P. Park (Mathikere)	B'lore North	Yeshwanthapura	Jalahalli-32 Mathikere-59 Thaniranahalli-01 Kasaba Yeshwanthpura-114	47-26 -- 20-39 -- **T-**
26	Kaikondanahalli kere	B'lore East	Varthuru	Kaikondanahalli -8 Kasavanahalli -70	18-18 30-05 **T-48-23**
27	Kalkere Agra kere	B'lore East	K.R. Puram & Bidarahalli	Kalkere-45 Kyalasanahalli-36 Beelisivale-101 & 106 Horamavu Agra-36	73-11 51-19 0-37 & 0-14 61-11 **T-187-12**
28	Kammagondanahalli	B'lore North	Yeshwanthapura	Kammagondanahalli-18 Shettyhalli-67 Myadarahalli (Medarahalli)-26	15-26 5-32 1-32 **T-23-10**
29	Kasavanhalli	B'lore East	Varthur	Kasavanahalli-50 Haralur-32	21-30 33-18 **T-56-08**
30	Kattiganahalli Kere-136	B'lore North	Jala	Kattiganahalli -136	**25-28**
31	Kattiganahalli Kere-31	B'lore North	Jala	Kattiganahalli -31	**20-10**
32	Kempambudhi Lake	B'lore North	B'lore	Kempambudhi-2	
33	Kodigehalli kere	B'lore North	Yeshwanthapura	Kodigehalli - 30	**9-25**
34	Kogilu Lake	B'lore North	Yelahanka Jala	Kogilu - 84 Kattigenahalli - 117	40-04 38-24 **T-78-28**
35	Koudenahalli kere	B'lore East	K.R. Puram	Koudenahalli -27	**55-05**
36	Kudlu Chikere	Anekal Taluk	Sarjapura	Koodlu-70	**13-05**
37	Kudlu doddakere	Anekal Talulk and B'lore South	Sarjapur & Begur	Koodlu-150 Parapanaagrahara-37	26-38 17-01 T-43-39
38	Kundalahalli Lake	B'lore East	K.R. Puram	Kundalahalli -05	30-20
39	Lingadiranahalli	B'lore North	Yeshwanthapura	Lingadiranahalli-2 & 4	5-32 4-08 **T-10-00**
40	Mahadevapura Lakde	B'lore East	K.R. Puram	Mahadevapura -7	26-23
41	Malgala kere	B'lore North	Yeshwanthapura	Malgala - 46	**6-26**
42	Munnekolalu kere	B'lore East	Varthur	Munnekolalu-25	**15-38**
43	Narasipura-20	B'lore North	Yelahanka	Narasipura-20	**15-30**
44	Narasipura-26	B'lore North	Yelahanka	Narasipura-26	**9-07**
45	Nayandanahalli kere	B'lore South	Kengeri	Nayadahalli -31	**15-18**
46	Parappana Agrahara	B'lore South	Beguru	Parappana Agrahara-23	**16-11**
47	Puttenahalli kere	B'lore South	Uttarahalli	Puttenahalli -42	**13-25**

48	Ramagondanahalli	B'lore North	Yelahanka	Ramagondanahalli-52	**36-26**
49	Sankey Tank	B'lore North	Vyalikaval	Vyalikaval - 21	35-00
50	Shilavantana kere	B'lore East	K.R. Puram	Whitefeild-41	19-32
51	Sigehalli	B'lore East	K.R Puram	Sigehalli-32	31-13
52	Singasandra Lake	B'lore South	Begur	Basapura-15 Singasandra -52	9-34 1-08 **T-11-02**
53	Sowl kere	B'lore East	Varthur	Bellandur-65 Doddakanelli-68 Kaigondanahalli-36	23-33 7-28 30-16 **T-61-37**
54	Thirumenahalli	B'lore North	Yelahanka	Thirumenahalli-63	7-10
55	Ulsoor	B'lore North	B'lore	Ulsoor	
56	Uttarahalli kere (Mogekere)	B'lore South	Uttarahalli	Uttarahalli -111	**15-16**
57	Veerasagara lake	B'lore North	Yelahanka	Veerasagara-26 Attur-25	'17-24 3-30 **T-21-14**
58	Vijanapura kere	B'lore East	K.R. Puram	Kowdenahalli -85 Krishnarajpura-97	11-28 2-07 **T-13-35**
59	Yediyur Lake	B'lore South	Utharahalli	Dasarahalli -01 Yediyur -59	No extent
60	Yelahanka kere (Kasaba Amanikere)	B'lore North	Yelahanka	Yelahanka-29 Kenchenahalli -15 Venkatala-39 Manchenahalli-19 Puttenahalli-49	53-36 30-23 199-31 7-34 18-04 **T-310-08**

Lakes with BDA

Sl. No.	**Name of the Lake**	**Taluk**	**Hobli**	**Name of the village Sy No.**	**Extent (A-G) as per RTC**
1	Abbigere kere	B'lore North	Yeshwanthpur	Abbigere-75 Singapura-95	26-06 21-7 **T-47-13**
2	Alahalli kere / Anjanapura	B'lore South	Uttarahalli	Allahalli -30 Gollahalli-3	15-35 5-30 **T-21-25**
3	Amruthalli kere	B'lore North	Yelahanka	Amruthalli-115	**24-36**
4	Annappahalli/ Yelachenahalli Lake	B'lore South	Uttarahalli	Yelachenahalli-06, Govinayakanahalli-14	4-39 1-33 **T-6-32**
5	Arakere	B'lore South	Beguru	Arakere-34	**37-21**
6	Avalahalli	B'lore North	Yelahanaka	Avalahalli-10 Shiganayakanahalli-64	11-01 2-10 **T-13-11**

7	B.Narayanapura	B'lore East	K.R. Puram	B.Narayanapura-109	15-06
8	Baiyappanahalli kere	B'lore East	K.R. Puram	Baiyappanahalli-61	8-09
9	Basapura Lake-2	B'lore South	Beguru	Basapura-66	10-29
10	Basavanapura Lake	B'lore South	Beguru	Basavanapura-14	**7-34**
11	Begur Lake	Bl'lore South	Begur	Begur-94	**137-24**
12	Bellahalli	B'lore North	Yelahanka	Bellahalli-68	**18-32**
13	Bellandur	B'lore East	Varthur	Yamaluru-62 Amanikere Bellandur Kahne-1 Ibbalur-12 Kempapura-6 Beluru-2	3-04 284-20 399-14 13-15 2-00 **T-700-13**
14	Beratena Agrahara Lake (Chowdeshwari Layout	B'lore South	Begur	Beratena Agrahara (Chowdeshwari)-18	**11-18**
15	Bhattralli kere	B'lore East	Bidarahalli	Bhattralli-2	**18-10**
16	Bheemanakuppe	B'lore South	Kengeri	Bheemanakuppe-180	75-15
17	Bhoganalli kere	B'lore East	Varthur	Bhoganalli-21	12-24
18	Byrasandra	B'lore South	Utharahalli	Byrasandra-56	15-11
19	Byrasandra kere (Chikkepet) (Melinakere)	B'lore East	K.R. Puram	Byrasandra-109	14-19
20	Chennasandra-2	B'lore East	K.R. Puram	Banasawadi-211	47-38
21	Chikka Banavara	B'lore North	Yeshwanthpur	Chikka Banavara-3, Somashettyhalli-73, Kere gullada halli-22 and Ganigarahalli-11,15	67-38 3-21 26-32 4-14 2-30 **T-105-15**
22	Chikka Bellandur kere	B'lore East	Varthur	Chikka Bellandur-9 Mullur -63	67-14 8-07 **T-75-21**
23	Chikkabasavanapura kere	B'lore East	K.R. Puram	Basavanapura-14	14-07
24	Chikkabasthi	B'lore South	Kengeri	Ramasandra-6	7-06
25	Chikkabettahalli	B'lore North	Yelahanka	Chikkabettahalli-52	1-32
26	Chick begur Lake	B'lore South	Begur	Begur-168, Singanadra-86	32-19 9-37 **T-42-16**
27	Chikkammanahalli Lake	B'lore South	Begur	Kammanahalli -22 Vamadevanahalli-	5-19
28	Chikkegowdana palya Lake	B'lore South	Kengeri	Hemmagepura-92	
29	Chunchanaghatta	B'lore South	Utharahalli	Chunchanaghatta-70, 70/2, 70/3	20-31 1-0 1-0 **T-22-31**

30	Chowdeshwari Layout Lake	B'lore South	Begur		
31	Devarakere Lake	B'lore South	Uttarahalli	Bikasipura-9	7-15
32	Doddabidarakallu	B'lore North	Yeshwanthpur	Doddabidarakallu-125 Nagasandra -06	23-21 16-36 **T-40-17**
33	Doddakallasandra	B'lore South	Uttarahalli	Doddakallasandra-27	**21-16**
34	Doddanakundi	B'lore East	K.R. Puram (village map) Varthur (In RTC-Bhoomi)	Doddanekundi -200 Kaggadasapura - 25 Vibhutipura -13	56-39 75-16 3-15 **T-135-30**
35	Dubasipalya Lake	B'lore South	Kengeri	Valagerehalli-43, 43/P1	23-35 1-0 **T-24-35**
36	Gangasetty kere (Diesel shed kere (Gangadhariahnakere) (Dyavasandrakunte kere)	B'lore East	K.R. Puram	KR Pura-58 Devasandra-46	18-32 2-35 **T-21-27**
37	Gandhinagara Lake	B'lore North			
38	Garudachar Palya Kere -1 (Achanakere)	B'lore East	K.R. Puram	Mahadevapura-31	**5-36**
39	Garudachar Palya Kere -2 (Goshala) Yekkalagatta kere	B'lore East	K.R. Puram	Mahadevapura-86	**5-14**
40	Garvebhavi Palya	B'lore South	Begur	Hongasandra -41	**18-04**
41	Gattigere palya Lake	B'lore South	Kengeri	Somapura-27/53	0-37
42	Gottigere Lake	B'lore South	Uttarahalli	Gottigere-71	**37-13**
43	Gowdana Palya Lake	B'lore South	Uttarahalli	Kadirenahalli-33	**9-30**
44	Gubbalala	B'lore South	Uttarahalli	Gubbalala-25 Vajarahalli-	**8-10**
45	Gunjur Kere (Carmelarm)	B'lore East	Varthur	Gunjur-95	**9-17**
46	Gunjur Mouji kere	B'lore East	Varthur	Gunjur-301, Kachamaranhalli-74	59-13 4-26 **T- 63-39**
47	Gunjur Palya kere	B'lore East	Varthur	Gunjur-83	**36-27**
48	Haralakunte Lake (Somasandrakere)	B'lore South	Begur	Haralakunte-51	**16-29**
49	Hoodi kere (GIDDANA KERE)	B'lore East	K.R. Puram	Hoodi-138	**28-31**
50	Hoodi kere -1	B'lore East	K.R. Puram	Hoodi-79	**15-10**
51	Horamavu Agara	B'lore East	K.R. Puram	Horamavu Agra-77	**51-34**
52	Horamavu kere	B'lore East	K.R. Puram	Horamavu-83	**37-14**
53	Hosakerehalli	B'lore South	Uttarahalli	Hosakerehalli-15	**59-26**
54	Hosakere	B'lore South			
55	Hulimavu	B'lore South	Beguru	Hulimavu-42 Kammanahalli -110	124-25 5-32 **130-17**
56	Ibbalur Lake	B'lore South	Beguru	Ibbalur-36	18-06

57	Jakkur & Sampigehalli	B'lore North	Yelahanka	Jakkur-15, 23 Yalahanka Amanikere-55 Sampigehalli-12 Agrahara-13	39-21,36-33 58-16 19-25 3-17 **T-157-32**
58	Jaraganahalli/Sarakki/Puttenahalli Lake	B'lore South	Uttarahalli	Jaraganahalli-7 Sarrakki-26 Puttenahalli - 5 Kothanuru-103 Chunchaghatta-28	38-14 38-0 6-10 11-21 13-07 **T-107-12**
59	Jimkenalli kere	B'lore East	Bidarahalli	Varanasi-47	**8-24**
60	Junnsandra kere	B'lore East	Varthur	Junnasandra-32	**24-33**
61	Kadirenapalya kere	B'lore East	KR Puram	Binnamangala-99	
62	K R Puram (BEML) Bendiganahalli kere	B'lore East	K.R. Puram	Benniganahalli-47 & 55	18-24, 27-14 **T- 45-39**
63	Kaggadasanapura	B'lore East	K.R. Puram (village map) Varthur (In RTC-Bhoomi)	Byrasandra -5 Kaggadasapura-141 Bendiganahalli - 24/3	14-24 32-16 3-26 **T-51-26**
64	Kalena Agrahara Lake	B'lore South	Begur	Kalena Agrahara-43	**7-30**
65	Kalkere Rampura kere	Anekal Taluk (B'lore East)	Jigani Bidarahalli	Kalkere-162 Rampura-22 Maragondanahalli-71 Huvineane-86	64-25 3-04 11-35 108-07 **T-187-31**
66	Kalyani / Kunte (Next to Sai Baba Temple)	B'lore South	Uttarahalli	Vasanthpura-21	**1-33**
67	Kannenahalli	B'lore North (Bng South)	Kengeri Yeshwanthpur		
68	Kelagina kere / Byrasandra	B'lore East	K.R. Puram	Byrasandra-112	**12-21**
69	Kembatha halli	B'lore South	Uttarahalli	Kembathahalli-3 Kathnuru-32/3	5-16 1-33 **T-7-20**
70	Kenchanapura	B'lore South	Kengeri	Kenchanapura-10	**17-20**
71	Kengeri Lake	B'lore South	Kengeri	Kengeri-15, Valagerehalli-85	27-03 5-13 **T-32-16**
72	Kommaghatta	B'lore South	Kengeri	Komaghatta-03 Ramasandra-46	9-04 28-01 **T-37-05**
73	Konankunte	B'lore South	Uttarahalli	Konanakunte - 2	**09-18**

74	Konasandra	Anekal Taluk	Jigani	Dyavasandra-9 Bommandahalli-18 Konasandra-17	21-13 7-39 3-20 **T-32-32**
75	Konnappana agrahara	B'lore South	Begur	Naganathpura (South)81	**5-17**
76	Kothnur	B'lore South	Utharahalli	Kothnur-54	**18-09**
77	Lakshmipura lake	B'lore North	Yeshwanthpur	Lakshmipura-25	**10-06**
78	Lingadheeranahalli	B'lore South	Kengeri	Lingadheeranahalli-13	**5-22**
79	Madavara	B'lore North	Dasanapura Yeshwanthpur	Madavara -48 Chikkabidarakallu-21 Tirumalapura-32 (from Yeshwanthpura hobli) Doddabidarakallu -98 (From Yeshwanthpura hobli	35-31 20-20 8-36 2-39 **T-68-06**
80	Mahadevapura (Bandemahadevpura kere)	B'lore East	K.R. Puram	Mahadevapura-187	**13-11**
81	Mallasandra Gudde lake	B'lore North	Dasanapura	Mallasandra-49, Mallasandra-50	11-28 5-23 **T-17-11**
82	Mallathahalli	B'lore North	Yeshwanthpur	Mallathahalli-101 Giddadakonenahalli-6	50-38 20-08 **T-71-06**
83	Manganahalli	B'lore North	Yeshwanthpur	Manganahalli - 43	**6-22**
84	Medi Agrahara	B'lore North	Yelahanka	Medi Agrahara-33	**13-15**
85	Meenakshi Kere	B'lore South	Begur	Kammanahalli (Meenakshi)-38	**18-37**
86	Mesthripalya Lake	B'lore South	Begur	Jakkasandra- 30	11-21
87	Nagarabhavi	B'lore North (Bng South)	Yeshwanthpur	Nagarabhavi-17	**17-39**
88	Nagareshwara-Nagenahalli Lake	B'lore East	K.R. Puram	Nagareshwara-Nagenahalli -10	11-08
89	Nellagaderanahalli	B'lore North	Yeshwanthpur	Nallagaderanahalli - 62	19-22
90	Nalluralli tank	B'lore East	K.R. Puram	Nalluralli-4 Pantandur Agrahara-85	20-34 27-05 **T-47-39**

91	Narasappanahalli	B'lore North	Yeshwanthpur	Karivabanahalli-40 Nelagadiranahalli - 90 Nelagadiranahalli -89 Doddabidarakallu - 24	27-13 19-05 5-26 1-20 **T-53-24**
92	Nyanappanahalli Lake	B'lore South	Begur	Begur-344	**6-07**
93	Panathur kere -38	B'lore East	Varthur	Panathur - 38	**27-17**
94	Panathur kere -48	B'lore East	Varthur	Panathur - 48	**6-30**
95	Pattandur Agrahara	B'lore East	K.R. Puram	Pattandur Agrahara-124	**16-35**
96	Pattandur Agrahara	B'lore East	K.R. Puram	Pattandur Agrahara-54	12-37
97	Pattanagere Kenchenhalli	B'lore South		Kenchenahalli-33 Pattanagere-43	3-39 0-31 **T-4-30**
98	Rachenahalli	B'lore North B'lore East	Yelahanka K.R Puram	Dasarahalli-61 (Bng East- KR Puram) Jakkur - 82 (Bng North-Yelahanka) Rachenahalli - 69 (Bng East-KR Puram)	73-23 39-07 18-16 **T-131-06**
99	Ramsandra (Hirekere)	B'lore South B'lore North	Kengeri Yeshwanthpur	Ramasandra-159 Kenchanpura-36/* Kenchenapura - 36/¥ÉÊQ Kannahalli-37 (Bng north-Yeshwanthpura)	66-20 56-05 5-0 12-29 **T-140-14**
100	Sadaramangala kere	B'lore East	K.R. Puram	Sadaramangala-61, Kodigehalli-8	51-04 1-17 **T-52-21**
101	Shivanahalli	B'lore North	Yelahanka	shivanahalli-48 Allalasandra-38, 48	14-30 3-22 0-27 **T-18-39**
102	Siddapura kere	B'lore East	Varthur	Siddapura -18	**27-38**
103	Singapura Kere	B'lore North	Yelahanka	Singapura-102	**66-18**
104	Singasandra	B'lore South	Beguru	Singasandra -99, 100	10-14 0-34 **T-11-08**
105	Sitaram Palya	B'lore East	K R Puram	Sonnenahalli (Seetharmapalya)-33	**23-37**
106	Sompura	B'lore South	Kengeri	Sompura - 11	17-38

107	Srigandadakaval (near Rajivgandhi nagar)	B'lore North	Yeshwanthpur	Srigandakavalu-15	**6-33**
108	Srinivasapura Kere	B'lore North	Yelahanaka	Srinivasapura-2	**3-14**
109	Subbarayanakere	B'lore South	Uttarahalli	Gottigere-12	**5-10**
110	Subedeharanakere	B'lore South	Begur	Begur-48	**6-05**
111	Subramanyapura Lake	B'lore South	Uttarahalli	Uttarahalli-64	**18-06**
112	Sulekere (Soolikere)	B'lore South	Kengeri	Maragondanahalli Krishnasagara	
113	Swarnakunte gudda kere	B'lore South	Begur	Chandrashekarpura-1	**09-05**
114	Talaghattapura (Gowdarakere)	B'lore South	Uttarahalli	Talaghattapura -73	**19-16**
115	Ullal	B'lore North	Yeshwanthpur	Ullal-93	**24-12**
116	Vaderahalli	B'lore North	Yelahanka	Vaderahalli-32	**9-34**
117	Varahasandra Lake	B'lore South	Kengeri	Hemigepura-4, Varahasandra-24	4-11 13-09 **T-17-20**
118	Varthur	B'lore East	Varthur	Varthur-319	**445-14**
119	Vasanthapura (Janardhanakere)	B'lore South	Utharahalli	Vasanthpura-28	**7-10**
120	Venkateshpura	B'lore North	Yelahanka	Ventateshpura-12 Sampigehalli-37	6-35 11-29 **T-18-24**
121	Vibhuthipura kere	B'lore East	Varthur	Vibhuthipura-175	**45-18**
122	Vishwa nidam lake	B'lore North	Yeshwanthpur	Herohalli-50	**4-30**
123	Yellenhalli Lake (Elenahalli)	B'lore South	Begur	Yellenhalli-55	**4-39**

Lakes under Lake Development Authority (LDA)

Sl.No	Name of the Lake	Taluk	Hobli	Name of the village Sy No.	Extent (A-G) as per RTC
1	Agaram Lake	B'lore South	Kengeri	Agara-11 Venkojiraokhane-11	5-39 136-30 **T-142-29**
2	Hebbal Lake	B'lore North	Kasaba	Hebbla-38 Kodigehalli-37	92-26 99-33 **T-192-19**
3	Nagavara Lake	B'lore North	Kasaba	Nagawara-58 Vishwanatanagenahalli - 12,13	56-17 12-35 6-01 **T-75-13**
4	Vengaiahnakere	B'lore East	K.R. Puram	Krishnarajapura-9 Sannathammanahalli-46	38-12 26-23 **T-64-35**

Lakes - Karnataka Forest Department

Sl.No	Name of the Lake	Taluk	Hobli	Name of the village Sy No.	Extent (A-G) as per RTC

1	Hennur (K.R.Puram Range)	B'lore North	Kasaba	Hennur - 53 Nagawara - 13	58-30 14-11 **T-73-01**
2	J.B.Kaval Tank (Bangalore Range)	B'lore North	Yelahanka	Jyarakabande Kavalu-P1-36	44-21 2-04
3	Madiwala (K.R.Puram Range)	B'lore South	Begur	Madivala- 7 Kodichikkanahalli-23 Belekannahalli-64 Rupena Agrahara-11	166-39 80-09 21-35 6-10 T-275-13
4	Mylsandra (Kaggalipura Range) Gumaiahanakere (Mylasandra 1) Mylasandra 2	B'lore South	Kengeri	Mylasandra-37 Kasaba Kengeri-58 Mylasandra - 27 Kasaba Kengeri-66	6-24 6-02 **T-12-26** 10-14 5-28 **T-16-02**
5	Puttenahalli (Yelahanka Range)	B'lore North	Yelahanka	Puttenehalli - 36 Attur - 49	29-14 7-26 **T-37-00**

Lakes - Minor Irrigation Department

Sl.No	**Name of the Lake**	**Taluk**	**Hobli**	**Name of the village Sy No.**	**Extent (A-G) as per RTC**
1	Agara kere	Bangalore South	Kengeri	Agara - 103 Agara -102 Agara - 104	13-11 0-08 0-06 **T-13-25**
2	Alluru kere	Bangalore North	Dasanapura	Aluru-132 Vaderahalli - 8 Mathahalli - 25 Narasipura - 41	39-38 27-23 5-32 1-21 **T-75-34**
3	Bhimanakuppe kere	Bangalore South	Kengeri	Bheemanakuppe-180	75-15
4	Bidara Amanikere	Anekal			
5	Bidarahalli kere	Bangalore East	Bidrahalli	Bidarahalli-8 Byappanahalli - 21	15-10 81-16 **T-96-26**
6	Chikkanahalli	Bangalore East			
7	Doddagubbi kere	Bangalore East	Bidarahalli	Doddagubbi-38 NadagowdaGollahalli-39 Chikkagubbi-9	105-18 16-37 1-32 **T-124-07**
8	Ghattahalli Bommankere	Anekal	Sarjapura	Gattahalli-62 Rayasandra - 33	51-17 21-22 **T-72-39**
9	Hoskuru kere (Huskur Lake)	Anekal	Sarjapura	Huskur - 163 Harohalli - 51 Avalahalli - 50	91-10 23-0 --- T-114-10

10	Hulimangala Doddakere	Anekal	Jigani	Hulimangala - 22	67-07
11	Kodatikere	Bangalore East	Varthru	Kodati-8 Solikunte - 52	40-32 37-09 T-78-01
12	Margondanahalli kere	Bangalore South	Kengeri	Margondanahalli -45	5-33
13	Rampura kere	Bangalore East			
14	Sakalavara Bujangadasana kere	Anekal	Jigani	Sakalavara - 93	23-34
15	Singanayakana halli kere	Bangalore North			
16	Singena Agrahara kere	Anekal	Sarjapura	Singena Agrahara-94 Narayanaghatta - 128 Gottammanahalli - 13	95-39 19-32 8-04 **T-123-35**
17	Vaderahalli kere	Bangalore South	Kengeri	B.M.Kaval P1 -136	21-07
18	Yellemallappa Shetty kere	Bangalore East	K.R. Puram	Avalahalli -57 Avalahalli -12 Heerandahalli - 95 Heerandahalli -96 Kurudu Sonnenahalli -2 Medahalli -63 Veerenahalli -29	13-26 17-26 170-16 33-24 31-2 91-35 132-06 **T-490-15**

Source: https://www.karnataka.gov.in/ldakarnataka/documents/Listof-210Lake-BDA,BBMP,LDA, KFD, MILIst.xlsx

The anthropogenic activities particularly, indiscriminate disposal of industrial effluents and sewage wastes, dumping of building debris have altered the physical, chemical as well as biological integrity of the ecosystem. This has resulted in the ecological degradation, which is evident from the current ecosystem valuation of wetlands. Global valuation of coastal wetland ecosystem shows a total of 14,785/ha US$ annual economic value. Valuation of relatively pristine wetland in Bangalore shows the value of Rs. 10,435/ha/day while the polluted wetland shows the value of Rs.20/ha/day (Ramachandra et al., 2005). In contrast to this, Varthur, a sewage fed wetland has a value of Rs.118.9/ha/day (Ramachandra et al., 2011). The pollutants and subsequent contamination of the wetland has telling effects such as disappearance of native species, dominance of invasive exotic species (such as African catfish, water hyacinth, etc.), in addition to profuse breeding of disease vectors and pathogens. Water quality analyses revealed of high phosphates (4.22-5.76 ppm) levels in addition to the enhanced BOD (119-140 ppm) and decreased DO (0-1.06 ppm). The amplified decline of ecosystem goods and services with degradation of water quality necessitates the implementation of sustainable management strategies to recover the lost wetland benefits.

CONSERVATION AND MANAGEMENT OF WETLANDS:

In recent years, there has been concern over the continuous degradation of wetlands due to unplanned developmental activities (Ramachandra, 2002)**.** Urban wetlands are seriously threatened by encroachment of drainage through landfilling, pollution (due to discharge of domestic and industrial effluents, solid wastes dumping), hydrological alterations (water withdrawal and inflow changes), and over-exploitation of their natural resources. This results in loss of biodiversity of the wetland and loss of goods and services provided by wetlands (Ramachandra, 2009). The mitigation of frequent floods and the associated loss of human life and properties entail the restoration of interconnectivity among wetlands, restoration of wetlands (removal of encroachments), conservation and sustainable management of wetlands (Ramachandra et al., 2012).

Status	Contaminated water, sediment and air
Cause	1. Encroachment of lakebed, flood plains, and lake itself; 2. Loss in lake interconnectivity - Encroachment of rajakaluves / storm water drains and loss of interconnectivity; 3. Lake reclamation for infrastructure activities; 4. Topography alterations in lake catchment; 5. Unauthorised dumping of municipal solid waste and building debris; 6. Sustained inflow of untreated or partially treated sewage and industrial effluents; 7. Removal of shoreline riparian vegetation; and unabated construction activities in the valley zone has threatened these urban wetlands. 8. Pollution due to enhanced vehicular traffic; 9. Too many para-state agencies and lack of co-ordination among them. 10. Too many para-state agencies and too less governance
Solution	❖ De-congest Bangalore: Urbansiation has surpassed the threshold evident from 925% increase in urban area (concrete area/paved area) in four decades with the loss of vegetation (78%) and water bodies (79%) ❖ Good governance (too many para-state agencies and lack of co-ordination) ❖ Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance and action against polluters (encroachers as well as those contaminate through untreated sewage and effluents, dumping of solid wastes) ❖ Digitation of land records (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query based information system to public. ❖ Removal of all encroachments (without any mercy) near to lakes after the survey based on reliable cadastral maps; ❖ Effective judicial system for speedy disposal of conflicts related to encroachment; ❖ Restriction of the entry of untreated sewage into lakes; ❖ To make land grabbing cognizable non-bail offence; ❖ Letting off only treated sewage into the lake (as in jakkur lake model); ❖ Regular removal of macrophytes in the lakes; ❖ Implementation of 'polluter pays' principle as per water act 1974; ❖ Plant native species of macrophytes in open spaces of lake catchment

	area; ❖ Stop solid wastes dumping into lakes; removal of contaminated silt ❖ Ensure proper fencing of lakes ❖ Restrictions on the diversion of lake for any other purposes; ❖ Complete ban on construction activities in the valley zones.
The restoration and conservation strategies has to be implemented for maintaining the ecological health of aquatic ecosystems, aquatic biodiversity in the region, inter-connectivity among lakes, preserve its physical integrity (shorelines, banks and bottom configurations) and water quality to support healthy riparian, aquatic and wetland ecosystems. The regular monitoring of water bodies and public awareness will help in developing appropriate conservation and management strategies.	

Despite good environmental legislations, loss of ecologically sensitive wetlands is due to the uncoordinated pattern of urban growth happening in Bangalore. Principal reason is lack of good governance and decentralized administration evident from lack of coordination among many Para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for:

- **Restoring and conserving the actual source of water -** the water cycle and the natural ecosystems that support it - are the basis for sustainable water management
- **Reducing the environmental degradation that is preventing us from reaching goals** of good public health, food security, and better livelihoods world-wide
- **Improving the human quality of life** that can be achieved in ways while maintaining and enhancing environmental quality
- **Reducing greenhouse gases to avoid the deleterious effects of climate change** is an integral part of protecting freshwater resources and ecosystems.
- **Maintaining intergeneration Equity**

A comprehensive approach to water resource management is needed to address the myriad water quality problems that exist today from non-point and point sources as well as from catchment degradation. Watershed-based planning and resource management is a strategy for more effective protection and restoration of aquatic ecosystems and for protection of human health. The watershed approach emphasizes all aspects of water quality, including chemical water quality (e.g., toxins and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., stream channel morphology, substrate composition, riparian zone characteristics, catchment land cover), and biological health and biodiversity (e.g., species abundance, diversity, and range). The suggestions to implement in lakes in order to maintain its healthy ecosystem include:

❖ **Good governance** (too many para-state agencies and lack of co-ordination) - Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance) and action against polluters (encroachers as well as those let untreated sewage and effluents, dumping of solid wastes).

- ❖ **De-congest Bangalore**: Growth in Bangalore has surpassed the threshold evident from stress on supportive capacity (insufficient water, clean air and water, electricity, traffic bottlenecks, etc.) and assimilative capacity (polluted water and sediments in water bodies, enhanced GHG – Greenhouse gases, etc.). No new projects shall be sanctioned and the emphasis would be on increasing green cover and restoration of lakes.
- ❖ **Disband BDA** – creation of Bangalore Development Agency has given impetus to inefficient governance evident from Bangalore, the garden city turning into 'dead city' during the functional life of BDA.
- ❖ **Digitation of land records** (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query option (Spatial Decision Support System) to public.
- ❖ **Comprehensive development plan (CDP) for the city** has to be developed through consultative process involving all stakeholders and should not be outsourced to outside agencies / consultants (from other countries).
- ❖ **Removal of encroachment** near to lakes after the survey based on reliable cadastral maps;
- ❖ Remove all encroachments (without any mercy) of wetlands, lakes, rajjakaluves (storm water drain) – encroachers have violated all humanitarian norms and deprived large section of the society of ecological services (provided by wetlands)
- ❖ Effective judicial system for speedy disposal of conflicts related to encroachment;
- ❖ Apply principles of 'polluter pays' principle to agencies responsible for contamination of Bangalore surface and ground water (Agency: BWSSB, industries);
- ❖ Action against regulatory agency (KSPCB) for dereliction of statutory duties and other responsibilities by allowing sustained contamination of water, land and air;
- ❖ Restriction of the entry of untreated sewage and industrial effluents into lakes;
- ❖ To make land grabbing cognizable non-bailable offence;
- ❖ Letting off only treated sewage into the lake through constructed wetlands and shallow algae ponds (as in Jakkur lake);
- ❖ Regular removal of macrophytes in the lakes;
- ❖ Implementation of 'polluter pays' principle as per water act 1974;
- ❖ Plant native species of macrophytes in open spaces of lake catchment area;
- ❖ Stop solid wastes (municipal and demolition debris) dumping into lakes; treatment and management of solid waste shall be as per MSW Rules 2000, GoI.
- ❖ Ensure proper fencing of lakes
- ❖ Restrictions on the diversion of lake for any other purposes - Lakes and wetlands provide ecological services (depending on the catchment integrity, duration may vary) – there are no dead lakes or wetlands
- ❖ Complete ban on construction activities in the valley zones;
- ❖ Monitoring of lakes through network of schools and colleges;

- ❖ Mandatory environment education at all levels (schools and colleges including professional courses).

Wetlands in Bangalore are to be restored considering:

Activities around lakes	Norms to protect and conserve Wetlands
Encroachment of lake bed and loss of interconnectivity among lakes	The Hon'ble Supreme Court in Civil appeal number 1132/2011 at SLP (C) 3109/2011 on January 28,2011 has expressed concern regarding encroachment of common property resources, more particularly lakes (and raja kaluves) and it has directed the state governments for removal of encroachments on all community lands. Eviction of encroachment: Need to be evicted as per Karnataka Public Premises (eviction of unauthorised occupants) 1974 and the Karnataka Land Revenue Act, 1964 In case of water bodies, a 30.0 m buffer of 'no development zone' is to be maintained around the lake (as per revenue records)
Buildings in the buffer zone of lakes	• As per BDA, RMP 2015 (Regional Master Plan, 2015) • Section 17 of KTCP (Karnataka Town and Country Planning) Act, 1961 and sec 32 of BDA Act, 1976 • Wetlands (Conservation and Management) Rules 2010, Government of India; Wetlands Regulatory Framework, 2008. • Valley zones are sensitive and are to be with any construction activities as per RMP 2015 of BDA
Valley Zones	LAND USE CHANGES WITH THE CONSTRUCTION ACTIVITIES IN THE PRIMARY VALLIES – SENSITIVE REGIONS (as per RMP, 2015 of BDA). For example, the Proposed SEZ in Agara-Bellandur region is located in the primary valley of the Koramangala Challaghatta valley. Primary valleys in Bangalore **are sensitive regions** as per sensitive zone notification - Circular/35/BBMP/2008, dated: 26/11/2008) and buffer zone for primary valley is 100 m.
Construction activities in the valley zone (SEZ by Karnataka Industrial Areas	This is contrary to sustainable development as the natural resources (lake, wetlands) get affected, eventually leading to the degradation/extinction of lakes. This reflects the ignorance of the administrative machinery on the importance of ecosystems and the need to protect valley

Development Board (KIADB)) **in the valley zone**	zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
Alterations in topography	Flooding of regions would lead to loss of property and human life and, spread of diseases.
Increase in deforestation in catchment area	Removing vegetation in the catchment area increases soil erosion and which in turn increases siltation and decreases transpiration
Documentation of biodiversity	• The biodiversity of every water body should form part of the School, College, People's Biodiversity Registers (SBR, CBR, PBR). • The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity. • The presence of endemic, rare, endangered or threatened species and economically important ones should be highlighted • A locally implementable conservation plan has to be prepared for such species
Implementation of sanitation facilities	• The lakes are polluted with sewage, coliform bacteria and various other pathogens • Preserving the purity of waters and safeguarding the biodiversity and productivity, dumping of waste has to be prohibited • All the settlements alongside the water body should be provided with sanitation facilities so as not to impinge in anyway the pristine quality of water
Violation of regulatory and prohibitory activities as per Wetlands (Conservation and Management) Rules, 2010; **Regulatory wetland framework, 2008**	Environment Impact Assessment (EIA) Notification, 2009. **Wetlands (Conservation and Management) rules 2010, Government of India; Regulatory wetland framework, 2008** **Regulated activity** • Withdrawal of water/impoundment/diversion/interruption of sources • Harvesting (including grazing) of living/non-living resources (may be permitted to the level that the basic nature and character of the biotic community is not adversely affected) • Treated effluent discharges – industrial/ domestic/agro-

	chemical. • Plying of motorized boats • Dredging (need for dredging may be considered, on merit on case to case basis, only in cases of wetlands impacted by siltation) • Constructions of permanent nature within 50 m of periphery except boat jetties • Activity that interferes with the normal run-off and related ecological processes – up to 200 m **Prohibited activity** i. Conversion of wetland to non-wetland use ii. Reclamation of wetlands iii. Solid waste dumping and discharge of untreated effluents
Damage of fencing, solid waste dumping and encroachment problems in Varthur lake series	High Court of Karnataka (WP No. 817/2008) had passed an order which include: • Protecting lakes across Karnataka, • Prohibits dumping of garbage and sewage in Lakes • Lake area to be surveyed and fenced and declare a no development zone around lakes • Encroachments to be removed • Forest department to plant trees in consultation with experts in lake surroundings and in the watershed region • Member Secretary of state legal services authority to monitor implementation of the above in coordination with Revenue and Forest Departments • Also setting up district lake protection committees • Implementation of Handling, Treatment and Management of Municipal Solid Waste as per MSW Rule 2000, GoI
Polluter Pays principle	**National Environment Policy, 2006** The principal objectives of NEP includes : • Protection and conservation of critical ecological systems and resources, and invaluable natural and man-made heritage • Ensuring judicious use of environmental resources to meet the needs and aspirations of the present and future generations • It emphasizes the "Polluter Pays" principle, which states the polluter should, in principle, bear the cost of pollution, with due regard to the public interest
Prevention of pollution of lake	**National Water Policy, 2002** Water is a scarce and precious national resource and

requires conservation and management.

Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted.

The water resources should be conserved by retention practices such as rain water harvesting and prevention of pollution.

The Environment (Protection) Act, 1986

Discharge of untreated sewage into lakes

- Lays down standards for the quality of environment in its various aspects
- Laying down standards for discharge of environmental pollutants from various sources and no persons shall discharge any pollutant in excess of such standards
- Restriction of areas in which industries, operations or processes shall not be carried out or carried out subject to certain safeguards

Water (Prevention and Control of Pollution) Act, 1974

- It is based on the **"**Polluter pays**"** principle.

The Pollution Control Boards performs the following functions :

The water pollution, prevention and its control measures were not looked upon

- Advice the government on any matter concerning the prevention and control of water pollution.
- Encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution.
- Inspects sewage and effluents as well as the efficiency of the sewage treatment plants.
- Lay down or modifiy existing effluent standards for the sewage.
- Lay down standards of treatment of effluent and sewage to be discharged into any particular stream.
- Notify certain industries to stop, restrict or modify their procedures if the present procedure is deteriorating the water quality of streams.

Pathetic water scenario and insufficient drinking water in Bangalore

The depletion of ground water and drying up off lakes has affected the water availability to meet the current population. At the 4% population growth rate of Bangalore over the past 50 years, the current population of Bangalore is 8.5 million (2011). Water supply from Hesaraghatta has dried, Thippagondanahalli is drying up, the only reliable water supply to Bangalore is from Cauvery with a gross of 1,410 million liters a day (MLD). There is no way of increasing the drawal from Cauvery as the allocation by the Cauvery Water Disputes Tribunal for the entire urban and rural population in Cauvery Basin in Karnataka is only 8.75 TMC ft (one thousand million cubic – TMC ft equals 78 MLD), Bangalore city is already drawing more water-1,400 MLD equals 18 TMC—than the allocation for the entire rural and urban population in Cauvery basin

The restoration and conservation strategies has to be implemented for maintaining the ecological health of aquatic ecosystems, aquatic biodiversity in the region, inter-connectivity among lakes, preserve its physical integrity (shorelines, banks and bottom configurations) and water quality to support healthy riparian, aquatic and wetland ecosystems. The regular monitoring of waterbodies and public awareness will help in developing appropriate conservation and management strategies (Ramachandra, 2005).

Ecological and Environmental Implications:

- Land use change: Conversion of watershed area especially valley regions of the lake to paved surfaces would alter the hydrological regime.
- Loss of Drainage Network: Removal of drain (Rajakaluve) and reducing the width of the drain would flood the surrounding residential as the interconnectivities among lakes are lost and there are no mechanisms for the excessive storm water to drain and thus the water stagnates flooding in the surroundings.
- Alteration in landscape topography: This activity alters the integrity of the region affecting the lake catchment. This would also have serious implications on the storm water flow in the catchment.
- The dumping of construction waste along the lakebed and lake has altered the natural topography thus rendering the storm water runoff to take a new course that might get into the existing residential areas. Such alteration of topography would not be geologically stable apart from causing soil erosion and lead to siltation in the lake.
- *Loss of Shoreline:* The loss of shoreline along the lakebed results in the habitat destruction for most of the shoreline birds that wade in this region. Some of the shoreline wading birds like the Stilts, Sandpipers; etc will be devoid of their habitat forcing them to move out such disturbed habitats. It was also apparent from the field investigations that with the illogical land filling and dumping taking place in the Bellandur lakebed, the shoreline are gobbled up by these activities.
- *Loss of livelihood:* Local people are dependent on the wetlands for fodder, fish etc. estimate shows that wetlands provide goods and services worth Rs 10500 per hectare per day (Ramachandra et al., 2005). Contamination of lake brings down goods and services value to Rs 20 per hectare per day.

Decision makers need to learn from the similar historical blunder of plundering ecosystems as in the case of Black Swan event (http://blackswanevents.org/?page_id=26) of evacuating half of the city in 10 years due to water scarcity, contaminated water, etc. or abandoning of FatehpurSikhri and fading out of AdilShahi'sBijapur, or ecological disaster at *Easter Island or* Vijayanagara empire

It is the responsibility of Bangalore citizens (to ensure intergeneration equity, sustenance of natural resources and to prevent human-made disasters such as floods, etc.) to stall the irrational conversion of land in the name of development and restrict the decision makers taking the system (ecosystem including humans) for granted as in the case of wetlands by KIADB, BDA, BBMP and many such para-state agencies.

Recommendations for Conservation and Sustainable Management of Wetlands

1. **Carrying capacity studies for all macro cities:** Unplanned concentrated urbanisation in many cities has telling impacts on local ecology and biodiversity, evident from decline of water bodies, vegetation, enhanced pollution levels (land, water and air), traffic bottlenecks, lack of appropriate infrastructure, etc. There is a need to adopt holistic approaches in regional planning considering all components (ecology, economic, social aspects). In this regard, we recommend carrying capacity studies before implementing any major projects in rapidly urbanizing macro cities such as Greater Bangalore, etc. Focus should be on
   - Good governance (too many para-state agencies and lack of co-ordination) - Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance) and action against polluters (encroachers as well as those let untreated sewage and effluents, dumping of solid wastes).
   - De-congest Bangalore: **Growth in Bangalore has surpassed the threshold evident from stress on supportive capacity** (insufficient water, clean air and water, electricity, traffic bottlenecks, etc.) **and assimilative capacity** (polluted water and sediments in water bodies, enhanced GHG – Greenhouse gases, etc.)
   - Disband BDA – creation of Bangalore Development Agency has given impetus to inefficient governance evident from Bangalore, the garden city turning into 'dead city' during the functional life of BDA.
   - Digitation of land records (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query option (Spatial Decision Support System) to public.

2. **Demarcation of the boundary of water bodies:**
   - The existing regulations pertaining to boundary demarcations within different states need to be reviewed according to updated norms and based on

geomorphology and other scientific aspects pertaining to individual water bodies.

- Maximum Water Level mark should form the boundary line of the water body.
- In addition, a specified width, based on historical records/ survey records etc. may be considered for marking a buffer zone around the water body. In case such records are not available, the buffer zones may be marked afresh considering the flood plain level and also maximum water levels.
- The width of the buffer zone should be set considering the geomorphology of the water body, the original legal boundaries, etc.
- The buffer zone should be treated as inviolable in the long term interests of the water body and its biodiversity.
- Declare and maintain floodplains and valley zones of lakes as no activity regions
- Remove all encroachments – free flood plains, valley zones, storm water drains, etc. of encroachments of any kind.
- Ban conversion of lake, lake bed for any other purposes.
- Urban wetlands, mostly lakes to be regulated from any type of encroachments.
- Regulate the activity which interferes with the normal run-off and related ecological processes – in the buffer zone (200 m from lake boundary / flood plains is to be considered as buffer zone)

3. **Mapping of water-bodies:** The mapping of water bodies should also include smaller wetlands, particularly streams, springs etc. The neglect of these hydrological systems could cause considerable impoverishment of water flow in the river systems as well as turn out to be threats to rare kinds of biodiversity. The waters of many of these streams are being diverted for private uses. This causes diminished water flow especially in the during the summer months. A judicious water sharing mechanism has to be worked out at the local level taking into account also the broader national interest as well as conservation of dependent biodiversity. The mapping of these smaller water-bodies, along with their catchments needs to be conducted involving also the local Biodiversity Management Committees. The jurisdictional agreements on the water usage and watershed protection need to be arrived at on a case to case basis involving all the stakeholders.
    - Spatial Extent of Water bodies,
    - Spatial extent of its catchment (watershed/basin),
    - Demarcate Flood plains,
    - Demarcate buffer zone – with a list of regulated activities,
    - Land cover in the catchment,
    - Ensure at least 33% of land cover is covered with natural vegetation (to ensure the lake perennial),
    - Identify the natural areas in the catchment,
    - Biodiversity inventory – capture entire food chain,

- The jurisdictional agreements on the water usage and watershed protection need to be arrived at on a case to case basis involving all the stakeholders,
- Develop a comprehensive database (spatial with attribute information) and available to public,
- Development of Spatial Decision Support System to aid decision makers,
- Identify and demarcate the region around the lake where all activities are to be prohibited (Flood plain)
- The biodiversity of every water body should form part of the Biodiversity Registers (BR),
- The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity,
- The presence of endemic, rare, endangered or threatened species and economically important ones should be highlighted,
- A locally implementable conservation plan has to be prepared for such species.

4. **Holistic and Integrated Approaches – Conservation and Management:** Integration of the activities with the common jurisdiction boundaries of Government para-state Agencies for effective implementation of activities related to management, restoration, sustainable utilization and conservation. This necessitates:
    - Common Jurisdictional boundary for all para-state agencies
    - To minimise the confusion of ownership – assign the ownership of all natural resources (lakes, forests, etc.) to a single agency – **Lake Protection and Management Authority** (or Karnataka Forest Department). This agency shall be responsible for protection, development and sustainable management of water bodies).
    - Custodian (single para-state agency) shall manage natural resources - let that agency have autonomous status with all regulatory powers to protect, develop and manage water bodies.
    - All wetlands to be considered as common property resources and hence custodians should carefully deal with these ensuring security.
    - Management and maintenance of lakes to be decentralized involving stakeholders, local bodies, institutions and community participation without any commercialization or commoditization of lakes.
    - Integrated aquatic ecosystem management needs to be implemented to ensure sustainability, which requires proper study, sound understanding and effective management of water systems and their internal relations.
    - The aquatic systems should be managed as part of the broader environment and in relation to socio-economic demands and potentials, acknowledging the political and cultural context.

- Wetlands lying within the protected area of National Parks and Wildlife Sanctuaries shall be regulated under the Wildlife Protection Act, 1972. Wetlands lying within the notified forest areas shall be regulated by the Indian Forest Act, 1927 and the Forest Conservation Act, 1980; and the relevant provisions of the Environment (Protection) Act, 1986. The Wetlands outside protected or notified forest areas shall be regulated by the relevant provisions of the Environment (Protection) Act, 1986.
- Immediate implementation of the regulatory framework for conservation of wetlands.
- Socio-economic studies with land use planning in and around the lakes can help in providing ecological basis for improving the quality of lakes.
- Prohibit activities such as conversion of wetlands for non-wetland purposes, dumping of solid wastes, direct discharge of untreated sewage, hunting of wild fauna, reclamation of wetlands.
- Maintain Catchment Integrity to ensure lakes are perennial and maintain at least 33% land cover should be under natural Vegetation.
- Plant native species of vegetation in each lake catchment.
- Create new water bodies considering the topography of each locality.
- Establish laboratory facility to monitor physical, chemical and biological integrity of lakes.
- Maintain physical integrity - Free storm water drains of any encroachments. Establish interconnectivity among water bodies to minimise flooding in certain pockets. The process of urbanization and neglect caused disruption of linkages between water bodies such as ancient lake systems of many cities. Wherever such disruptions have taken place alternative arrangements should be provided to establish the lost linkages.
- Encroachment of lake beds by unauthorized /authorized agencies must be immediately stopped. Evict all unauthorized occupation in the lake beds as well as valley zones.
- Restrictions on the diversion of lake for any other purposes - Lakes and wetlands provide ecological services (depending on the catchment integrity, duration may vary) – there are no dead lakes or wetlands
- Remove all encroachments (without any mercy) of wetlands, lakes, rajjakaluves (storm water drain) – encroachers have violated all humanitarian norms and deprived large section of the society of ecological services (provided by wetlands)
- Any clearances of riparian vegetation (along side lakes) and buffer zone vegetation (around lakes) have to be prohibited
- Penalise polluters dumping solid waste in the lake bed.

- Implement polluter pays principle for polluters letting liquid waste in to the lake either directly or through storm water drains.
- Lake privatized recently to be taken over and handed over to locals immediately thus restoring the traditional access to these lakes by the stakeholders.
- Restore surviving lakes in urban areas strengthening their catchment area and allowing sloping shorelines for fulfilling their ecological function.
- Alteration of topography in lake / river catchments should be banned.
- Appropriate cropping pattern, water harvesting, urban development, water usage, and waste generation data shall be utilized and projected for design period for arriving at preventive, curative and maintenance of aquatic ecosystem restoration action plan (AERAP).
- Desilting of lakes for removal of toxic sediment, to control nuisance macrophytes; further silting in the catchment should be checked by suitable afforestation of catchment areas and the provision of silt traps in the storm water drains.
- Maintaining the sediment regime under which the aquatic ecosystems evolve including maintenance, conservation of spatial and temporal connectivity within and between watersheds.
- Conversion of land around the lakes particularly in the valley zones and storm water drains for any kind of development must be totally banned.
- Flora in the catchment area should be preserved & additional afforestation programmes undertaken.
- Check the overgrowth of aquatic weeds like *Eichhornia, Azolla, Alternanthera* etc. through manual operations.
- Aquatic plants greatly aid in retarding the eutrophication of aquatic bodies; they are the sinks for nutrients & thereby play a significant role in absorption & release of heavy metals. They also serve as food and nesting material for many wetland birds. Therefore, knowledge of the ecological role of aquatic species is necessary for lake preservation.
- Adopt biomanipulation (Silver carp and Catla– surface phytoplankton feeders, Rohu – Column zooplankton feeder Gambusia and Guppies – larvivorous fishes for mosquito control), aeration, and shoreline restoration (with the native vegetation) in the management of lakes.
- Environmental awareness programmes can greatly help in the protection of the water bodies.

▪ Government Agencies, Academies, Institutions and NGO’s must co-ordinate grass-root level implementation of policies and activities related to conservation of lakes and wetlands (both Inland and Coastal), their sustainable utilization, restoration and development including human health. There is also a need for management and conservation of aquatic biota including their health aspects. Traditional knowledge and practices have to be explored as remedial measures. Cost-intensive restoration measures should be the last resort after evaluating all the cost-effective measures of conservation and management of the wetlands.

- A Committee be constituted consisting of Experts, Representatives of Stakeholders (researchers, industrialists, agriculturists, fishermen, etc.) and Line Agencies, in addition to the existing Committee(s), if any, in order to evolve policies and strategies for reclamation, development, sustainable utilization and restoration of the wetlands and socio-economic development of the local people.
- At regional level, **Lake Protection and Management Authority (LPMA)** with autonomy, corpus funds from plan allocations of state and center and responsibility and accountability for avoiding excessive cost and time over runs. LPMA shall have stakeholders-representatives from central and state and local body authorities, NGO's and eminent people and experts shall be constituted
- Generous funds shall be made available for such developmental works through the Committee, as mentioned above. Local stakeholders be suggested to generate modest funds for immediate developmental needs in the aquatic systems in their localities.
- Provisions should be made for adoption of lakes and wetlands by the NGO's and Self-help groups for their conservation, management, sustainable utilization and restoration.
- Aquatic ecosystem restoration works taken up by any agency, Govt. or NGO's should have 10% of restoration costs (per annum) spent or set off for creating awareness , research and monitoring compulsorily in future.
- Public education and outreach should be components of aquatic ecosystem restoration. Lake associations and citizen monitoring groups have proved helpful in educating the general public. Effort should be made to ensure that such groups have accurate information about the causes of lake degradation and various restoration methods.

5. **Documentation of biodiversity:** The biodiversity of every water body should form part of the School, College, People's Biodiversity Registers (SBR, CBR, PBR). The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity. The presence of endemic, rare, endangered or threatened species and economically important ones should be highlighted. A locally implementable conservation plan has to be prepared for such species.
    - All kinds of introduction of Exotic species and Quarantine measures be done in consultation with the concerned Authorities and the data bank
    - There is an urgent need for creating a `Data Bank' through inventorisation and mapping of the aquatic biota.

- Identify water bodies of biodiversity importance and declare them as wetland conservation reserves (WCR)

6. **Pollution Prevention:**

Letting only treated sewage into the lake (Integration of sewage treatment plant with the constructed wetlands and shallow algal pond would help in the removal of nutrients from the sewage).

Complete restriction on disposal of industrial effluents into the lake directly or through drains to the lake.

Handling, treatment and management of municipal solid waste as per MSW RULE 2000, GoI

Ban on dumping building/construction debris, excavated earth in the drains as well as in the lake bed.

7. **Preparation of management plans for individual water bodies:** Most large water bodies have unique individual characteristics. Therefore it is necessary to prepare separate management plans for individual water bodies.
   - Greater role and participation of women in management and sustainable utilization of resources of aquatic ecosystems.
   - Impact of pesticide or fertilizers on wetlands in the catchment areas to be checked.
   - Regulate illegal sand and clay mining around the wetlands.

7. **Implementation of sanitation facilities:** It was noted with grave concern that the water bodies in most of India are badly polluted with sewage, coliform bacteria and various other pathogens. This involves:
   - Preserving the purity of waters and safeguarding the biodiversity and productivity, dumping of waste has to be prohibited;
   - In addition to this, all the settlements alongside the water body should be provided with sanitation facilities so as not to impinge in anyway the pristine quality of water.

8. **Management of polluted lakes:** This programme needs priority attention. This involves:
   - Implementation of bioremediation method for detoxification of polluted water bodies.
   - The highly and irremediably polluted water bodies to be restored on priority to prevent health hazards.
   - Based on the concept of **polluter pays**, a mechanism be evolved to set up efficient effluent treatment plants [ETP], individual or collective, to reduce the

pollution load. Polluting industries be levied **Environmental Cess,** which can be utilised for conservation measures by the competent authorities. A `waste audit' must be made compulsory for all the industries and other agencies.

9. **Restoration of lakes:** The goals for restoration of aquatic ecosystems need to be realistic and should be based on the concept of expected conditions for individual eco-regions. Further development of project selection and evaluation technology based on eco-region definitions and description should be encouraged and supported by the national and state government agencies.
    - Ecosystem approach in aquatic ecosystem restoration endeavor considering catchment land use plan as of pre-project status and optimal land use plan shall first be prepared for short term (10 to 30 years) and long term (>30) periods keeping in view developmental pressure over time span.
    - Research and development is needed in several areas of applied limnology, and this programme should take an experimental approach which emphasizes manipulation of whole ecosystems.
    - Appropriate technologies for point and non-point sources of pollution and *in situ* measures for lake restoration shall be compatible to local ethos and site condition as well as objectives of Aquatic Ecosystem Restoration Action Plan (AERAP).
    - Traditional knowledge and practices have to be explored as remedial measures. Cost-intensive restoration measures should be the last resort after evaluating all the cost-effective measures of conservation and management of ecosystems.
    - Public needs to be better informed about the rational, goal and methods of ecosystem conservation and restoration. In addition, the need was realized for scientist and researchers with the broad training needed for aquatic ecosystem restoration, management and conservation.
    - Improved techniques for littoral zone and aquatic microphytes management need to be developed. Research should go beyond the removal of nuisance microphytes to address the restoration of native species that are essential for waterfowl and fish habitat.
    - Basic research is necessary to improve the understanding of fundamental limnological processes in littoral zones and the interactions between littoral and pelagic zones of lakes.
    - Bio manipulation (food web management) has great potential for low-cost and long-term management of lakes, and research in this emerging field must be stimulated.
    - Innovative and low-cost approaches to contaminant clean up in lakes need to be developed.
    - The relations between loadings of stress-causing substances and responses of lakes need to be understood more precisely. Research should be undertaken to improve predictions of trophic state and nutrient loading relationships.

- Improved assessment programmes are needed to determine the severity and extent of damage in lakes and wetlands and a change in status over time. Innovative basic research is required to improve the science of assessment and monitoring.
- There is a great need for cost effective, reliable indicators of ecosystems function, including those that would reflect long-term change and response to stress.
- Research on indicators should include traditional community and ecosystem measurements, paleoecological trend assessments and remote sensing.
- Effective assessment and monitoring programme would involve network of local schools, colleges and universities.

10. **Only treated sewage into the Lake**: Prohibition on partially treated or untreated sewage getting into the lake. Integration of constructed wetlands and shallow algal ponds with the sewage treatment plant (as in JAKKUR LAKE) helps in the removal of nutrients and other contaminants. Treatment and management of treated sewage at decentralised levels would help in the prevention of groundwater contamination and also recharge of groundwater resources.
11. **Valuation of goods and services :** Goods and services provided by the individual water bodies and the respective species to be documented, evaluated through participatory approach and be made part of the Biodiversity Registers (PBR: People's Biodiversity Registers, SBR: School Biodiversity Registers). If in any case the traditional fishing rights of the local fishermen are adversely affected by lake conservation or by declaring it as a bird sanctuary, etc. they should be adequately compensated.
    - Ecological values of lands and water within the catchment / watershed shall be internalised into economic analysis and not taken for granted. Pressure groups shall play as watchdogs in preventing industrial and toxic and persistent pollutants by agencies and polluters.
11. **Regulation of boating:** Operation of motorized boats should not be permitted within lakes of less than 50 ha. In larger lakes the number of such boats should be limited to restricted area and carrying capacity of the water body. In any case boating during the periods of breeding and congregations of birds should be banned.
12. **Protection of riparian and buffer zone vegetation:** Any clearances of riparian vegetation (along side rivers) and buffer zone vegetation (around lakes) have to be prohibited.
13. **Restoration of linkages between water bodies:** The process of urbanization and neglect caused disruption of linkages between water bodies such as ancient lake systems of many cities. Wherever such disruptions have taken place alternative arrangements should be provided to establish the lost linkages.
14. **Rainwater harvesting:** Intensive and comprehensive implementation of rain water harvesting techniques can reduce taxation of water bodies and also minimize electricity requirements. The country needs in principle a holistic rainwater harvesting

policy aimed at directing water literally from "roof-tops to lakes" after catering to the domestic needs.

15. **Environment Education:** It was felt among the participants that public needs to be better informed about the rational, goal and methods of ecosystem conservation and restoration. In addition, the need was realized for scientist and researchers with the broad training needed for aquatic ecosystem restoration, management and conservation. Public education and outreach should include all components of ecosystem restoration. Lake associations and citizen monitoring groups have proved helpful in educating the general public. Effort should be made to ensure that such groups have accurate information about the causes of lake degradation and various restoration methods. Funding is needed for both undergraduate and graduate programmes in ecosystem conservation and restorations. Training programmes should cross traditional disciplinary boundaries such as those between basic and applied ecology: water quality management and fisheries or wildlife management: among lakes, streams, rivers, coastal and wetland ecology. In this regard the brainstorming session proposes:
    - Environmental education program should be more proactive, field oriented and experiential (with real time examples) for effective learning.
    - Environmental education should be made mandatory at all levels – schools, colleges, universities, professional courses, teachers and teacher educators at the teachers' training institutes (C P Ed, B P Ed, B Ed, D Ed)
16. **Adopt Inter-disciplinary Approach:** Aquatic ecosystem conservation and management requires collaborated research involving natural, social, and inter-disciplinary study aimed at understanding 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. This requires multidisciplinary-trained professionals who can spread the understanding of ecosystem's importance at local schools, colleges, and research institutions by initiating educational programmes aimed at rising the levels of public awareness of aquatic ecosystems' restoration, goals and methods. Actively participating schools and colleges in the vicinity of the water bodies may value the opportunity to provide hands-on environmental education, which could entail setting up of laboratory facilities at the site. Regular monitoring of water bodies (with permanent laboratory facilities) would provide vital inputs for conservation and management.

Wetland Protection Laws and Government Initiatives

The primary responsibility for the management of these ecosystems is in the hands of the Ministry of Environment and Forests. Although some wetlands are protected after the formulation of the Wildlife Protection Act, the others are in grave danger of extinction. Effective coordination between the different ministries, energy, industry, fisheries revenue, agriculture, transport and water resources, is essential for the protection of these ecosystems. Thus, wetlands were not delineated under any specific administrative jurisdiction. Recently the Ministry of Environment and Forests of the Government of India issued Notification 2010 Regulatory Framework for Wetlands Conservation (Wetland Conservation Rules). Wetlands in India are protected by an array of laws given below:

- The Indian Fisheries Act - 1857
- The Indian Forest Act - 1927
- Wildlife (Protection) Act - 1972
- Water (Prevention and Control of Pollution) Act - 1974
- Water (Prevention and Control of Pollution) Cess Act - 1977
- Forest (Conservation) Act - 1980
- The Environment (Protection) Act - 1986
- Wildlife (Protection) Amendment Act - 1991
- National Conservation Strategy and Policy Statement on Environment and Development – 1992
- Environment Impact Assessment Notification, 2009
- Wetlands Regulatory Framework, 2008
- Wetlands (Conservation and Management) Rules 2010, Government of India

In addition to the above laws, India is a signatory to the Ramsar Convention on Wetlands and the Convention of Biological Diversity. According to these formulations India is expected to conserve the ecological character of these ecosystems along with the biodiversity of the flora and fauna associated with these ecosystems. Despite these, there is no significant development towards sustaining these ecosystems due to the lack of awareness of the values of these ecosystems among the policymakers and implementation agencies. The effective management of these wetlands requires a thorough appraisal of the existing laws, institutions and practices. The involvement of various people from different sectors is essential in the sustainable management of these wetlands.

Apart from government regulation, development of better monitoring methods is needed to increase the knowledge of the physical and biological characteristics of each wetland resources, and to gain, from this knowledge, a better understanding of wetland dynamics and their controlling processes. Discussions based on accurate knowledge and increased awareness of wetland issues can then begin to develop management strategies (to protect, restore and/or mitigate) that account for the function and value of all wetland resources in the face of natural and socioeconomic factors, while continuing to satisfy critical resource needs of the human population.

The Legal framework for the conservation and management of Wetland Ecosystems is provided by the following National and International Legal instruments:

The Wildlife Protection Act, 1972: This act provides for the protection of wild animals, birds and plants. For the purpose of this act, the state government constitutes the Wildlife Advisory board, which performs the following functions: It advices the state government:

- In the selection of areas to be declared as Sanctuaries, National Parks and Closed Areas.
- In the formulation of policy of protection and conservation of wildlife and specified plants.
- In relation to the measures to be taken for harmonizing the needs of the tribals and forest dwellers with the protection and conservation of wildlife.

This Act imposes prohibition on hunting of wild animals, their young ones as well as their eggs except with prior permission of the Chief Wildlife Warden. This acts prohibits the picking, uprooting, destroying, damaging, possessing of any plant in a protected area, except with prior permission of the Chief Wildlife Warden. The State government may declare any area; which it considers to have adequate ecological, faunal, geomorphological, natural or zoological significance for the purpose of protecting, propagating or developing wildlife or its environment; to be included in a sanctuary or a National Park. No person shall, destroy, exploit or remove any wildlife from a National Park and Sanctuary or destroy or damage the habitat or deprive any wild animal or plant its habitat within such National Park and Sanctuary. The State government may also declare any area closed to hunting for a designated period of time if it feels the ecosystem of that area is disturbed by hunting.

Water (Prevention and Control of Pollution) Act, 1974: for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water. To carry out the purposes of this act, the Central and the State government constitutes the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) respectively. The main functions of the pollution control boards include:

- Advice the government on any matter concerning the prevention and control of water pollution.
- Encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution.
- Lay down or modify standards on various parameters for the release of effluents into streams.
- Collect and examine effluent samples as well as examine the various treatment procedures undertaken by the industries releasing the effluent.
- Examine the quality of streams.
- Notify certain industries to stop, restrict or modify their procedures if it feels that the present procedure is deteriorating the water quality of streams.
- Establish or recognize laboratories to perform its functions including the analysis of stream water quality and trade effluents.

Forest (Conservation) Act, 1980: Without the permission of the Central government, no State government or any other authority can:

- Declare that any reserved forest shall cease to be reserved.

- Issue permit for use of forest land for non-forest purpose.
- Assign any forest land or portion thereof by way of lease or otherwise to any private person, authority, corporation, agency or any other organization, not owned, managed or controlled by government.
- Clear off natural trees from a forest land for the purpose of reafforestation.

The Biological Diversity Act, 2002: India is a signatory to the United Nations Convention on Biological Resources, 1992 and in accordance with that convention, brought into force The Biological Diversity Act, 2002. This act prohibits biodiversity related activities as well as transfer of the results of research pertaining to biodiversity to certain persons. It also necessitates the approval of National Biodiversity Authority before applying for Intellectual Property Rights on products pertaining to biological diversity. This act emphasizes the establishment of National Biodiversity Authority to carry out various functions pertaining to the Act, viz guidelines for approving collection, research and patents pertaining to biological diversity. It also notifies the central government on threatened species. The central government to develop plans, programmes and strategies for the conservation, management and sustainable use of the biodiversity. Where the Central Government has reason to believe that any area rich in biological diversity, biological resources and their habitats is being threatened by overuse, abuse or neglect, it shall issue directives to the concerned State Government to take immediate ameliorative measures.

Convention on Wetlands of International Importance, especially as Waterfowl habitats, (Ramsar) 1971: To stem the progressive destruction of the wetlands, Ramsar convention was signed. Waterfowls are birds ecologically dependent on the wetlands. The various points agreed under Ramsar convention includes:

- Each contracting party should nominate at least one wetland having significant value in terms of ecology, botany, zoology, limnology or hydrology to be included in the List of Wetlands of International Importance (Ramsar sites) and precisely describe its boundaries.
- The contracting parties will have right to add further wetland sites to the list, expand the boundaries of the existing sites and also to delete or minimize the boundaries of the existing sites.
- Each contracting party shall strive for the conservation, management and restoration of the wetlands in the list.
- Establishment of nature reserves in the area of wetlands thereby protecting it as well as the biological diversity it supports.
- Restriction of boundaries or deletion of a wetland listed as Ramsar sites should be immediately compensated by the creation of additional nature reserves for the protection of waterfowls and other species habiting that wetland.

International convention for the protection of Birds, 1950: To abate the ever dwindling number of certain bird species (particularly the migratory ones) as well as the other birds, this convention was made. This is an amendment to the "International Convention for the Protection of Birds useful to Agriculture, 1902". The objectives of this convention include:

- Protection to all birds, their young ones and their eggs especially in their breeding season.
- Prohibit hunting, killing, mass capture or captivating birds, except those causing intense damage to crops or other components of the ecosystem, such so that the above said components is in the danger of extinction.
- Adopt measures to prohibit industries and other processes causing contamination of air and water that has adverse effects on the survival of birds.
- Adopt measures to prohibit the destruction of suitable breeding grounds and the bird habitat and also encourage the creation of suitable land and water habitat for the birds.

Bonn Convention on Conservation of Migratory Species, 1979: According to the Bonn Convention on Conservation of Migratory Species, the participating parties:

- Should promote, co-operate in and support research relating to migratory species.
- Shall endeavour to provide immediate protection for migratory species which are endangered.
- Shall strive to conserve and restore those habitats of the endangered species in an effort to eliminate the chances of extinction of that species.
- Shall prohibit or minimize those activities or obstacles that seriously impede or prevent the migration of the species.

Convention on Biological Diversity, 1992: The main objectives of this convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources. In accordance with this convention, each contracting party shall –

- Identify places supporting immense biological diversity.
- Monitor through sampling or other means the components of biological diversity identified and strive for the conservation of those components requiring urgent attention.
- Develop new or adapt existing strategies, plans and programmes for the conservation and sustainable use of biological diversity.
- Identify activities which have or may have significant adverse impact on the sustainability of the biodiversity in an area.
- It prescribes conservation of biological diversity by either *In situ* conservation mechanisms or *Ex situ* conservation mechanisms or both.

In situ conservation: Each contracting parties shall declare a region harbouring immense biological diversity as a protected area and develop various plans and strategies for the establishment, conservation and management of these protected areas and also strive to conserve biodiversity beyond these protected areas.

- Promote environmentally sound and sustainable development in the areas adjacent to the protected areas so as to further enhance the development and protection of these protected areas.
- Promote the protection of ecosystems, prevent the introduction of alien species likely to have an adverse effect on the existing ecosystem and also rehabilitate & restore degraded ecosystems.
- Enforce legislative measures for the protection of threatened species and population.

Ex situ conservation : Each contracting party shall establish facilities for ex situ conservation and for research on plants, animals and micro-organisms, especially the threatened species, augment their number and take steps for their reintroduction in their own natural habitat.

Relative merits and scope of the respective Indian laws with respect to the wetlands protection and conservation is given in Table 2.

Table 2: Sections applicable to Wetlands in the various environmental laws

No.	Act	Relevant Sections
1	The Wildlife (Conservation) Act, 1972	Prohibits hunting of wild animals, their young ones as well as their eggs Prohibits the picking, uprooting, destroying, damaging, possessing of any plant in a protected area Can declare any area with high ecological significance as a national park, sanctuary or a closed area.
2	The Biological Diversity Act, 2002	Prior approval needed from National Biodiversity Authority for collection of biological materials occurring in India as well as for its commercial utilization. Panchayath to document biodiversity and maintain biodiversity registers
3	Forest (Conservation) Act, 1980	Without the permission of the Central government, no State government or any other authority can : • Declare that any reserved forest shall cease to be reserved. • Issue permit for use of forest land for non-forest purpose. • Assign any forest land by way of lease or otherwise to any private person, authority,

		corporation, agency or any other organization, not owned, managed or controlled by government. • Clear off natural trees from a forest land for the purpose of re-afforestation.
4	Water (Control and Prevention of Pollution) Act, 1974	It is based on the "Polluter pays" principle. The Pollution Control Boards performs the following functions : • Inspects sewage and effluents as well as the efficiency of the sewage treatment plants. • Lay down or modifies existing effluent standards for the sewage. • Lay down standards of treatment of effluent and sewage to be discharged into any particular stream. • Notify certain industries to stop, restrict or modify their procedures if the present procedure is deteriorating the water quality of streams.
5	Wetlands (Conservation and Management) Rules, 2010	Prohibited Activities • Conversion of wetland to non-wetland use • Reclamation of wetlands • Solid waste dumping and discharge of untreated effluents. Regulated activities • Withdrawal of water, diversion or interruption of sources • Treated effluent discharges – industrial/domestic/agro-chemical. • Plying of motorized boats • Dredging • Constructions of permanent nature within 50 m • Activity which interferes with the normal run-off and related ecological processes – up to 200 m
6	National Environment Policy, 2006	The principal objectives of NEP includes : • Protection and conservation of critical ecological systems and resources, and invaluable natural and man made heritage. • Ensuring judicious use of environmental

		resources to meet the needs and aspirations of the present and future generations. • It emphasizes the "Polluter Pays" principle, which states the polluter should, in principle, bear the cost of pollution, with due regard to the public interest.
8	The Environment (Protection) Act, 1986	Lays down standards for the quality of environment in its various aspects. Laying down standards for discharge of environmental pollutants from various sources and no persons shall discharge any pollutant in excess of such standards. Restrictions of areas in which industries, operations or processes shall not be carried out or carried out subject to certain safeguards.
9	National Water Policy, 2002	Water is a scarce and precious national resource and requires to be conserved and management. Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted. The water resources should be conserved by retention practices such as rain water harvesting and prevention of pollution.
10	KARNATAKA LAKE CONSERVATION AND DEVELOPMENT AUTHORITY ACT, 2014, **KARNATAKA ACT NO. 10 OF 2015** **RMP 2015 (BDA)**	Conservation of lakes and wetlands Primary valleys in Bangalore **are sensitive regions** as per sensitive zone notification - Circular/35/BBMP/2008, dated: 26/11/2008) and buffer zone for primary valley is 100 m. NEEDS PROTECTION – possible only with the implementation of norms without any dilutions and violations.

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II. Bangalore to Bengaluru (transition from green landscape to brown landscape)

Status	**Disappearing water-bodies and vegetation**
Cause:	**Unplanned urbanisation**
Recommendation	"**Decongest and decontaminate Bangalore**" so that at least next generation enjoys better environment in Bangalore Need to ensure the ecosystem integrity to sustain goods and services for maintaining inter-generation equity. **Carrying capacity studies for all macro cities:** Unplanned concentrated urbanisation in many cities has telling impacts on local ecology and biodiversity, evident from decline of water bodies, vegetation, enhanced pollution levels (land, water and air), traffic bottlenecks, lack of appropriate infrastructure, etc. There is a need to adopt holistic approaches in regional planning considering all components (ecology, economic, social aspects). In this regard, we recommend carrying capacity studies before implementing any major projects in rapidly urbanizing macro cities such as Greater Bangalore, etc.
Action Plan	❖ Good governance (too many para-state agencies and lack of co-ordination) - Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance and action against polluters (encroachers as well as those let untreated sewage and effluents, dumping of solid wastes). ❖ De-congest Bangalore: Growth in Bangalore has surpassed the threshold evident from stress on supportive capacity (insufficient water, clean air and water, electricity, traffic bottlenecks, etc.) and assimilative capacity (polluted water and sediments in water bodies, enhanced GHG – Greenhouse gases, etc.) ❖ Disband BDA – creation of Bangalore Development Agency has given impetus to inefficient governance evident from Bangalore, the garden city turning into 'dead city' during the functional life of BDA. ❖ Digitation of land records (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query option (Spatial Decision Support System) to public. ❖ Threshold on high raise building in the region. Need to protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015 ❖ Evict all encroachments from lake bed and raja kaluves ❖ Reestablish interconnectivity among lakes ❖ Restoration of lakes

1.0 Bangalore to Bengaluru (transition from green landscape to brown landscape)

Bangalore (77°37'19.54'' E and 12°59'09.76'' N), is the principal administrative, cultural, commercial, industrial, and knowledge capital of the state of Karnataka. With an area of 741 sq. km., Bangalore's city administrative jurisdiction was widened in 2006 (Greater Bangalore) by merging the existing area of Bangalore city spatial limits with 8 neighbouring Urban Local Bodies (ULBs), and 111 Villages of Bangalore Urban District (Ramachandra and Kumar, 2008; Ramachandra et al., 2012). Thus, Bangalore has grown spatially more than ten times since 1949 (69 square kilometres) and is a part of both the Bangalore urban and rural districts (figure 1.1). The mean annual total rainfall is about 880 mm with about 60 rainy days a year over the last ten years. The summer temperature ranges from 18° C – 38° C, while the winter temperature ranges from 12° C – 25° C. Bangalore is located at an altitude of 920 meters above mean sea level, delineating three watersheds, viz. Hebbal, Koramangala-Challaghatta and Vrishabhavathi watersheds (Figure 1.2). The undulating terrain in the region has facilitated creation of a large number of tanks providing for the traditional uses of irrigation, drinking, fishing, and washing. Bangalore had the distinction of having hundreds of water bodies through the centuries. Even in early second half of 20th century, in 1961, the number of lakes and tanks in the city stood at 262 (and spatial extent of Bangalore was 112 sq. km). However, number of lakes and tanks in 1985 was 81 (and spatial extent of Bangalore was 161 sq. km). This forms important drainage courses for the interconnected lake system (Figure 1.2), which carries storm water beyond the city limits. Bangalore, being a part of peninsular India, had the tradition of harvesting water through surface water bodies to meet the domestic water requirements in a decentralised way. After independence, the source of water for domestic and industrial purpose in Bangalore is mainly from the Cauvery River and ground water. Untreated sewage is let into the storm water drains, which progressively converge at the water bodies. Now, Bangalore is the fifth largest metropolis in India currently with a population of about 8.72 million as per the latest population census. Spatial extent of the city has increased from 69 (1941) to 161 (1981), 226 (2001) and 745 (2011) sq.km. Due to the changes in the spatial extent of the city, the population density varies from 5956 (1941) to 18147 (1981), 25653 (1991), 25025 (2001) and 11704 (2011) persons per sq.km.

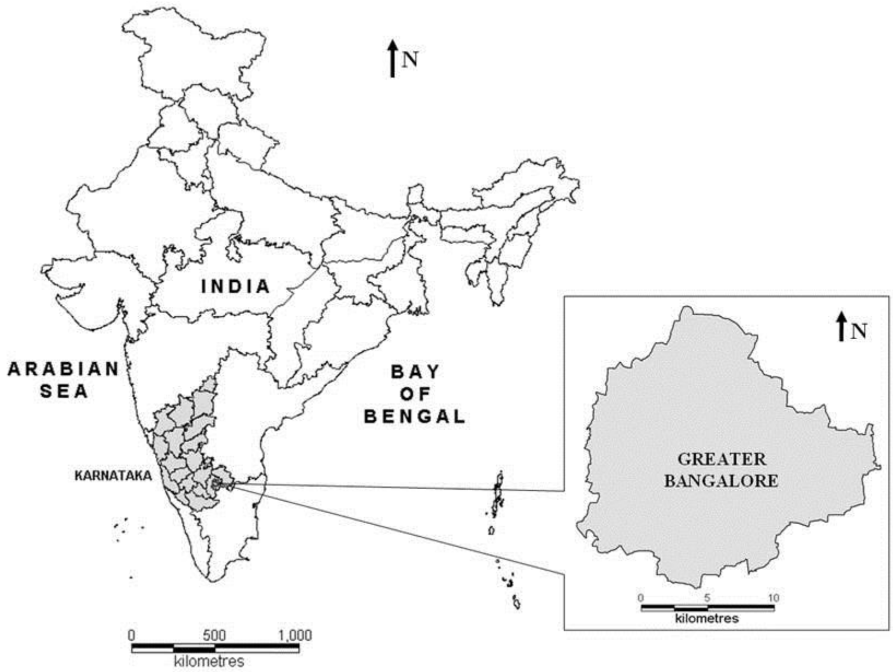
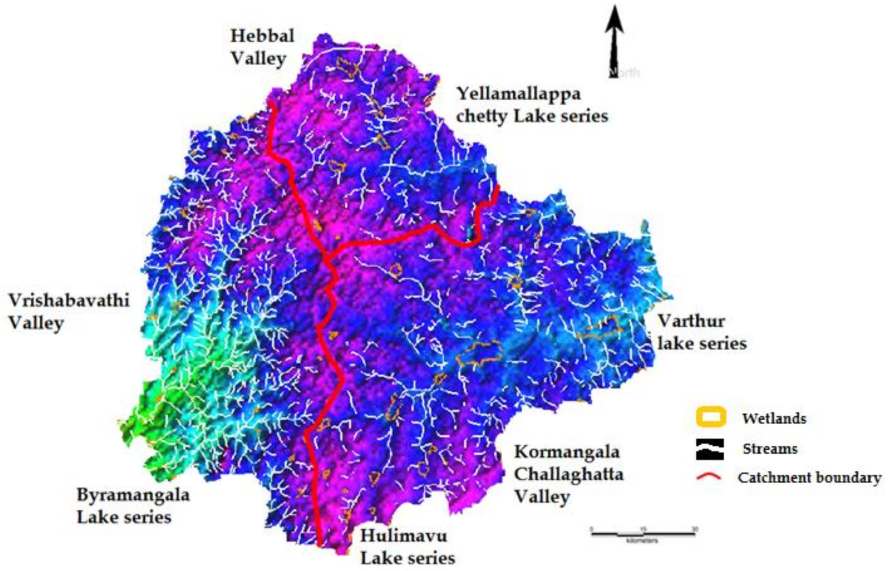


Figure 1.1: Study area –Bangalore



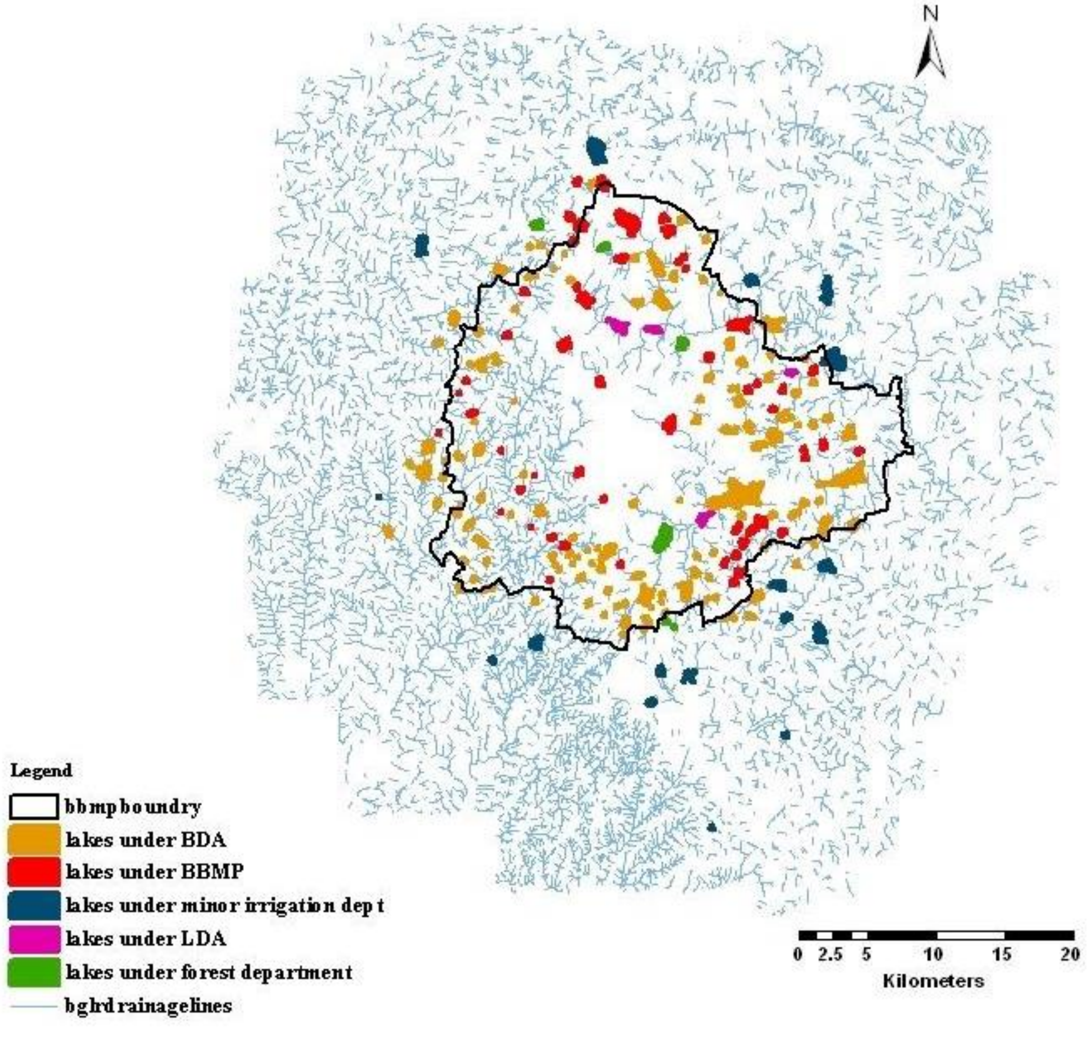


Figure 1.2: Watersheds (drainage with water bodies) of Bangalore

Land use analyses were carried out using supervised pattern classifier - Gaussian maximum likelihood classifier (GMLC) for Landsat and IRS data, and Bayesian Classifier (MODIS data). The method involved (Ramachandra *et al*., 2012): i) generation of False Colour Composite (FCC) of remote sensing data (bands – green, red and NIR). This helped in locating heterogeneous patches in the landscape ii) selection of training polygons (these correspond to heterogeneous patches in FCC) covering 15% of the study area and uniformly distributed over the entire study area, iii) loading these training polygons co-ordinates into pre-calibrated GPS, vi) collection of the corresponding attribute data (land use types) for these polygons from the field. GPS helped in locating respective training polygons in the field, iv) supplementing this information with Google Earth (latest as well as archived data), v) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment.

Land use analysis carried out using GRASS - Geographic Resources Analysis Support System (http://wgbis.ces.iisc.ernet.in/ grass) for the period 1973 to 2013 and details are in table 1.1 and urban dynamics is illustrated in Figure 1.3. There has been a 925% increase in built up area from 1973 to 2013 leading to a sharp decline of 79% area in water bodies in Bangalore mostly attributing to intense urbanisation process. Analyses of the temporal data reveals an increase in urban built up area of 342.83% (during 1973 to 1992), 129.56% (during 1992 to 1999), 106.7% (1999 to 2002), 114.51% (2002 to 2006) and 126.19% (2006 to 2010). The rapid development of urban sprawl has many potentially detrimental effects including the loss of valuable agricultural and eco-sensitive (e.g. wetlands, forests) lands, enhanced energy consumption and greenhouse gas emissions from increasing private vehicle use (Ramachandra and Shwetmala, 2009). Vegetation has decreased by 32% (during 1973 to 1992), 38% (1992 to 2002) and 64% (2002 to 2013). Disappearance of water bodies or sharp decline in the number of water bodies in Bangalore is mainly due to intense urbanisation and urban sprawl. Many lakes (54%) were encroached for illegal buildings. Field survey of all lakes (in 2007) shows that nearly 66% of lakes are sewage fed, 14% surrounded by slums and 72% showed loss of catchment area. In addition, lake catchments were used as dumping yards for either municipal solid waste or building debris (Ramachandra, 2009a). The surrounding of these lakes have illegal constructions of buildings and most of the times, slum dwellers occupy the adjoining areas. At many sites, water is used for washing and household activities and even fishing was observed at one of these sites. Multi-storied buildings have come up on some lake beds that have totally intervene the natural catchment flow leading to sharp decline and deteriorating quality of water bodies. This is correlated with the increase in built up area from the concentrated growth model focusing on Bangalore, adopted by the state machinery, affecting severely open spaces and in particular water bodies. Some of the lakes have been restored by the city corporation and the concerned authorities in recent times.

Table 1.1: Land use changes in Bengaluru during 1973 to 2013

Class →	**Urban**		**Vegetation**		**Water**		**Others**	
Year ↓	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**
1973	5448	7.97	46639	68.27	2324	3.40	13903	20.35
1992	18650	27.30	31579	46.22	1790	2.60	16303	23.86
1999	24163	35.37	31272	45.77	1542	2.26	11346	16.61
2002	25782	37.75	26453	38.72	1263	1.84	14825	21.69
2006	29535	43.23	19696	28.83	1073	1.57	18017	26.37
2010	37266	54.42	16031	23.41	617	0.90	14565	21.27
2013	50440	73.72	10050	14.69	445.95	0.65	7485	10.94

Urbanisation in Greater Bangalore

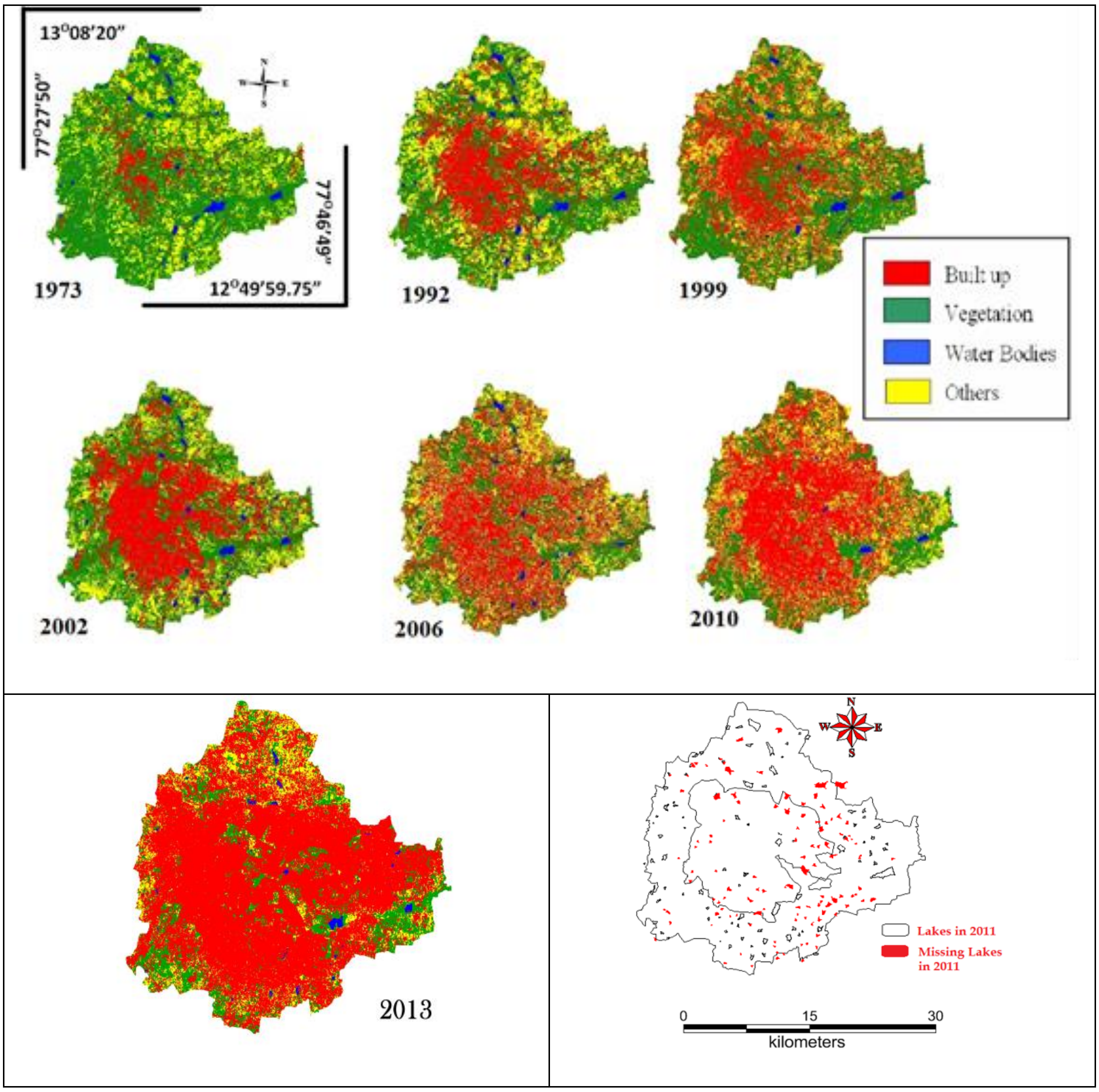


Figure 1.3: Land use dynamics since 1973

Increase in Built-up (concrete / paved surface): 925%

Loss of vegetation: 78%

Loss of water bodies: 79%

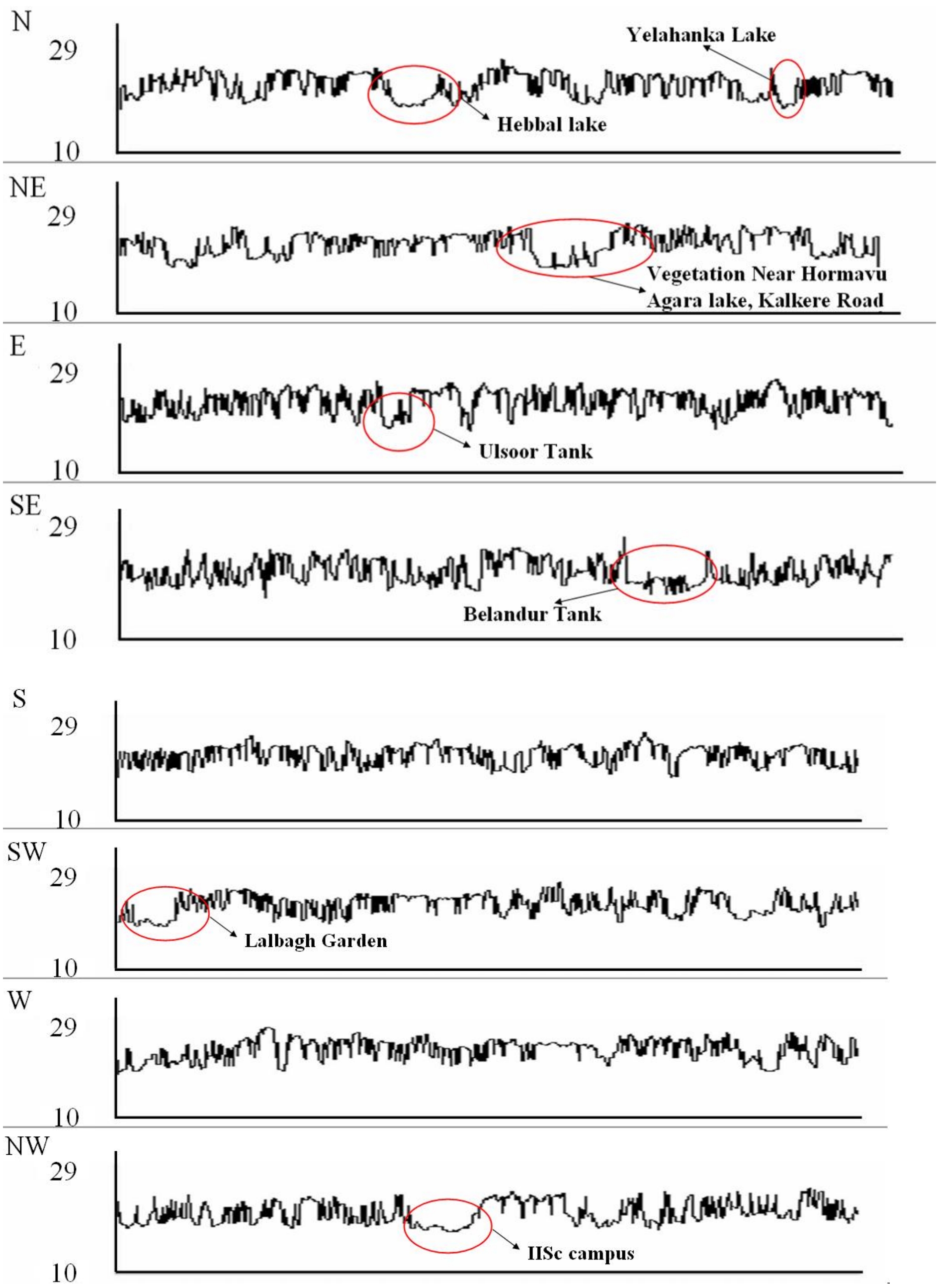


Figure 1.4: Temperature profile in various directions. X axis – Movement along the transacts from the city centre, Y-axis - Temperature (°C)

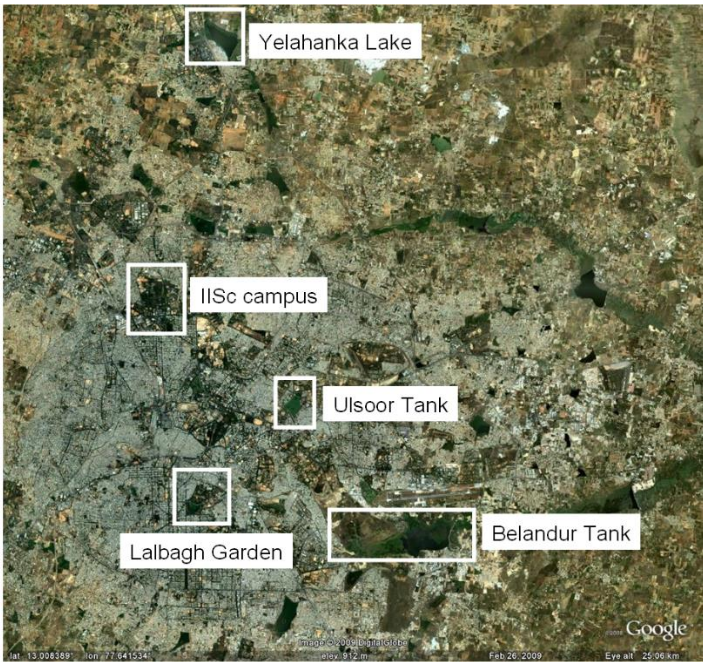


Figure 1.5: Google Earth image showing the low temperature areas [Source: http://earth.google.com/]

The temperature profile plot fell below the mean when a vegetation patch or water body was encountered on the transact beginning from the centre of the city and moving outwards eight directions along the transact as in figure 1.4 It is evident that major natural green area and water bodies act as microclimate moderators responsible for lower temperature (marked with circle in Figure 1.5). The spatial location of these green areas and water bodies are marked in figure 1.5.

Conclusion

Urbanisation and the consequent loss of lakes has led to decrease in catchment yield, water storage capacity, wetland area, number of migratory birds, flora and fauna diversity and ground water table. Temporal land use analysis reveal that there has been a 925% increase in built up area from 1973 to 2013 leading to a sharp decline of 79% area in water bodies in Bangalore mostly attributing to intense urbanisation process. The increase in urban built up area ranges from 342.83% (during 1973 to 1992), 129.56% (during 1992 to 1999), 106.7% (1999 to 2002), 114.51% (2002 to 2006) to 126.19% (2006 to 2010). The gradient analysis showed that Bangalore grew radially from 1973 to 2010 indicating that the urbanization is intensifying from the city centre and has reached the periphery of the Bangalore. The temperature profile analysis by overlaying the LST on the land use reveal of higher temperatures in urban area while vegetation and water bodies aided in moderating temperature at local levels (evident from at least 2 to 2.5 °C lower temperature compared to urban pockets).

Frequent flooding in the city is a consequence of the drastic increase in impervious area (of 925% in 4 decades) and loss of wetlands (and interconnectivity of wetlands) with the high-density urban developments. The uncoordinated pattern of urban growth is attributed to a lack of good governance and decentralized administration, which was evident from the lack of coordination among many Para-state agencies. This has led to unsustainable use of the land and other resources. The mitigation of frequent floods and the associated loss of human life and properties entail the restoration of interconnectivity among wetlands, restoration of wetlands (removal of encroachments), conservation, and sustainable management of wetlands.

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III. Environmental Auditing of Bangalore Wetlands

Introduction

Wetlands, especially in tropical ecosystems have received much attention in recent times because of the increased knowledge about their economic values and benefits, and also consequences of many anthropogenic activities. By definition "wetlands are wide ranging aquatic habitats including marsh, fen, peat land/ open water, flowing water (rivers and streams) or static (lakes and ponds), it could be fresh, brackish or salt water, artificial or natural, not exceeding 1-2 m depth" (Boon and Pringle, 2009). Wetland status is characterised by presence of macrophytes, chemical and ionic concentrations, organic matter in water, sediment deposition rate and water depth (Brown et al., 2009). The non-stratified photic zone enhances the growth of photosynthetic organisms particularly benthic and planktonic algae. Wetlands helps in mitigating global warming by aiding as carbon sink with the CO_2 sequestration rate in water logged wetlands (2.23-3.71 metric tons/acre/year) being higher than forests (0.05-3.9) (Bernal and Mitsch, 2012). However, wetland economic services often borders between ecological function and destruction which makes it more fragile either due to natural (salinity, floods, etc.) or human disturbance (defecation, effluents, agricultural fields, eutrophication, etc.) (discussed in later part).

Merely 1.3% of earth surface is occupied by inland water bodies comprising wetlands, rivers and streams (Spellman, 2008). Recent conferences and wetland community meetings established policy and guidelines to protect wetland ecosystems across countries in Asia. However, continued changes in developing settlements since 1980's reflects prolific new and very large urban populations and built-up regions. This not only influences wetland geomorphology but also the essential biodiversity components. With the increased population and followed urbanization, a decline in environmental quality and degradation of surrounding ecosystems amplified spontaneously. Major shift was noticed from predominantly rural to urban, wetlands to water tanks and recreation centres which also lead to climate variability, habitat fragmentation and critical loss threatening biodiversity and extinction (Adriaensen *et al.,* 2003).

Wetlands in peninsular India are mostly formed by the formation of tributaries of large rivers and streams, man-made ancient lakes and ponds and formation of valleys, to be found in Western Ghats and Deccan plateau regions. Though some of these wetlands are considered as

Ramsar sites, many of the other man-made wetlands are significant that uphold large population of migratory birds, amphibians, microbial flora and macro-invertebrates. Efficient monitoring of wetlands should include consideration of habitation, benthic biodiversity, sedimentation and flow rates and nutrients (forms of nitrogen and phosphorous) balance through sewage network diversion. Man-made wetlands located in urban centres are exposed to changes due to sewage inflow, over fishing, human destructions and seasonal changes. It is therefore very important to recognize geomorphological and biological features of each wetland for preservation and restoration from being destroyed.

Wetlands in Bangalore (spatial extent 190 sq.km.) located in Karnataka are well known for hundreds of man-made wetlands from centuries with rich flora and fauna. ~262 wetlands were constructed in 16th century to meet domestic and agricultural needs of the city which are now anthropogenic degraded and have been reduced to less than 80 and named as tanks (Lakshman Rau, 1986). A sharp decline of 58% in Bangalore attributes to intense urbanization processes, evident from a 46% increase in built-up area from 1973 to 2007 (Ramachandra and Uttam Kumar, 2008). Mora than a decade studies from Ramachandra and Kiran,1999; Ramachandra et al., 2005; Ramachandra et al., 2013 showed that even though wetlands are studied, there has been a sustained effort to develop database with physical, chemical, morphological and biological conditions of wetlands. Few of the already restored wetlands showed failure to restore and maintain clean for not more than 3 years which needs immediate attention by government bodies. An attempt was made in the current study to carry out environmental auditing of Bangalore wetlands to understand the ecological status and recommend guidelines for biological restoration of wetlands. Some of the wetland features such as size, catchment area, depth, location, type of anthropogenic activities, eutrophication, etc. were recorded.

Methods

45 wetlands with size ranged from 1.5 to 200 hectares, located within the Greater Bangalore were selected randomly. These wetlands are being used for various purposes (Irrigation, recreational and other activities). Water samples from more than 4 locations in each wetland was selected so as to cover different sampling points and analysed for physical and chemical analysis. Location of sampling sites was based on the preliminary survey on sewage inflow and outflow sites along with non-point sources so as to provide representative sample for

marked change in water quality. Details (including sketch maps) of the site location were compiled from the Survey of India topographical maps (1:50,000) that included geographical co-ordinates (Latitude, Longitude, altitude) and name of village/watershed. Local human disturbances at sampling sites such as road construction waste, solid waste disposal site, washing waste were collected during field visits. Three replicates of water samples were collected from inlets, outlets and other sites (such as center) to observe and to understand the water quality variations at the regional scale. Onsite variables like pH, electric conductivity (EC), salinity (SAL), total dissolved solids (TDS), water temperature (WT), air temperature (AT) and dissolved oxygen (DO) were measured using meters (Extech pH/conductivity EC500). The samples were carried to laboratory on the same day of sampling and stored at 4^{o}C for further chemical analyses. Methods mentioned in American public health association (APHA, 2010) was followed for nitrates (N), inorganic phosphates/or phosphorous (P), total hardness (TH), calcium hardness (CaH), magnesium hardness (MgH), chlorides (CHL), alkalinity (ALK), chemical oxygen demand (COD), biological oxygen demand (BOD), sodium (Na) and Potassium (K).

Details of environmental auditing of wetlands in Bangalore

Environmental Auditing of Bangalore Wetlands

Contents

1. ANCHEPALYA KERE

NAME OF THE LAKE	**ANCHEPALYA LAKE**
GEOGRAPHIC DETAILS	13°3'3"N 77°28'47"
AREA (2000/2010)	18.44 / 22.66 ha
AUTHORIZATION	LDA
WARD / VILLAGE NAME	Peenya
STATUS	Highly Polluted/ Eutrophicated
RESTORATION	Under Restoration (2011)
WATER CONDITION	Poor, Green color, Eutrophication

Figure 1 Google Earth map and area of Anchepalya Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 1 Water quality of Anchepalya Lake with BIS standards

Sampling sites	Anchepalya inlet (ACIN)	Anchepalya Outlet (ACOT)	BIS standards for Surface waters
pH	8.73	8.70	6.5-9
Electric conductivity (µS/cm)	9210.00	9220.00	<1200
Total dissolved solids (ppm)	6410.00	6500.00	<700
Dissolved oxygen (mg/L)	10.38	10.60	>5
Biological oxygen demand (ppm)	48.80	55.40	<5
Chemical oxygen demand (ppm)	160.67	182.00	<30
Nitrates (ppm)	0.511	0.438	--
Inorganic phosphates (ppm)	0.438	0.375	--
Total hardness (mg/L)	400.00	632.00	<300
Calcium hardness (mg/L)	307.93	531.92	<80
Chlorides (mg/L)	508.36	451.56	<250
Total alkalinity (mg/L)	520.00	580.00	<600

Chemical variables of Anchepalya Lake has been listed in Table 1. An alkaline range of pH was recorded at both inlet and outlet sampling site. The ionic concentration at both sites ranged from 9210-9220 µS/cm exceeding BIS limits. A high amount of organic matter was reflected through BOD and COD values (range, 48.80-55.40 ppm and 160.67-182 ppm respectively). Hardness accounted for industrial while chlorides concentration reflected untreated domestic inflow into the lake bed.

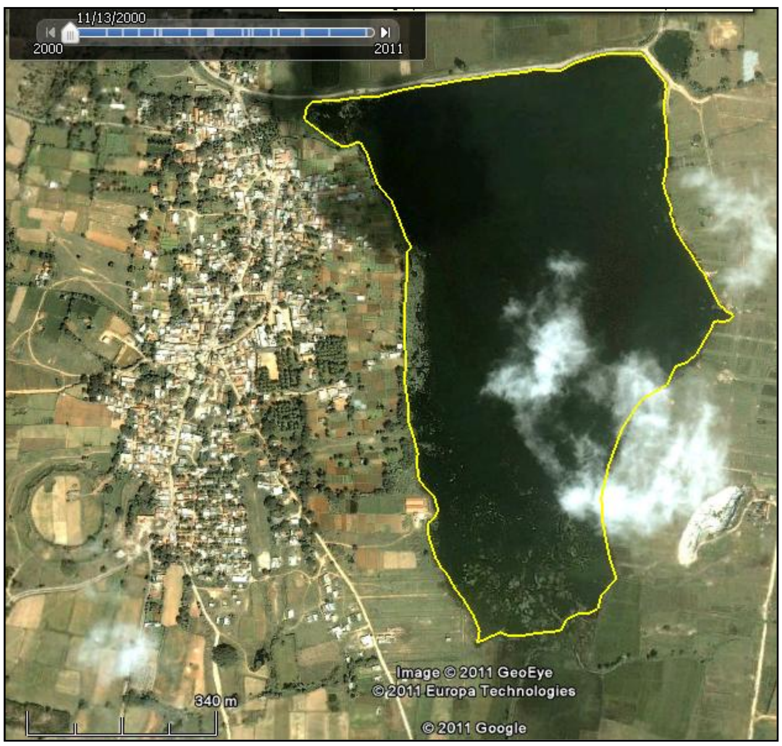
CURRENT THREATS (Refer Figure 1 and Plate 1)

a. Industrial waste and untreated sewage inflow from nearby Industries and household in Peenya,
b. Macrophyte cover (*Eichornia* sp.)
c. Dumping of construction waste, solid waste, etc.
d. Lake bed has been occupied for construction, Encroachment (filling of lake bed with construction waste).
e. No shoreline
f. Sludge deposition, Eutrophication.

PLATE 1

2. BEGUR DODDA LAKE

NAME OF THE LAKE	BEGUR DODDA LAKE
GEOGRAPHIC DETAILS	13°2'20"N 77°2'0"E
AREA (2002/2010)	47.08/46.65 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	192- Begur
STATUS	Moderately Polluted
RESTORATION	NO
WATER CONDITION	Moderate



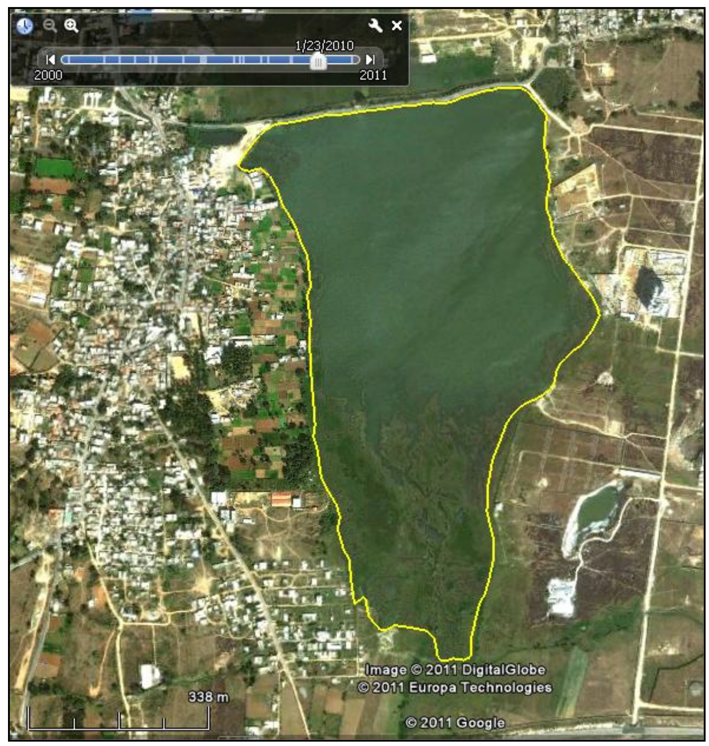


Figure 2 Google Earth and area of Begur Lake during 2002 and 2004 respectively.

WATER QUALITY

Table 2 water quality of Begur Lake with BIS standards

Sampling sites	Begur 1 (BGR1)	Begur 2 (BGR2)	BIS standards for Surface waters
pH	8.50	8.12	6.5-9
Electric conductivity (µS/cm)	722	706	<1200
Total dissolved solids (ppm)	572	563	<700
Dissolved oxygen (mg/L)	8.94	5.85	>5
Biological oxygen demand (ppm)	6.7	7.2	<5
Chemical oxygen demand (ppm)	25.6	26.7	<30
Nitrates (ppm)	0.012	0.005	--
Inorganic phosphates (ppm)	0.02	0.014	--
Total hardness (mg/L)	224	176	<200
Calcium hardness (mg/L)	126.08	96.08	<80
Chlorides (mg/L)	116.44	110.76	<250
Total alkalinity (mg/L)	240	220	<600

Chemical variables of Begur Lake has been listed in Table 2. pH ranged between 8.12-8.5. Water ionic concentration and dissolved solids were well within the BIS limits ranging from 706-722 µS/cm and 563-572 ppm respectively. BOD and COD of lake showed presence of less/ moderate amount of organic matter. Dumping of plastic and household waste was observed near sampling site 2 which led to blockage of water (Plate 2). Hardness was high at accounting for local human disturbances such as washing clothes and bathing. Chlorides and alkalinity was found to be less than 300 and 500 mg/L which also showed lake water is less/moderately polluted.

CURRENT THREATS (Refer Figure 2 and Plate 2)

a. Dumping of household waste.
b. Local disturbances (Washing clothes and open defecation)

PLATE 2

NAME OF THE LAKE	**BELLANDUR LAKE**
GEOGRAPHIC DETAILS	12°56'11"N 77°39'33"E
AREA (2002/ 2010)	284.6/260.2 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	174- Mahadevapura
STATUS	Polluted
RESTORATION	NO
WATER CONDITION	Eutrophication, Green color, rotten smell

3. BELANDUR LAKE

Figure 3 Google Earth and area of Belandur Lake during 2002 and 2010 respectively.

WATER QUALITY

Table 3 Water quality of Belandur Lake and BIS standards mentioned.

Sampling sites	Belandur inlet (BLI2)	Belandur outlet (BLO1)	BIS standards for Surface waters
pH	6.89	7.67	6.5-9
Electric conductivity (µS/cm)	1148.00	1172.00	<1200
Total dissolved solids (ppm)	813.00	820.00	<700
Dissolved oxygen (mg/L)	2.64	3.68	>5
Biological oxygen demand (ppm)	44.32	44.66	<5
Chemical oxygen demand (ppm)	93.33	88.67	<30
Nitrates (ppm)	0.469	0.445	--
Inorganic phosphates (ppm)	1.580	1.960	--
Total hardness (mg/L)	260.00	312.00	<200
Calcium hardness (mg/L)	151.91	183.90	<80
Chlorides (mg/L)	267.56	167.56	<250
Total alkalinity (mg/L)	520.00	620.00	<600

Water chemistry variables of Belandur Lake inlet and outlet have been listed in Table 3. pH was recorded as slightly acidic to neutral condition ranging from 6.89-7.67 because of industrial acidic waste inflow at inlet of lake. Ionic concentration, total dissolved solids, Chlorides and alkalinity were higher than the BIS standards for surface water (Table 3) which could also harm aquatic insects and algal growth. Fish species has been decreased due to increased macrophyte cover and thus decreased dissolved oxygen (range 2.64-3.68). Phosphate concentration ranged from 1.55-1.96 which has also led to increase in Eutrophication in lake.

CURRENT THREATS (Refer Figure 3 and Plate 3)

a. Macrophyte cover (*Eichornia* sp.)
b. Dumping of construction waste, solid waste. Lake bed has been occupied for construction, Encroachment (filling of lake bed with construction waste)
c. Untreated sewage inflow
d. No shoreline
e. Sludge deposition

PLATE 3

OUTLET VIEW

CONSTRUCTION WASTE IN LAKE BED


CONSTRUCTION OF BUILDING IN LAKE CATCHMENT


MACROPHYTE COVER

4. BOMMASANDRA LAKE

NAME OF THE LAKE	BOMMASANDRA LAKE
GEOGRAPHIC DETAILS	12°49'30"N 77°41'41"E
AREA (2004/2009)	18.97/18.57 ha
ORGANIZATION	LDA/ Fisheries department
WARD / VILLAGE NAME	Bommasandra
STATUS	Polluted
RESTORATION	Completed (2004-2005)
WATER CONDITION	Moderate - Poor

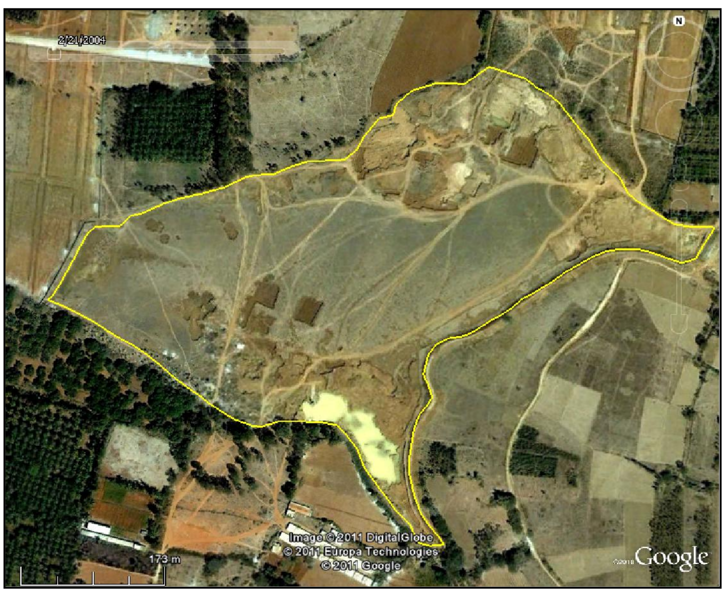


Figure 4 Google Earth and area of Bommasandra Lake during 2004 and 2009 respectively

WATER QUALITY

Table 4 Water quality variables of Bommasnadra Lake with BIS standards mentioned.

Sampling sites	Bommasandra inlet (BMIN)	Bommasandra outlet (BMOT)	BIS standards for Surface waters
pH	7.65	8.56	6.5-9
Electric conductivity (µS/cm)	1320.00	1265.00	<1200
Total dissolved solids (ppm)	860.00	800.00	<700
Dissolved oxygen (mg/L)	1.24	6.50	>5
Biological oxygen demand (ppm)	42.69	36.50	<5
Chemical oxygen demand (ppm)	89.00	76.00	<30
Nitrates (ppm)	0.230	0.240	--
Inorganic phosphates (ppm)	2.500	2.100	--
Total hardness (mg/L)	266.00	234.00	<200
Calcium hardness (mg/L)	146.00	140.00	<80
Chlorides (mg/L)	234.00	205.00	<250
Total alkalinity (mg/L)	640.00	624.75	<600

Water quality of Bommasandra Lake has been listed in Table 4. Water quality status reflected contamination of water with sewage and nearby industrial untreated waste. Lake water showed high amount ions along with calcium (range, 140-146 mg/L) and chlorides (range, 205-234 mg/L) concentration. Alkalinity of water exceeds BIS limit ranged 624.75-640 mg/L which could also imbalance the aquatic life. Lake is covered with *Eichornia* sp. and hence oxygen level has been decreased to 1.24 mg/L at Inlet of lake. Fish kill was observed during later 2011 due to decreased oxygen and increased amount of ionic concentration. Piggery waste and household waste is observed near inflow region which has led to foul smell, green color of water (increased algal bloom) and has also blocked a portion of water body.

CURRENT THREATS (Refer Figure 4 and Plate 4)

a. Dumping of construction waste, solid waste, etc.
b. Local disturbances (Open defecation).
c. Decrease in water depth due to Sludge deposition.
d. Piggery waste and household waste and Fishing.

PLATE 4

EUTROPHICATION

MACROPHYTE COVER


DECREASED WATER DEPTH

5. DODDABIDAREKALLU LAKE

NAME OF THE LAKE	DODDABIDAREKALLU LAKE
GEOGRAPHIC DETAILS	13°2'32"N 77°29'34"E
AREA (2000/2009)	11.67/12.06 ha
ORGANIZATION	BDA/ BBMP
WARD / VILLAGE NAME	14- Bagalakunte
STATUS	Highly Polluted
RESTORATION	NO
WATER CONDITION	Eutrophication, high pollution

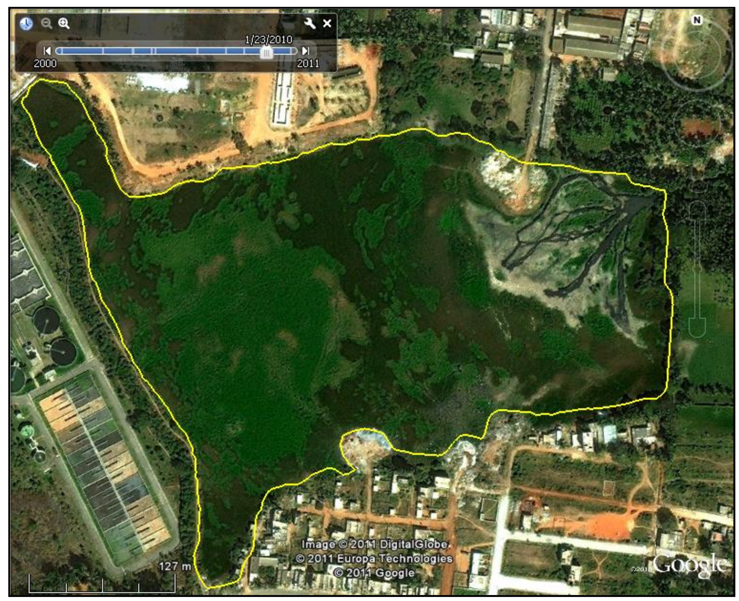


Figure 5 Google Earth and spatial extent of Doddabidarekallu Lake during 2000 and 2009 respectively

WATER QUALITY

Table 5 Water quality of Doddabidarekallu Lake with BIS standard limits

Sampling site	Doddabidarekallu site 1 (DDU1)	BIS standards for Surface waters
pH	8.21	6.5-9
Electric conductivity (µS/cm)	3320	<1200
Total dissolved solids (ppm)	2370	<700
Dissolved oxygen (mg/L)	0.00	>5
Biological oxygen demand (ppm)	65.79	<5
Chemical oxygen demand (ppm)	240	<30
Nitrates (ppm)	0.35	--
Inorganic phosphates (ppm)	0.65	--
Total hardness (mg/L)	680	<200
Calcium hardness (mg/L)	439	<80
Chlorides (mg/L)	610.6	<250
Total alkalinity (mg/L)	1080	<600

Due to the macrophyte cover on Doddabidarekallu Lake sampling of water was difficult. The sampled collected and analysed at inflow has been listed in Table 5. All the chemical variables exceeding the required BIS values. Ionic concentration and dissolved solids showed the amount of pollution in water. BOD and COD concentration showed high organic matter in the lake. No fish is found due to decrease in water oxygen level. The black colored water observed at the inflow along with local human disturbances such as open defecation which has also led to contamination of water. This lake receives major industrial effluents from Peenya industrial area and domestic waste from surrounding village. Construction waste has been occupied at one side of lake bed.

CURRENT THREATS (Refer Figure 5 and Plate 5)

a. Dumping of construction waste and solid waste

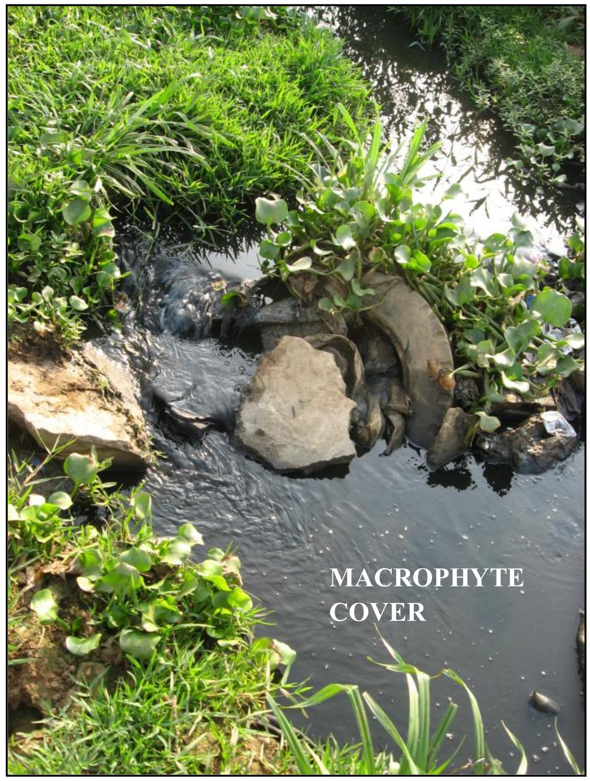
b. Local disturbances

c. Sludge deposition

d. Completely covered with Macrophyte.

e. Untreated sewage and industrial inflow into the lake bed

PLATE 5




STAGNANT WATER NEAR LAKE

6. DODDANEKKUNDI LAKE

NAME OF THE LAKE	**DODDANEKKUNDI KERE**
GEOGRAPHIC DETAILS	12°58'29"N 77°41'16"E
AREA (2002/2010)	42.01/38.66 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	85- Doddanekkundi
STATUS	Polluted
RESTORATION	NO
WATER CONDITION	Eutrophication, Green color, rotten smell

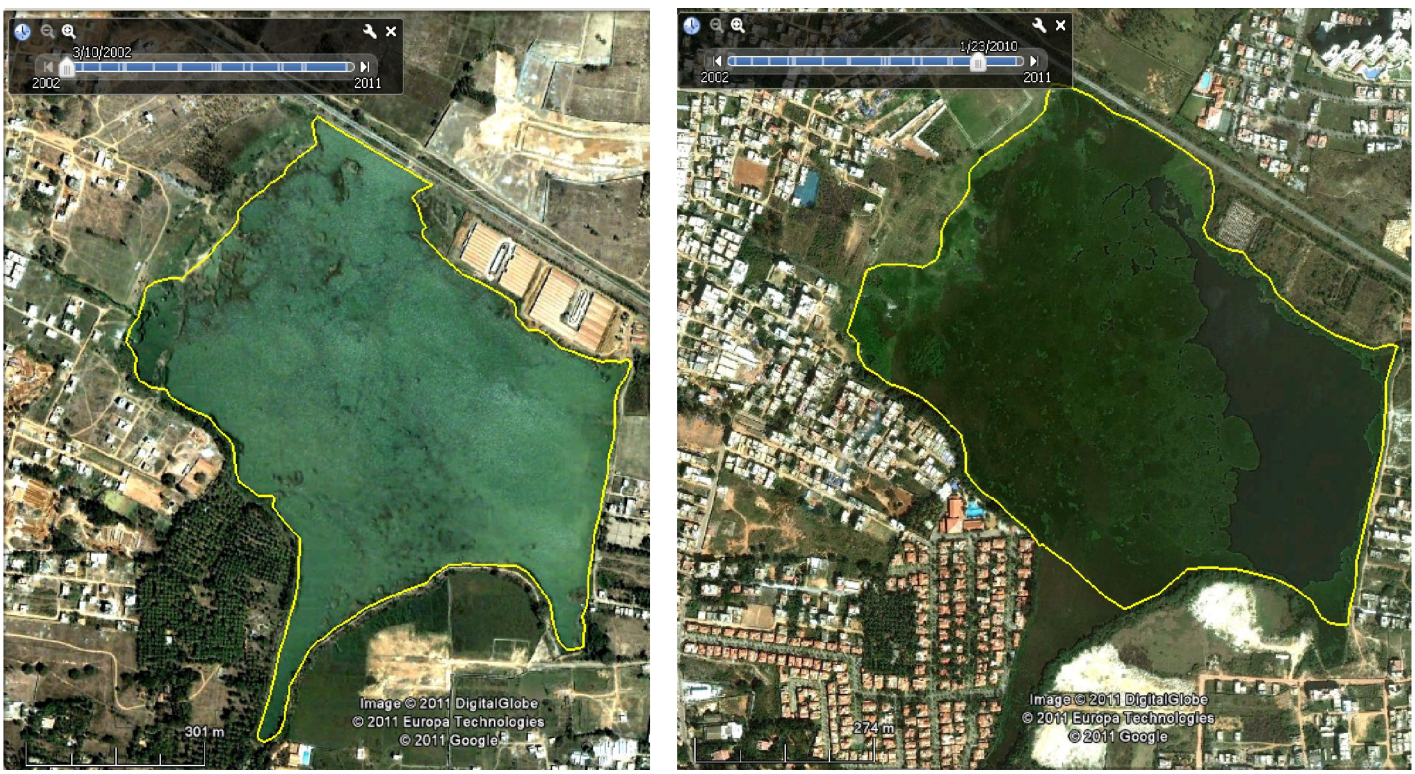


Figure 6 Google Earth and area of Doddanekkundi Lake during 2002 and 2010 respectively.

WATER QUALITY

Table 6 Water quality of Doddanekkundi Lake with surface water limits.

Sampling site	Doddanekkundi outlet DDO1	Dodanekkundi inlet DDI1	BIS standards for Surface waters
pH	7.37	7.9	6.5-9
Electric conductivity (µS/cm)	1339	1368	<1200
Total dissolved solids (ppm)	1049	1108	<700
Dissolved oxygen (mg/L)	0.00	1.30	>5
Biological oxygen demand (ppm)	39.586	45.079	<5
Chemical oxygen demand (ppm)	89.172	100.158	<30
Nitrates (ppm)	0.29	0.41	--
Inorganic phosphates (ppm)	1.29	1.42	--
Total hardness (mg/L)	296	320	<200
Calcium hardness (mg/L)	163	175	<80
Chlorides (mg/L)	456	482	<250
Total alkalinity (mg/L)	683	782	<600

Water quality was distinctive of heavy pollution at both sampling sites (Table 6). Electric conductivity and total dissolved solids ranged from 1339-1368 µS/cm and 1049-1108 ppm respectively. Pollution was also measured with high BOD and COD as it reveals the organic pollution. Lake is in the verge of extinction with increasing phosphates which will lead to Eutrophication. Untreated domestic sewage accounted for high amount of hardness and chlorides. Alkalinity which measures the buffering capacity of a lake to neutralize acids from waste inflow was higher than the BIS limits. The high alkalinity explains the poor buffering capacity of water. This lake recorded more of organic pollution and needs immediate priority for conservation.

CURRENT THREATS (Refer Figure 6 and Plate 6)

a. Macrophyte cover (*Eichornia* sp.),
b. Dumping of construction waste, Lake bed is encroached for construction of temple, building etc.
c. Encroachment (filling of lake bed with construction waste)
d. Untreated sewage inflow,
e. No shoreline,
f. Sludge deposition.

PLATE 6


OUTLET- MACROPHYTE COVER

ENCROACHMENT IN LAKE BED

7. HEBBAL LAKE

NAME OF THE LAKE	**HEBBAL**
GEOGRAPHIC DETAILS	13°2'50"N 77°35'8"E
AREA (2000/2010)	50.8/46.14 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	8-Kodigehalli
STATUS	Moderately Polluted
RESTORATION	Completed (Year)
WATER CONDITION	Poor quality

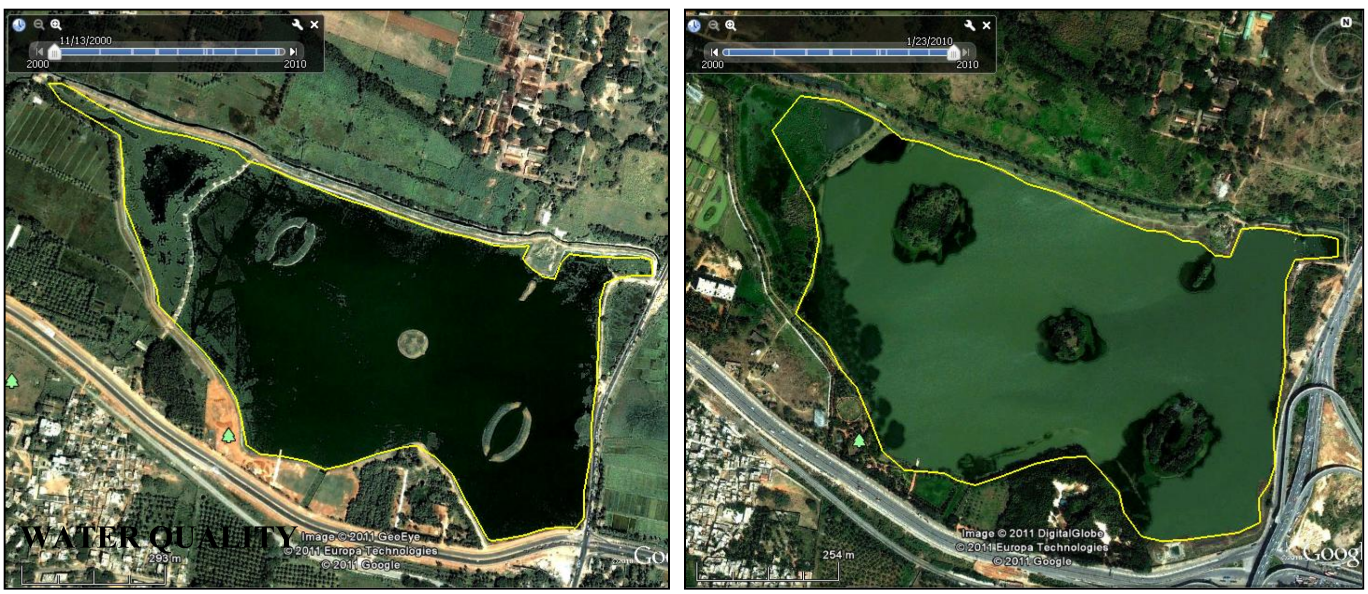


Figure 7 Google Earth and area of Doddanekkundi Lake during 2002 and 2010 respectively.

WATER QUALITY

Table 7 Water quality of Hebbal Lake with BIS limits

Sampling site	Hebbal inlet (HBI1)	Hebbal outlet (HBO1)	BIS standards for Surface waters
pH	7.63	8.35	6.5-9
Electric conductivity (µS/cm)	660	623	<1200
Total dissolved solids (ppm)	523	523	<700
Dissolved oxygen (mg/L)	5.12	8.13	>5
Biological oxygen demand (ppm)	17.43	15.69	<5
Chemical oxygen demand (ppm)	42.21	40.23	<30
Nitrates (ppm)	0.092	0.064	--
Inorganic phosphates (ppm)	0.15	0.18	--
Total hardness (mg/L)	156	148.32	<200
Calcium hardness (mg/L)	93	89.16	<80
Chlorides (mg/L)	341	298	<250
Total alkalinity (mg/L)	238	213	<600

Water quality analysed has been listed in Table 7. pH ranged from neutral to slightly alkaline condition. Biological oxygen demand and Chemical oxygen demand ranged from 1569 -17.43 ppm and 40.23- 42.21 ppm which were more than BIS standard limits revealing the organic pollution in lake. Chlorides exceeding <200 mg/L was recorded at both inlet and outlet because of improper sewage management which adds to lake water at inflow region. Lake has been constructed with cement bunds during restoration which led to unavailability of shoreline region, aquatic habitats for birds and aquatic insects. Water hyacinth growth could be found at Inflow region. Ionic concentration, total dissolved solids were well within the range of BIS limits and thus the lake is said to be moderately polluted.

CURRENT THREATS (Refer Figure 7 and Plate 7)

a. No shoreline
b. Human disturbances and Fishing
c. Untreated sewage inflow.

PLATE 7

WASTE INFLOW


MOUNTAINS OF MACROPHYTE

8. HENNAGARA LAKE

NAME OF THE LAKE	HENNAGARA LAKE
GEOGRAPHIC DETAILS	12°46'42"N 77°39'43"E
AREA (2002/2009)	41.70/69.93 ha
ORGANIZATION	BBMP, Irrigation tank
WARD / VILLAGE NAME	Jigani
STATUS	Less Polluted
RESTORATION	NO
WATER CONDITION	Clean – Moderately polluted.

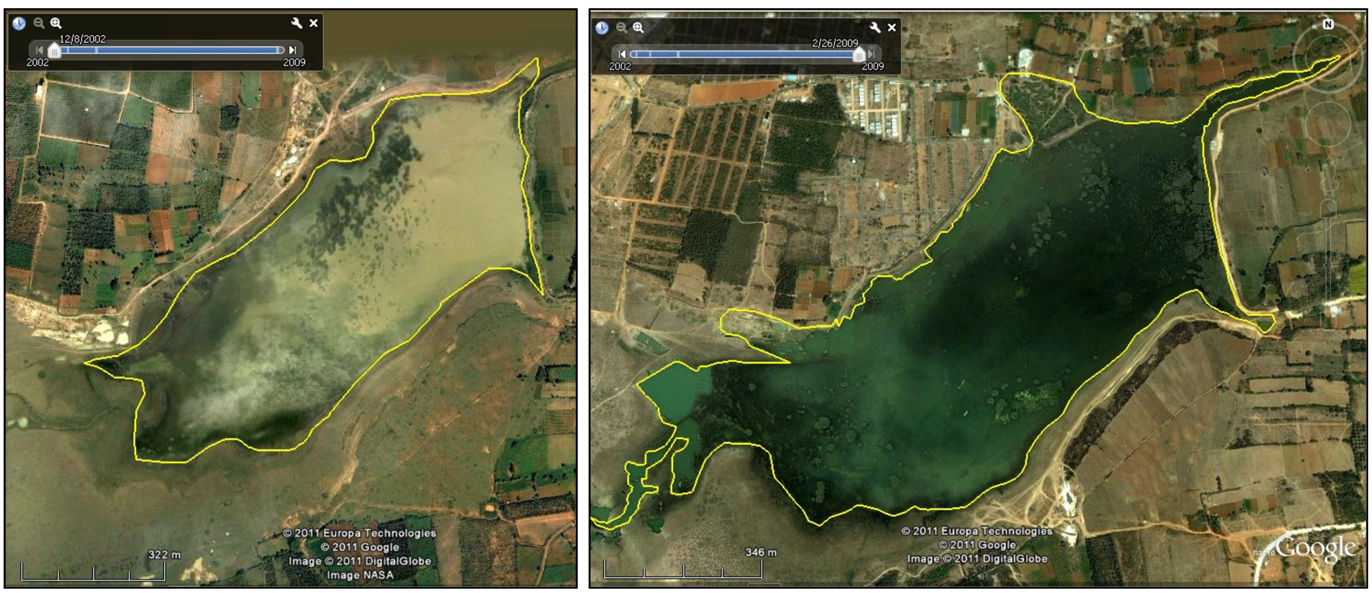


Figure 8 Google Earth and area of Hennagara Lake during 2002 and 2009 respectively.

WATER QUALITY

Table 8 Water quality variables of Hennagara Lake with BIS standards

Sampling site	Hennagara site 1 (HNA1)	Hennagara site 2 HNA2	BIS standards for Surface waters
pH	8.3	8.5	6.5-9
Electric conductivity (µS/cm)	632	626	<1200
Total dissolved solids (ppm)	505	501	<700
Dissolved oxygen (mg/L)	5.69	5.93	>5
Biological oxygen demand (ppm)	4.93	3.76	<5
Chemical oxygen demand (ppm)	19.86	17.52	<30
Nitrates (ppm)	0.076	0.066	--
Inorganic phosphates (ppm)	0.12	0.12	--
Total hardness (mg/L)	141	139	<200
Calcium hardness (mg/L)	85.5	84.5	<80
Chlorides (mg/L)	76	63	<250
Total alkalinity (mg/L)	128	132	<600

Chemical variables at Hennagara Lake has been listed in Table 8. Alkaline pH was recorded at both sampling sites along with an alkalinity range of 128-132 mg/L respectively. Electric conductivity and total dissolved solids were less than the explained BIS limits (refer Table) and hence water is least or not polluted with any pollution source such as untreated sewage waste. Biological oxygen demand and chemical oxygen demand ranged from 3.76- 4.93 ppm and 17.52-19.86 ppm respectively. The main source of increase in hardness is attributed to washing of clothes. Chlorides and alkalinity were recorded as low as 63-76 mg/L and 128-132 mg/L respectively and hence this lake is considered as less polluted ecosystem.

CURRENT THREATS

a. Local human disturbances

b. Aquatic weeds

PLATE 8

9. HESARAGHATTA RESERVOIR/LAKE

NAME OF THE LAKE	HESARAGHATTA
GEOGRAPHIC DETAILS	13°10'14"N 77°30'6"E
AREA (2004/2011)	61.88-32.37 ha
ORGANIZATION	Arkavati for drinking water
WARD / VILLAGE NAME	Hesaraghatta
STATUS	Clean
RESTORATION	NO
WATER CONDITION	Good (NO/less Water since 2010).

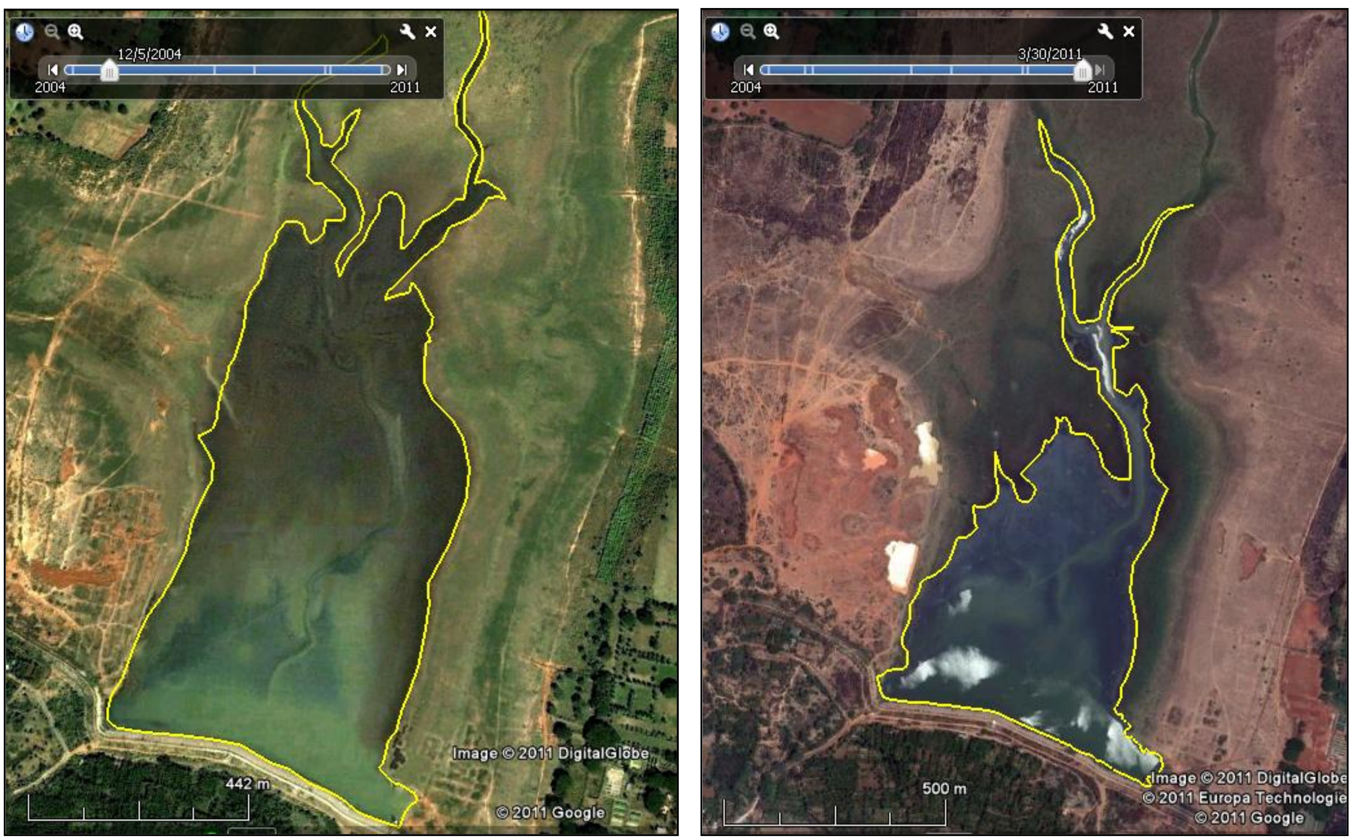


Figure 9 Google Earth and area of Hesaraghatta Lake during 2004 and 2011 respectively.

WATER QUALITY

Table 9 Water quality variables of Hesaraghatta Lake with BIS standards

Sampling site	Hesaraghatta site 1 (HSA1)	BIS standards for Surface waters
pH	9.78	6.5-9
Electric conductivity (µS/cm)	33	<1200
Total dissolved solids (ppm)	25.6	<700
Dissolved oxygen (mg/L)	6.18	>5
Biological oxygen demand (ppm)	3.45	<5
Chemical oxygen demand (ppm)	16.9	<30
Nitrates (ppm)	0.01	--
Inorganic phosphates (ppm)	0.17	--
Total hardness (mg/L)	70	<200
Calcium hardness (mg/L)	50	<80
Chlorides (mg/L)	22.72	<250
Total alkalinity (mg/L)	211	<600

Table 9 includes the results of water quality analysis of Hesaraghatta reservoir which is comparatively clean than any other lake. This reservoir water is known to be utilized only for drinking water requirements but in recent years the water level has been decreased drastically. Due to unavailability of water cover area only one sample was collected. pH of the Lake is high alkaline which depends on the type of soil. Conductivity and dissolved solids were well within the standards of surface waters. Biological oxygen demand and chemical oxygen demand reflected less organic contamination with 3.45 and 16.9 ppm respectively. Nitrates and phosphates were recorded as low as oligotrophic lake nutrient concentrations i.e., 0.01 and 0.17 ppm respectively. The source of chlorides could be considered as asphalted road and local human disturbances such as open defecation.

CURRENT THREATS (Refer Figure 9 and Plate 9)

a. Decrease in water level

b. Human disturbances, Open defecation, fishing.

PLATE 9

DUMPING OF PLASTIC AND PAPER WASTE IN LAKE BED DURING VILLAGE FESTIVAL

10. HOSAKERE LAKE

NAME OF THE LAKE	HOSAKERE LAKE
GEOGRAPHIC DETAILS	12°56'17"N 77°26'3"E
AREA (2004/2009)	7.649/15.58 ha
ORGANIZATION	Outskirts of Bangalore BBMP boundary
WARD / VILLAGE NAME	Near Kommaghatta
STATUS	Clean/ No pollution
RESTORATION	NO
WATER CONDITION	Good

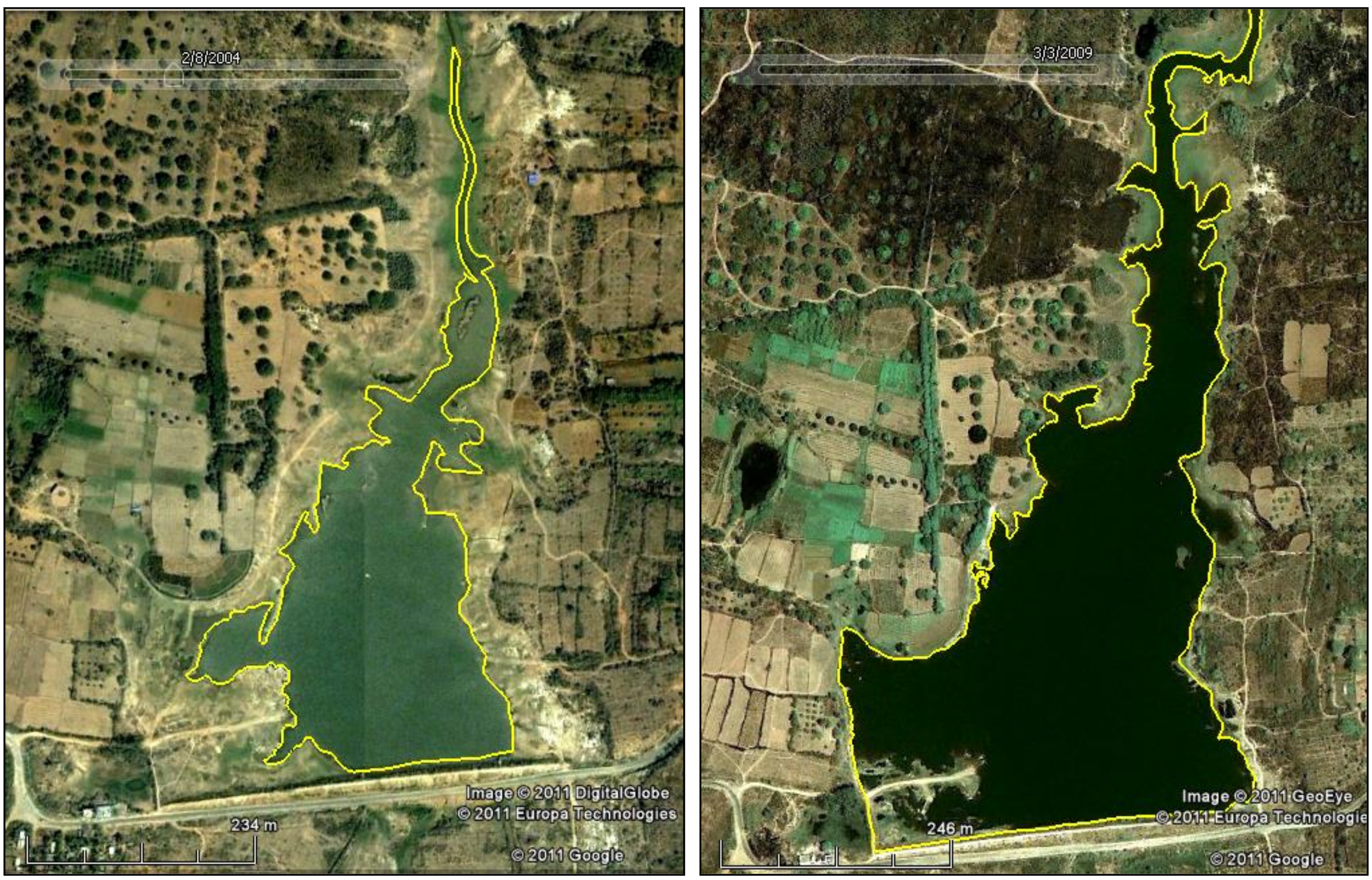


Figure 10 Google Earth and area of Hosakere Lake during 2004 and 2009 respectively.

WATER QUALITY

Table 10 Water quality of Hosakere Lake with BIS standards

Sampling site	Hosakere site 1 (HSI1)	Hosakere site 2 (HSO1)	BIS standards for Surface waters
pH	7.25	7.58	6.5-9
Electric conductivity (µS/cm)	401.00	335.00	<1200
Total dissolved solids (ppm)	260.00	233.00	<700
Dissolved oxygen (mg/L)	7.50	8.20	>5
Biological oxygen demand (ppm)	3.32	4.59	<5
Chemical oxygen demand (ppm)	18.67	18.00	<30
Nitrates (ppm)	0.246	0.842	--
Inorganic phosphates (ppm)	0.004	0.083	--
Total hardness (mg/L)	116.00	96.00	<200
Calcium hardness (mg/L)	79.97	55.97	<80
Chlorides (mg/L)	42.60	45.44	<250
Total alkalinity (mg/L)	180.00	168.00	<600

Water quality variables of Hosakere Lake is listed in Table 10. pH was showing neutral condition with a range of 7.25-7.58. Conductivity of lake was recorded as 335-401 µS/cm while total dissolved solids were 233-260 ppm. The oxygen demand was very less and within the BIS standard values with an average of 3.96 and 18.33 ppm respectively which reflected the no influence of organic matter in lake. There is no/ minimal sewage inflow into the lake and hence the chlorides level was within the limits with a value ranges from 42.6-45.44 mg/L. The shoreline region attacked several birds and dissolved oxygen level attributed to presence of fish diversity in lake. The water color was observed as clear with no macrophyte cover.

CURRENT THREATS (Refer Figure 10 and Plate 10)

Local human disturbances (Open defecation, washing clothes)

PLATE 10

11. HULIMAVU LAKE

NAME OF THE LAKE	HULIMAVU LAKE
GEOGRAPHIC DETAILS	12°52'13"N 77°36'18"E
AREA	44.26 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	193- Arekere
STATUS	Polluted
RESTORATION	NO
WATER CONDITION	Poor.

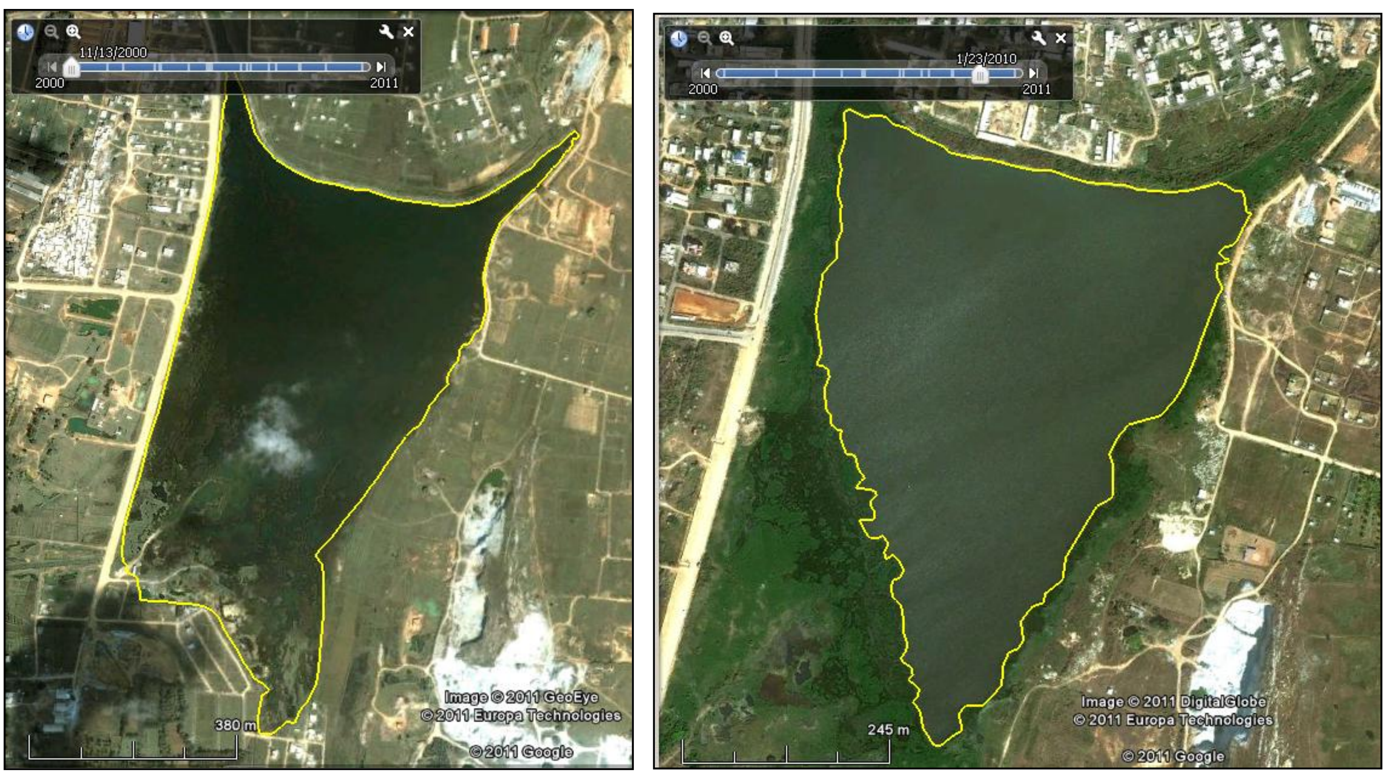


Figure 11 Google Earth and area of Hulimavu Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 11 Water quality of Hulimavu Lake with BIS standards

Sampling site	Hulimavu outlet (HLO1)	Hulimavu inlet (HLI1)	BIS standards for Surface waters
pH	8.53	8.23	6.5-9
Electric conductivity (µS/cm)	1072.00	1070.00	<1200
Total dissolved solids (ppm)	753.00	759.00	<700
Dissolved oxygen (mg/L)	7.2	2.39	>5
Biological oxygen demand (ppm)	22.3679	26.66666667	<5
Chemical oxygen demand (ppm)	49.92	52.98	<30
Nitrates (ppm)	0.01	0.05	--
Inorganic phosphates (ppm)	0.21	0.17	--
Total hardness (mg/L)	240	232	<200
Calcium hardness (mg/L)	91.88	123.91	<80
Chlorides (mg/L)	261.28	232.88	<250
Total alkalinity (mg/L)	380	520	<600

Chemical variables analyzed are listed in table 11. Hulimavu inlet water quality was distinctive form that of outlet. High amount of ionic concentration was characteristic of untreated sewage inflow and its effects on both the sampling sites. Biological oxygen demand and chemical oxygen demand ranged from 22.367-26.66 ppm and 49.92-52.98 ppm respectively exceeding the BIS standard limits which reflected the presence of organic matter. The source of organic pollution has been accounted for inflow of contaminated water. A high quantity of calcium hardness could also be observed due to increased amount of soap content in water.

CURRENT THREATS (Refer Figure 11 and Plate 11)

a. Dumping of construction waste on lake bund

b. Local human disturbances such as washing clothes, open defecation, fishing

c. Untreated sewage inflow into the lake

PLATE 11


CONSTRUCITON WORK


STONE MINING


MACROPHYTE COVER


WASTE DUMPING IN LAKE

12. ISRO LAYOUT LAKE

NAME OF THE LAKE	ISRO layout LAKE/ DEVERAKERE
GEOGRAPHIC DETAILS	12°53'52"N 77°33'18"E
AREA	10.5 ha
ORGANIZATION	FOREST DEPT.
WARD / VILLAGE NAME	ISRO layout
STATUS	Moderate pollution
RESTORATION	Completed ()
WATER CONDITION	Poor.

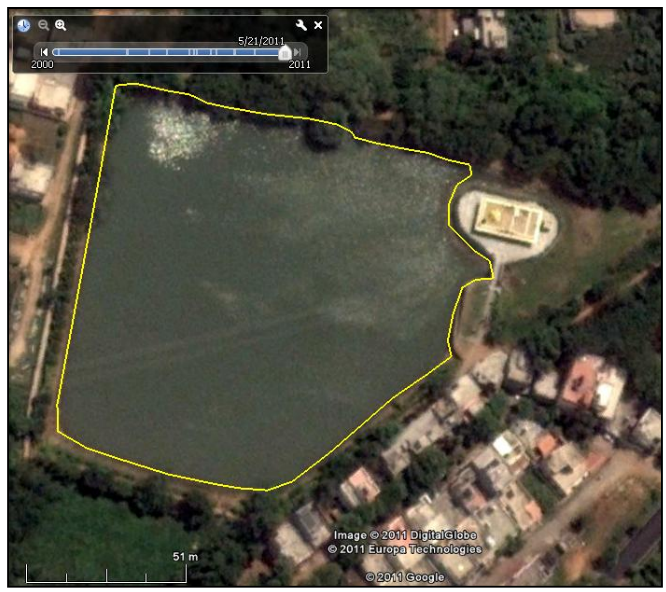


Figure 12 Google Earth and area of ISRO layout Lake during 2000 and 2011 respectively.

WATER QUALITY

Table 12 Water quality of ISRO Layout Lake with BIS standards

Sampling site	ISRO layout inlet (IRI1)	ISRO layout Outlet (IRO1)	BIS standards for Surface waters
pH	9.78	9.85	6.5-9
Electric conductivity (µS/cm)	1041.00	1030.00	<1200
Total dissolved solids (ppm)	725.00	719.00	<700
Dissolved oxygen (mg/L)	9.76	6.42	>5
Biological oxygen demand (ppm)	24.22	22.58	<5
Chemical oxygen demand (ppm)	53.33	50.67	<30
Nitrates (ppm)	0.432	3.797	--
Inorganic phosphates (ppm)	1.691	1.251	--
Total hardness (mg/L)	352.00	316.00	<200
Calcium hardness (mg/L)	259.93	239.94	<80
Chlorides (mg/L)	195.96	195.96	<250
Total alkalinity (mg/L)	460.00	360.00	<600

Water quality analyzed for ISRO Layout Lake has been listed in Table 12. Variation in water quality was observed in terms of Biological oxygen demand (BOD) and Chemical oxygen demand (COD) concentration in both the sampling sites. BOD and COD ranged from 22.58-24.22 ppm and 50.67-53.33 ppm respectively. Inorganic phosphate concentration was found to be high (range, 1.251-1.69 ppm), which led to lake Eutrophication. Total hardness of water ranged from 316-352 mg/L exceeding the BIS limits because of temple waste accumulation in lake bed. Even though, the lake water reveals low ionic concentration, it is slightly polluted with high organic matter due to the local human disturbances such as inflow of temple waste water and materials such as plastics, garlands etc., in lake water.

CURRENT THREATS (Refer Figure 12 and Plate 12)

a. Dumping of garbage, Foul smell, Poor maintenance,
b. Sewage of ISRO layout to lake inflow, Temple waste, etc.

PLATE 12


SEWAGE INFLOE SITE


THERMACOL WASTE IN LAKE WATER

13. JAKKUR LAKE

NAME OF THE LAKE	JAKKUR LAKE
GEOGRAPHIC DETAILS	13°5'12"N 77°36'34"E
AREA	59 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Jakkur
STATUS	Moderate pollution
RESTORATION	August 2009- August 2010 (Incomplete)
WATER CONDITOIN	Poor (Before restoration)

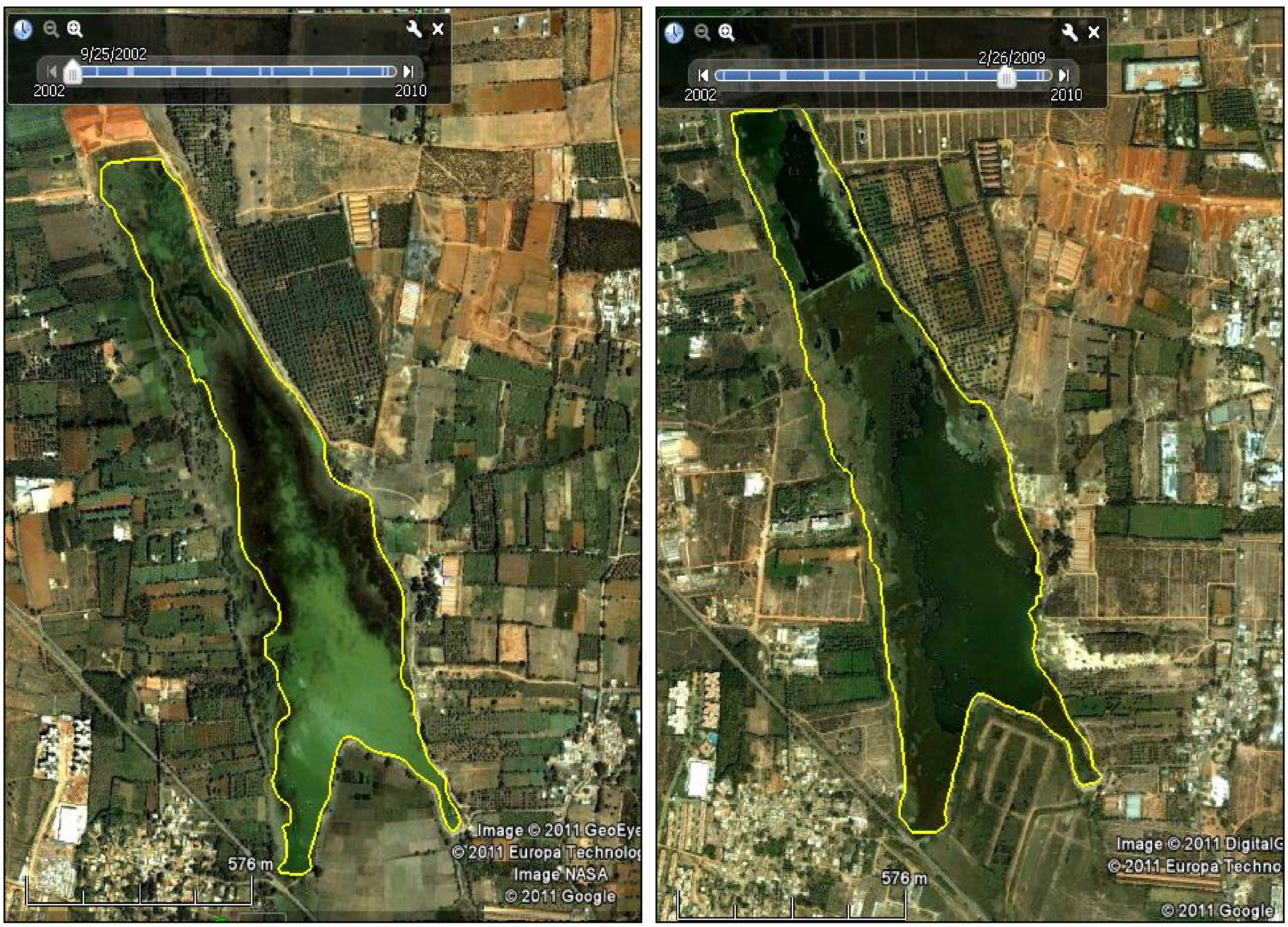


Figure 13 Google Earth and area of Jakkur Lake during 2002 and 2009 respectively.

WATER QUALITY

Table 13 Water quality of Jakkur Lake with BIS limits mentioned.

Sampling site	Jakkur Inlet (JKI1)	Jakkur Outlet (JKI2)	BIS standards for Surface waters
pH	8.02	8.07	6.5-9
Electric conductivity (µS/cm)	1240.33	1325.67	<1200
Total dissolved solids (ppm)	870.67	947.00	<700
Dissolved oxygen (mg/L)	4.67	6.91	>5
Biological oxygen demand (ppm)	24.20	23.60	<5
Chemical oxygen demand (ppm)	79.31	48.72	<30
Nitrates (ppm)	0.016	0.015	--
Inorganic phosphates (ppm)	0.026	0.030	--
Total hardness (mg/L)	326.67	346.67	<200
Calcium hardness (mg/L)	93.33	100.00	<80
Chlorides (mg/L)	286.84	295.36	<250
Total alkalinity (mg/L)	163.33	163.33	<600

Among all water quality variables listed in Table 13, Electric conductivity (range, 1240.33-1325.67 µS/cm), total dissolved solids (range, 870.67-947 ppm) and chlorides (range, 286.84- 295.36 mg/L) concentrations showed a higher values at both sampling sites which was beyond the BIS standards as mentioned in Table 13. This water condition was representing characteristic polluted water due to improper maintenance of sewage inflow at inflow region. Organic content in lake was high at inflow with 79.31 ppm of COD and 24.2 ppm of BOD while a lesser concentration at outlet region i.e., 48.72 ppm and 23.6 ppm respectively. Higher hardness and calcium at both the sites revealed higher pollution due to increased human disturbances such as washing clothes, waste dumping etc. macrophyte cover at inflow showed a lower oxygen penetration rate and hence low oxygen level compared to outlet region.

CURRENT THREATS (Refer Figure 13 and Plate 13)

a. Domestic sewage run-off of Jakkur village,
b. urbanization
c. Inflow of fields and plantations surrounding lake

PLATE 13


APPARTMENT IN LAKE BED


ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
BANGALORE DEVELOPMENT AUTHORITY
NAME OF WORK: RESTORATION & OVERALL DEVELOPMENT
OF JAKKUR-SAMPIGEHALLI LAKE
COST OF ESTIMATE: Rs 2191-00 LAKHS
NAME OF CONTRACTOR: M/S R.M.N. INFRASTRUCTURES Ltd
DCF
PERIOD OF COMPLETION: 12 MONTHS
BDA
DATE OF COMMENCEMENT: 17-07-2009
B'lore
DATE OF COMPLETION: 16-07-2010.

14. KANNUR LAKE

NAME OF THE LAKE	KANNUR LAKE
GEOGRAPHIC DETAILS	13°6'0"N 77°39'4"E
AREA	20.5 ha
ORGANIZATION	Outskirts of BBMP boundary
WARD / VILLAGE NAME	Kannur
STATUS	Moderately polluted
RESTORATION	NO
WATER CONDITION	Clean- Moderate pollution

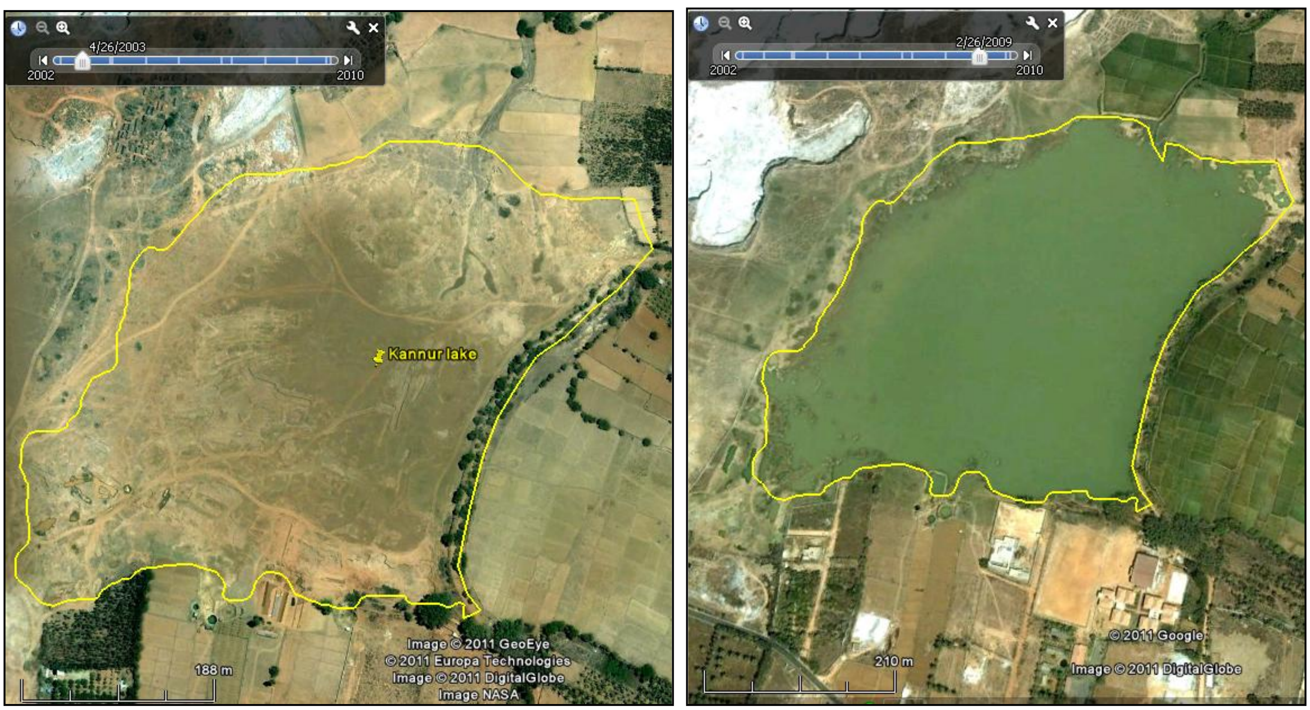


Figure 14 Google Earth and area of Kannur Lake during 2003 and 2009 respectively.

WATER QUALITY

Table 14 water quality of Kannur Lake with BIS standards

Sampling site	Kannur site 1 (KNR1)	Kannur site 2 (KNR2)	BIS standards for Surface waters
pH	8.57	8.16	6.5-9
Electric conductivity (µS/cm)	478	505	<1200
Total dissolved solids (ppm)	331	357	<700
Dissolved oxygen (mg/L)	10.57	10.89	>5
Biological oxygen demand (ppm)	6.36	5.49	<5
Chemical oxygen demand (ppm)	22.72	20.98	<30
Nitrates (ppm)	0.01	0.02	--
Inorganic phosphates (ppm)	0.11	0.14	--
Total hardness (mg/L)	111	93	<200
Calcium hardness (mg/L)	70.5	61.5	<80
Chlorides (mg/L)	62	43	<250
Total alkalinity (mg/L)	132	160	<600

The water quality of Kannur Lake revealed less or no impact of sewage and contamination at both the sampling sites. All the chemical variables analysed were well within the BIS surface water standards except an alkaline range pH. BOD values were slightly above the BIS limits reasoning the organic pollution due to local human disturbances such as open defecation, washing clothes, mining and inflow of agricultural waste into lake water. A good amount of oxygen availability was recorded and thus inhabits fish diversity.

CURRENT THREATS (Refer Figure 14 and Plate 14)

a. Mining
b. Local human disturbances
c. Agricultural run-off

PLATE 14

15. KOMMAGHATTA LAKE

NAME OF THE LAKE	KOMMAGHATTA LAKE
GEOGRAPHIC DETAILS	12°55'48"N 77°28'2"E
AREA	ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Kommaghatta
STATUS	Clean/ No pollution
RESTORATION	September 2009- August 2010 (COMPELTED)
WATER CONDITION	Good.

Figure 15 Google Earth image and area of Kommaghatta Lake during 2000 and 2011 respectively.

WATER QUALITY

Table 15 Water quality of Kommaghatta Lake with BIS standards

Sampling site	Kommaghatta inlet 1 (KMI1)	Kommaghatta inlet 2 (KMI2)	Kommaghatta outlet (KMO1)	BIS standards for Surface waters
pH	9.32	9.01	8.98	6.5-9
Electric conductivity (µS/cm)	812.00	782.00	764.50	<1200
Total dissolved solids (ppm)	594.00	558.00	548.50	<700
Dissolved oxygen (mg/L)	5.98	4.55	6.14	>5
Biological oxygen demand (ppm)	12.96	25.30	13.71	<5
Chemical oxygen demand (ppm)	24.00	84.00	28.00	<30
Nitrates (ppm)	0.049	0.056	0.066	--
Inorganic phosphates (ppm)	0.038	0.020	0.022	--
Total hardness (mg/L)	264.00	298.00	286.00	<200
Calcium hardness (mg/L)	24.05	15.23	32.87	<80
Chlorides (mg/L)	121.41	109.48	119.42	<250
Total alkalinity (mg/L)	276.00	248.00	170.00	<600

Water quality analyzed for Kommaghatta Lake before restoration has been mentioned in table 15. Inlet water pH exceeding the BIS limits ranging from 8.98-9.32. Dissolved oxygen level was less at inlet sites while was 6.14 mg/L at outlet. Organic matter was reflected by high amount of Biological and chemical oxygen demand which ranged from 12.96-25.30 ppm and 24-84 ppm respectively. Higher amount of hardness was also recorded at inlet 2 (298 mg/L) and outlet (286 mg/L) which was reasoning the local human disturbances and domestic sewage concentration. The lake before restoration was polluted with organic matter which has been reduced after restoration but lacks the biodiversity present prior to restoration.

CURRENT THREATS (Refer Figure 15 and Plate 15)

Untreated sewage and road runoff

PLATE 15

16. KAMMAGONDANAHALLI LAKE

NAME OF THE LAKE	KAMMAGONDANAHALLI LAKE
GEOGRAPHIC DETAILS	13°3'54"N 77°31'41"E
AREA	11.29 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	12- Shettihalli
STATUS	Highly Polluted
RESTORATION	NO
WATER CONDITION	Poor

Figure 16 Google Earth image and area of Kommagondanahalli Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 16 Water quality of Kommagondanahalli Lake with BIS standards

Sampling site	Kommagondanahalli outlet (KMH1)	Kommagondanahalli inlet (KMH2)	BIS standards for Surface waters
pH	8.73	8.08	6.5-9
Electric conductivity (µS/cm)	419.00	1452.00	<1200
Total dissolved solids (ppm)	329.00	1136.00	<700
Dissolved oxygen (mg/L)	7.30	8.60	>5
Biological oxygen demand (ppm)	23.32	19.33	<5
Chemical oxygen demand (ppm)	50.92	45.21	<30
Nitrates (ppm)	0.68	0.58	--
Inorganic phosphates (ppm)	1.120	1.340	--
Total hardness (mg/L)	277	281	<200
Calcium hardness (mg/L)	238.00	215.00	<80
Chlorides (mg/L)	233	256	<250
Total alkalinity (mg/L)	220	234	<600

Water quality of Kommagondanhalli Lake has been listed in Table 16. Significant change has been noticed in terms of water quality from inlet to outlet. Inlet sampling site had high concentration of electric conductivity (1452 µS/cm), total dissolved solids (1136 ppm), phosphates (1.340 ppm), total hardness (281 mg/L) and calcium (215 mg/L). Organic matter measured through biological and chemical oxygen demand was recorded more than the BIS limits for surface standards. This was due to the dumping of solid waste, plastic waste near the outlet while the untreated sewage inflow accounted for pollution at inlet site. A high macrophyte cover occupied one side of the lake and led to the Eutrophication of lake.

CURRENT THREATS (Refer Figure 16 and Plate 16)

a. Dumping of solid and construction waste on lake bund
b. Growth of macrophyte and thus Eutrophication
c. Local human disturbances.

PLATE 17

DUMPING OF CONSTRUCTION WASTE

WATER EUTROPHICATION


WEED COVER

Contents

17. KONASANDRA LAKE

NAME OF THE LAKE	**KONASANDRA LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°53'32"N 77°29'1"E
AREA (2000/2010)	12.07/11.94 ha
ORGANIZATION	BDA
WARD/ VILLAGE NAME	Konasandra
STATUS	Moderately pollution
RESTORATION	2009- 2010 (Incomplete)
WATER CONDITION	Clean – Moderately polluted.

Figure 1 Google Earth image and area of Konasandra Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 1 Water quality of Konasandra Lake with BIS limits

Sampling site	Konasandra fensinf side (KNFN)	Konasandra inlet (KNI1)	Konasandra outlet (KNO1)	Konasandra layout (KNLY)	BIS standards for Surface waters
pH	8.80	8.97	8.69	8.80	6.5-9
Electric conductivity (µS/cm)	792.00	766.00	825.67	718.00	<1200
Total dissolved solids (ppm)	551.33	537.67	582.00	548.00	<700
Dissolved oxygen (mg/L)	6.37	7.28	6.11	6.41	>5
Biological oxygen demand (ppm)	12.63	13.44	10.75	12.35	<5
Chemical oxygen demand (ppm)	38.67	39.33	26.67	30.67	<30
Nitrates (ppm)	0.067	0.058	0.070	0.067	--
Inorganic phosphates (ppm)	0.015	0.005	0.007	0.006	--
Total hardness (mg/L)	88.67	80.00	85.33	86.00	<200
Calcium hardness (mg/L)	22.98	23.99	24.90	22.98	<80
Chlorides (mg/L)	69.20	41.75	71.95	57.46	<250
Total alkalinity (mg/L)	406.00	327.33	398.00	334.67	<600

Water quality of Konasandra Lake is listed in Table 17. pH ranged from 8.69- 8.8. Electric conductivity and total dissolved solids ranged from 718-825.67 µS/cm and 537.67-582 ppm respectively. Biological oxygen demand was slightly higher than the BIS permissible limit while chemical oxygen demand was found higher at inlet site (39.33 ppm). Nutrients such as nitrates and inorganic phosphates were in minimal concentration. The amount of hardness in water reflected less influence of sewage and other human disturbances on water quality of Konasandra. The main source of pollution was observed due to dumping of solid waste along with construction waste near the lake bed.

CURRENT THREATS (Refer Figure 17 and Plate 17)

a. Sewage inflow
b. Local human disturbances such as washing clothes, swimming, open defecation
c. Weed cover
d. Dumping of solid waste

PLATE 17


RESTORATION WORK


ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಕೆಲಸದ ಹೆಸರು : ಕೋನಸಂದ್ರ ಕೆರೆಯ ಪುನಃಶ್ಚೇತನ ಮತ್ತು
ಸಮಗ್ರ ಅಭಿವೃದ್ಧಿ ಕಾಮಗಾರಿ
ಅಂದಾಜು ಮೊತ್ತ : ರೂ. 610.00 ಲಕ್ಷಗಳು
ಟೆಂಡರಿಗಿಟ್ಟ ಮೊತ್ತ : ರೂ. 550.61 ಲಕ್ಷಗಳು
ಗುತ್ತಿಗೆದಾರರ ಹೆಸರು : ಮೆ|| ರೆಡ್ಡಿ ವೀರಣ್ಣ ಕನ್ಸಟ್ರಕ್ಷನ್ಸ್ ಲಿ.,
ಪ್ರಾರಂಭಿಕ ದಿನಾಂಕ : 30.07.2009
ಮುಕ್ತಾಯದ ದಿನಾಂಕ : 29.07.2010
ಗುತ್ತಿಗೆಯ ಅವಧಿ : 12 ತಿಂಗಳು
ಸಹಿ/-
ಉಪ ಅರಣ್ಯ ಸಂರಕ್ಷಣಾಧಿಕಾರಿ
ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಬೆಂಗಳೂರು
ಸಹಿ/-
ಆಯುಕ್ತರು
ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಬೆಂಗಳೂರು

18. KOTHNUR LAKE

NAME OF THE LAKE	KOTHNUR LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°52'24"N 77°34'48"E
AREA (2000/2011)	5.982/4.08 ha
ORGANIZATION	187- Puttenahalli
WARD / VILLAGE NAME	JP Nager
STATUS	High pollution
RESTORATION	July 2009 – July 2010 (Incomplete)
WATER CONDITION	Pre restoration-Polluted, Post restoration- Polluted.

Figure 2 Google Earth image and area of Kothanur Lake during 2000 and 2011 respectively.

WATER QUALITY

Table 2 Water quality of Kothanur Lake with BIS limits

Sampling site	Kothanur inlet (KTI1)	Kothanur outlet (KTO1)	BIS standards for Surface waters
pH	9.13	9.12	6.5-9
Electric conductivity (µS/cm)	681.00	653.00	<1200
Total dissolved solids (ppm)	472.00	467.00	<700
Dissolved oxygen (mg/L)	6.91	7.56	>5
Biological oxygen demand (ppm)	22.58	21.22	<5
Chemical oxygen demand (ppm)	51.00	42.00	<30
Nitrates (ppm)	0.068	0.079	--
Inorganic phosphates (ppm)	0.056	0.056	--
Total hardness (mg/L)	182.50	167.50	<200
Calcium hardness (mg/L)	125.05	123.05	<80
Chlorides (mg/L)	242.00	239.16	<250
Total alkalinity (mg/L)	194.00	192.00	<600

Water quality variation among sampling sites of Kothanur Lake has been listed in Table 18. pH was highly alkaline in condition ranging from 9.12-9.13. Electric conductivity and dissolved solids were well within the BIS standard for surface waters while the chloride concentration was found to be as high as 242 mg/L at inlet and 239 mg/L at outlet which revealed domestic sewage as the major source. Both the biological and chemical demand for oxygen was increased at both the sampling sites ranging from 21.22-22.58 ppm and 42-51 ppm respectively. The Lake immediate surrounding was occupied by apartments which led to the pollution into the Lake through sewage, dumping waste and washing vehicles. Even though the restoration work was in process, black, foul odor water was characteristic of untreated sewage inflow into the Lake which also carried plastic and other waste along with it.

CURRENT THREATS (Refer Figure 18 and Plate 18)

a. Sewage inflow,
b. Construction of apartment in lake bed, dumping of waste in surrounding area
c. Eutrophication, Algal bloom was observed
d. Sewage inflow even after restoration

PLATE 18


ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಅಂದಾಜು : ರೂ. 360:00. ಲಕ್ಷಗಳು.
ಟೆಂಡರಿಗಿಟ್ಟ ಮೊತ್ತ : ರೂ. 293:43. ಲಕ್ಷಗಳು.
ಪ್ರಾರಂಭಿಕ ದಿನಾಂಕ : 30:07:2009.
ಮುಕ್ತಾಯದ ದಿನಾಂಕ : 29:07:2010.
ಸಹಿ/-
ಆಯುಕ್ತರು
ಬೆಂಗಳೂರು ಅಭಿವೃದ್ಧಿ ಪ್ರಾಧಿಕಾರ
ಬೆಂಗಳೂರು.


MACROALGAL MAT NEAR INLET

WASTE WATER NEAR INLET AFTER RESTORATION

LOCAL HUMAN DISTURBANCES

19. MADIVALA LAKE

NAME OF THE LAKE	**MADIWALA LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°54'23"N 77°36'57"E
AREA (2000/2009)	93.11/85.6 ha
ORGANIZATION	BBMP/ Forest dept.
WARD / VILLAGE NAME	188- Bilekhalli
STATUS	High pollution
RESTORATION	Completed (Year)
WATER CONDITION	Polluted.

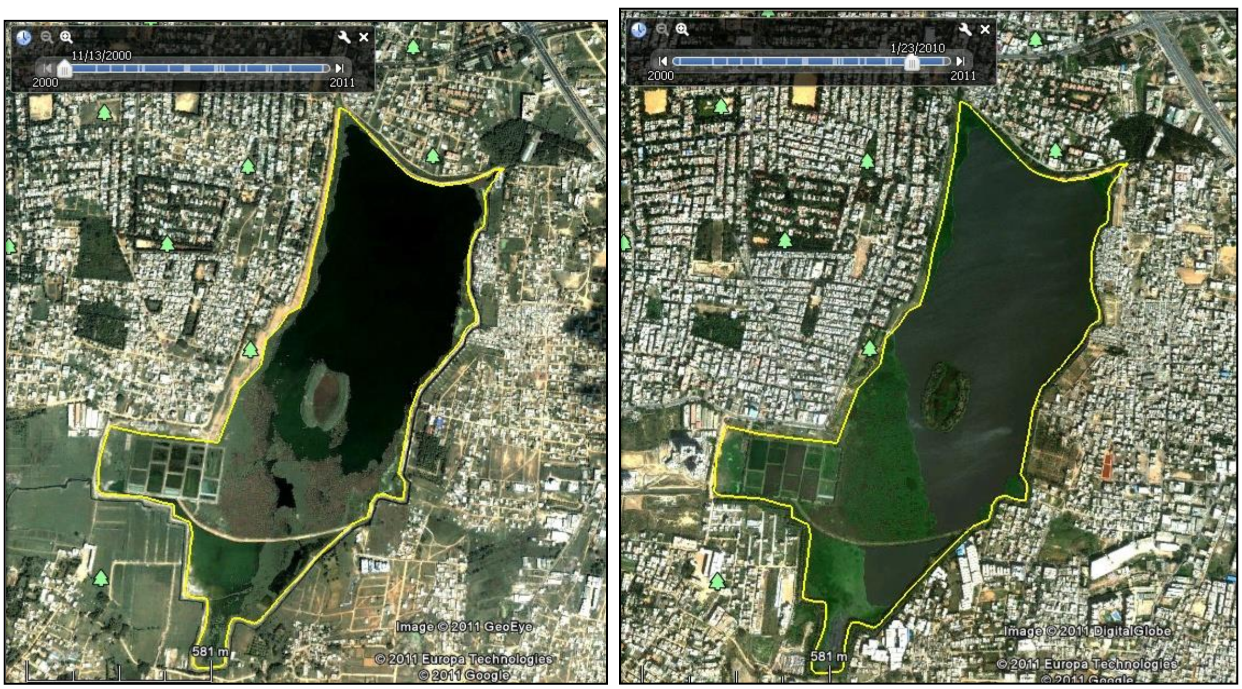


Figure 3 Google Earth image and area of Madivala Lake during 2000 and 2010 respectivley.

WATER QUALITY

Table 3 Water quality of Madivala Lake with BIS limts

Sampling site	Madivala inlet (MDI1)	Madivala outlet (MDO1)	BIS standards for Surface waters
pH	8.41	8.35	6.5-9
Electric conductivity (µS/cm)	775.00	759.00	<1200
Total dissolved solids (ppm)	538.00	532.00	<700
Dissolved oxygen (mg/L)	8.37	8.13	>5
Biological oxygen demand (ppm)	22.00	19.48	<5
Chemical oxygen demand (ppm)	52.43	49.02	<30
Nitrates (ppm)	0.585	0.486	--
Inorganic phosphates (ppm)	0.023	0.120	--
Total hardness (mg/L)	201.20	194.00	<200
Calcium hardness (mg/L)	131.54	102.73	<80
Chlorides (mg/L)	130.64	143.42	<250
Total alkalinity (mg/L)	246.00	240.00	<600

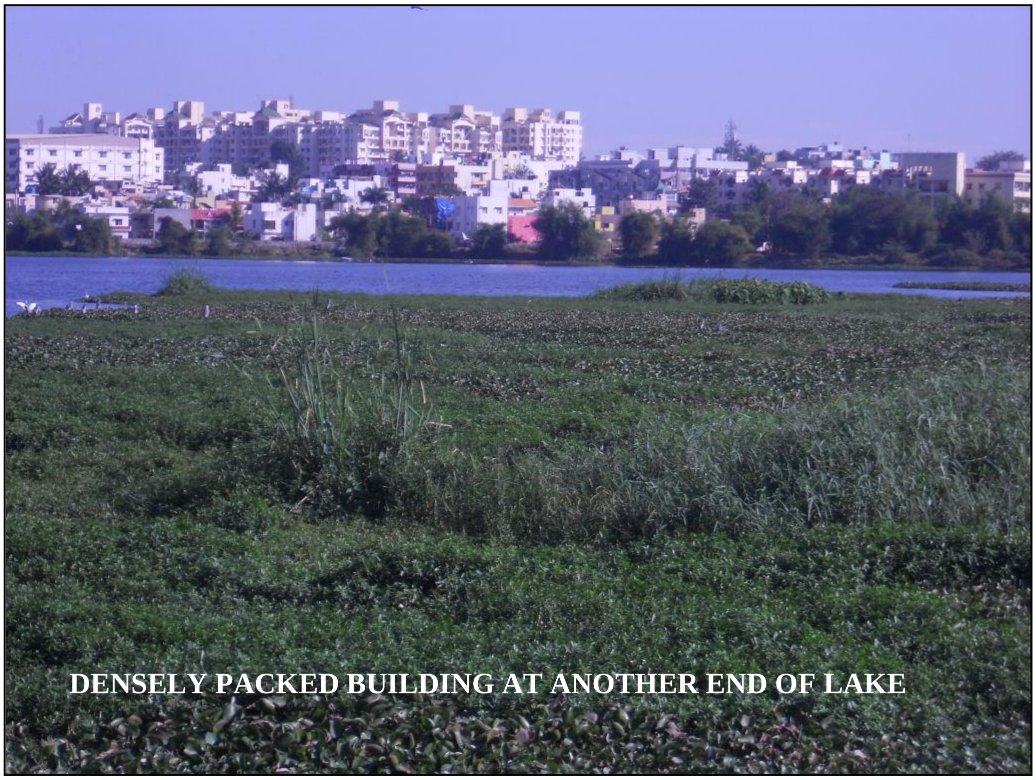
Variation in water quality of Madivala Lake is listed in Table 19. Water quality results showed the significant organic pollution through biological and chemical oxygen demand which ranged higher than that of BIS surface standards. Nutrients did not vary much which could also add to Eutrophication of water. Among all variables total hardness and calcium hardness ranged in higher concentration i.e., 194-201.2 mg/L and 102.73-131.54 mg/L respectively which clearly showed the sewage and local human disturbances influenced the water quality. The fisherman revealed that the fish diversity has been declined and frequent fish death resulted due to increased organic concentration in lake. The built-up area in catchment has been increased which could increase the pollution load. Even though this lake has been restored, improper maintenance of lake has led to dumping of waste and spoiled the lake water.

CURRENT THREATS (Refer Figure 19 and Plate 19)

a. Sewage inflow
b. Construction of apartment in lake bed
c. Dumping of solid waste surrounding lake
d. Local human disturbances such as washing clothes, swimming, open defecation

PLATE 19

MASSIVE MACROPHYTE COVER AT ONE SIDE OF THE LAKE



DENSELY PACKED BUILDING AT ANOTHER END OF LAKE

DUMP OF PLASTIC WASTE AND HENCE ALGAL BLOOM

20. MALLATHAHALLI LAKE

NAME OF THE LAKE	MALLATHAHALLI LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°57'56"N 77°29'41"E
AREA (2000/2009)	22.89/21.87 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Mallathahalli
STATUS	Moderate pollution
RESTORATION	July 2009 – July 2010 (Incomplete)
WATER CONDITION	Polluted.

Figure 4 Google Earth image and area of Mallathahalli Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 4 Water quality of Mallathahalli Lake

Sampling site	Mallathahalli outlet (MLO1)	Mallathahalli inlet (MLI1)	BIS standards for Surface waters
pH	9.28	10.30	6.5-9
Electric conductivity (µS/cm)	1105.00	1160.00	<1200
Total dissolved solids (ppm)	803.00	807.00	<700
Dissolved oxygen (mg/L)	7.44	9.39	>5
Biological oxygen demand (ppm)	20.80	38.58	<5
Chemical oxygen demand (ppm)	42.00	110.00	<30
Nitrates (ppm)	0.062	0.072	--
Inorganic phosphates (ppm)	0.046	0.064	--
Total hardness (mg/L)	302.00	278.00	<200
Calcium hardness (mg/L)	124.05	132.87	<80
Chlorides (mg/L)	106.50	214.42	<250
Total alkalinity (mg/L)	301.00	252.00	<600

Mallathahalli Lake water showed higher values for all the chemical variables which affected the growth of aquatic organisms. pH at both the sampling sites was in high alkaline range while, nutrient concentration was ranged as 0.062-0.072 ppm of nitrates and 0.046-0064 ppm of inorganic phosphates. The increased amount of sewage from upstream built- up resulted in increased organic matter in water along with high amount of hardness in water (range, 278-302 ppm). In later period, the lake water turned gradually to green in color because of algal bloom and led to fish death during 2009. Although the restoration work is in progress, the aquatic weeds have massively spread across region and consequently a decrease in oxygen level was recorded.

CURRENT THREATS (Refer Figure 20 and Plate 20)

a. Sewage inflow
b. Construction of buildings, dumping of waste in surrounding area
c. Eutrophication, Algal bloom was observed
d. Fishing.

PLATE 20

EUTROPHIC GREEN WATER PRIOR TO RESTORATION

21. MALSANDRA LAKE

NAME OF THE LAKE	MALSANDRA KERE
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°3'29"N 77°31'5"E
AREA (2000/2010)	2.278/0.9722 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	12- Shettihalli
STATUS	Less polluted
RESTORATION	NO
WATER CONDITION	Clean- Moderate pollution.

Figure 5 Google Earth image and area of Malsandra Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 5 Water quality of Malsandra Lake with BIS standards mentioned

Sampling site	Malsandra site 1 (MLA1)	Malsandra site 2 (MLA2)	BIS standards for Surface waters
pH	9.23	8.9	6.5-9
Electric conductivity (µS/cm)	835	790	<1200
Total dissolved solids (ppm)	658	565	<700
Dissolved oxygen (mg/L)	8.13	10.57	>5
Biological oxygen demand (ppm)	12.93	14.59	<5
Chemical oxygen demand (ppm)	80.00	42.67	<30
Nitrates (ppm)	0.03	0.056	--
Inorganic phosphates (ppm)	0.24	0.18	--
Total hardness (mg/L)	108	136	<200
Calcium hardness (mg/L)	72.34	96.25	<80
Chlorides (mg/L)	192.24	214.92	<250
Total alkalinity (mg/L)	268	243	<600

Water quality of Malsandra at different sampling sites has been listed in Table 21. pH of water ranged from 8.9- 9.23 while the oxygen level was as well significantly high indicating photosynthetic activity. Biological oxygen demand and chemical oxygen demand was higher at site 2 than at site 1 which was near road construction and stone mining. Total hardness ranged for 108-136 mg/L whereas calcium hardness was recorded as high at both the sampling sites i.e., ranging from 72.34- 96.25 mg/L. The lake water is clear and very less or no sewage inflow was observed into the lake and thus, the ionic concentration and total dissolved solids values were within the permissible limits.

CURRENT THREATS (Refer 21 and Plate 21)

a. No defined lake boundary
b. Human disturbances such as washing clothes, Open Defecation.

PLATE 21

22. MUTHANALLUR LAKE

NAME OF THE LAKE	**MUTHANALLUR KERE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°49'23"N 77°43'40"E
AREA (2002/2009)	110.8/106.4 ha
ORGANIZATION	BBMP
WARD NAME	Anekal taluk
STATUS	Clean/ No pollution
RESTORATION	NO
WATER CONDITION	Clean.

Figure 6 Google Earth image and area of Muthanallur Lake during 2004 and 2009 respectively.

WATER QUALITY

Table 6 Water quality of Muthanallur Lake with BIS limits

Sampling site	Muthanallur site 1 (MTR1)	Muthanallur site 2 (MTR2)	BIS standards for Surface waters
pH	8.75	8.1	6.5-9
Electric conductivity (µS/cm)	1218	901	<1200
Total dissolved solids (ppm)	954	890	<700
Dissolved oxygen (mg/L)	8.13	9.76	>5
Biological oxygen demand (ppm)	7.35	5.89	<5
Chemical oxygen demand (ppm)	24.7	21.78	<30
Nitrates (ppm)	0.08	0.064	--
Inorganic phosphates (ppm)	0.22	0.29	--
Total hardness (mg/L)	93	90.2	<200
Calcium hardness (mg/L)	61.5	60.1	<80
Chlorides (mg/L)	119	123	<250
Total alkalinity (mg/L)	249	234	<600

Muthanallur Lake water along with BIS limits has been listed in Table 22. The highest ionic concentration of 1218 µS/cm and lowest of 901 was recorded at site 1 and site 2 respectively. Except the slight high amount of biological and chemical oxygen demand, all the chemical variables were well within the BIS permissible limits which resulted in good water quality. Muthanallur was found less affected by any anthropogenic activities but certainly higher values of electric conductivity and total dissolved solids require immediate attention and conservation of lake.

CURRENT THREATS (Refer Figure 22 and Plate 22)

a. Washing clothes, Open Defecation
b. Sewage from Electronic city (Initial stage).

PLATE 22

23. NELAGADARENAHALLI/ NARASAPPANAHALLI LAKE

NAME OF THE LAKE	**NARASAPPANAHALLI / NELAGADARANAHALLI LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°1'14"N 77°29'49"E
AREA (2000/2010)	17.81/15.01 ha
ORGANIZATION	BBMP
WARD NAME	41-Peenya Industrial Area
STATUS	Highly Polluted
RESTORATION	NO
WATER QUALITY	Poor

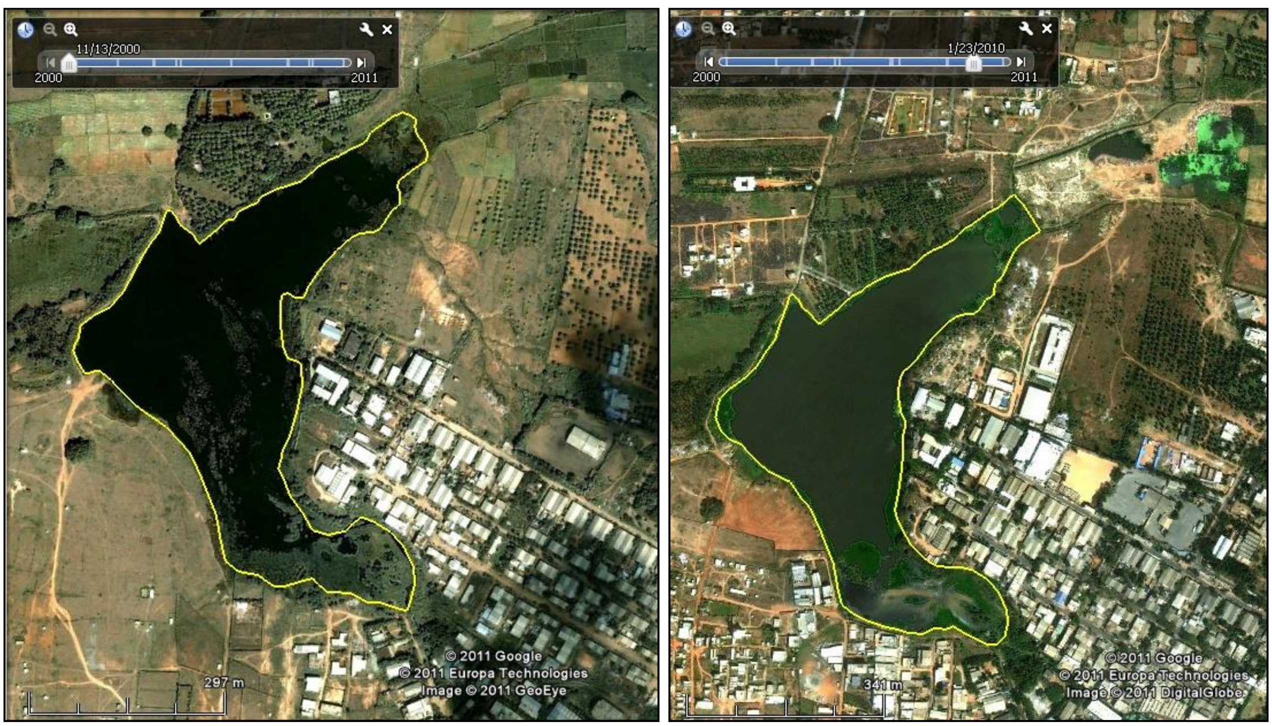


Figure 7 Google earth image and area of Nelagadarenahalli Lake during 2000 and 2010 respectively

WATER QUALITY

Table 7 Water quality of Nelagedarahalli Lake with BIS limits

Sampling site	Nelag. Halli outlet (NRO1)	Nelag. Halli inlet (NRI1)	BIS standards for Surface waters
pH	8.36	8.71	6.5-9
Electric conductivity (µS/cm)	11160	10890	<1200
Total dissolved solids (ppm)	7790	7530	<700
Dissolved oxygen (mg/L)	5.36	0.00	>5
Biological oxygen demand (ppm)	39.02	34.73	<5
Chemical oxygen demand (ppm)	83.02	90.321	<30
Nitrates (ppm)	0.5078	0.44488	--
Inorganic phosphates (ppm)	0.375117	0.23439	--
Total hardness (mg/L)	712	820	<200
Calcium hardness (mg/L)	623.9298112	735.9330016	<80
Chlorides (mg/L)	843.48	874.72	<250
Total alkalinity (mg/L)	380	360	<600

Nelakondossi Lake water quality (Table 23) reflected high contamination of water with Eutrophication status. Alkaline pH ranged from 8.36- 8.71. Electric conductivity and total dissolved solids were very high in concentration i.e., 10890- 11160 µS/cm and 7530- 7790 ppm respectively. Dissolved oxygen was found to be as low as zero at inlet site because of higher amount of sewage and industrial waste from nearby industries. The low oxygen was also due to massive growth of water hyacinth and thus the increased organic pollution. The lake bed occupied with small scale industries and water at one side was completely covered with plastic and other waste dumps. Chloride and hardness concentration were observed to be more than the BIS standard limits for surface water because of their high concentration let in to the lake. No fish were found at this high amount of pollution while inhabited water birds.

CURRENT THREATS (Refer Figure 23 and Plate 23)

a. No defined lake boundary
b. Washing clothes, Open Defecation,
c. Construction of buildings next to lake bed
d. Dumping of solid waste, Industrial waste.

PLATE 23


ENCROACHMENTS IN LAKE BED

24. NELAKONDODDI LAKE

NAME OF THE LAKE	**NELAKONDODDI KERE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°48'22"N 77°31'47"E
AREA (2004/2011)	9.074/14.75 ha
ORGANIZATION	BBMP (Outskirts of Bangalore BBMP Boundary)
WARD / VILLAGE NAME	Nelakondoddi
STATUS	Clean/ No pollution
RESTORATION	NO
WATER CONDITION	Clean.

Figure 8 Google Earth image and area of Nelakondoddi Lake during 2004 and 2011 respectively.

WATER QUALITY

Table 8 Water quality of Nelakondoddi Lake with BIS limits

Sampling site	Nelakondoddi outlet (NLO1)	Nelakondoddi inlet (NLI1)	BIS standards for Surface waters
pH	9.25	9.01	6.5-9
Electric conductivity (µS/cm)	816.00	814.00	<1200
Total dissolved solids (ppm)	562.00	552.00	<700
Dissolved oxygen (mg/L)	7.50	8.50	>5
Biological oxygen demand (ppm)	2.31	2.11	<5
Chemical oxygen demand (ppm)	10.66666667	10.66666667	<30
Nitrates (ppm)	0.25612	0.44917	--
Inorganic phosphates (ppm)	0.120	0.150	--
Total hardness (mg/L)	148	140	<200
Calcium hardness (mg/L)	49.9776672	44.968096	<80
Chlorides (mg/L)	159.04	153.36	<250
Total alkalinity (mg/L)	320	320	<600

Water quality of Nelakondoddi Lake reflected a pristine water condition with conductivity, total dissolved solids, biological oxygen demand and chemical oxygen demand concentrations well within the BIS standards and lesser than the polluted water. Nitrates ranged from 0.256- 0.449 ppm awhile phosphates were 0.12-0.15 ppm. Total hardness and calcium hardness ranged from 140-148 mg/L and 44.96- 49.97 mg/L respectively. The source of hardness in such lakes could be accounted for local human disturbances such as washing clothes. This lake is located in 10 km buffer zone of Bangalore BBMP boundary and in less populated region and thus less pollution.

CURRENT THREATS (Refer Figure 24 and Plate 24)

Local human disturbances, grazing

PLATE 24

CLEAN WATER CONDITION

25. RACHENAHALLI LAKE

NAME OF THE LAKE	RACHENAHALLI LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°3'45"N 77°36'50"E
AREA (2002/2009)	26.64/ 42.14 ha
ORGANIZATION	BDA
WARD/ VILLAGE NAME	6- Thanisandra
STATUS	Moderate pollution
RESTORATION	July 2009- July 2010 (Incomplete)
WATER CONDITION	Moderate pollution.

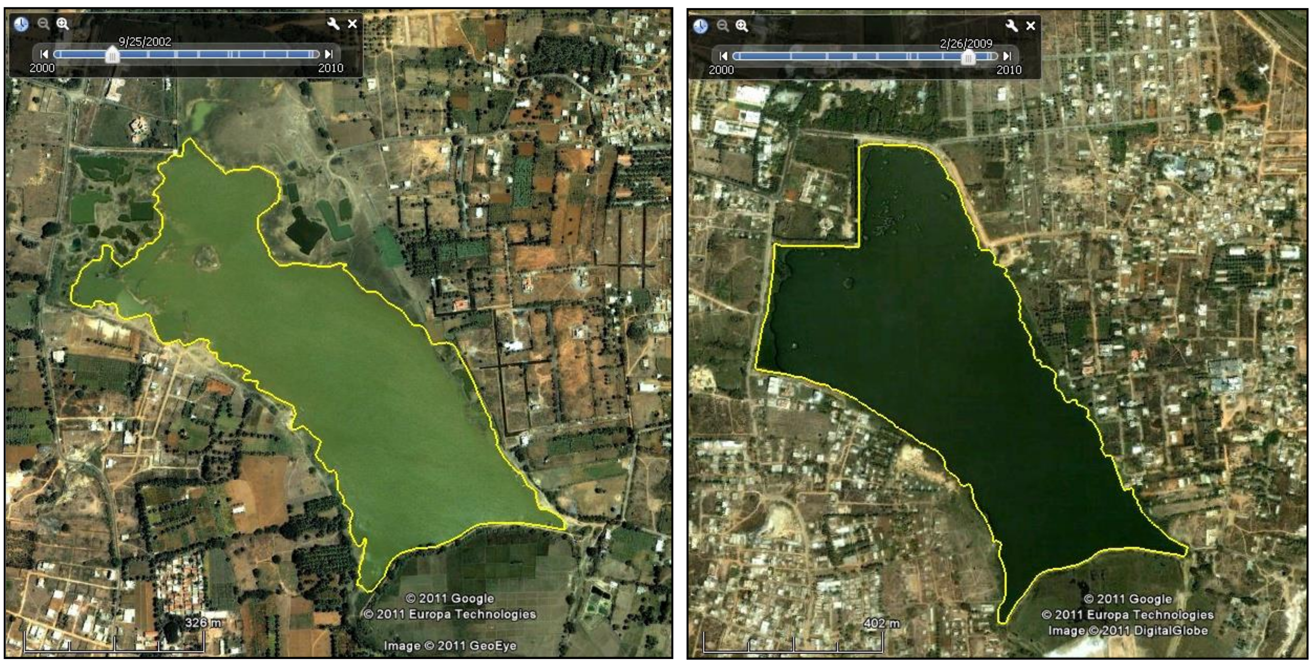


Figure 9 Google Earth image and area of Rachenahalli Lake during 2002 and 2009 respectively.

WATER QUALITY

Table 9 Water quality of Rachenahalli Lake with BIS surface water limits

Sampling site	Rachenahalli outlet 1 (RCO1)	Rachenahalli inlet 2 (RCI2)	BIS standards for Surface waters
pH	9.05	9.10	6.5-9
Electric conductivity (µS/cm)	854.33	885.67	<1200
Total dissolved solids (ppm)	609.33	620.00	<700
Dissolved oxygen (mg/L)	7.32	7.75	>5
Biological oxygen demand (ppm)	13.22	24.05	<5
Chemical oxygen demand (ppm)	35.91	77.55	<30
Nitrates (ppm)	0.020	0.018	--
Inorganic phosphates (ppm)	0.023	0.023	--
Total hardness (mg/L)	222.67	221.33	<200
Calcium hardness (mg/L)	80.00	72.67	<80
Chlorides (mg/L)	208.27	191.23	<250
Total alkalinity (mg/L)	120.00	120.00	<600

Rachenahalli water quality has been listed in Table 25. pH was slightly alkaline in condition. EC and TDS ranged to be moderately polluted i.e., 854.3- 885.67 µS/cm and 609-620 ppm respectively. A slight higher amount of organic matter revealed pollution status at both the sampling sites. Total hardness was high at both the sites i.e, range of 221.33-222.67 mg/L because of high amount of calcium and soap water into the lake. The lake was at one side, occupied with agricultural field and to the other side inflow from nearby built-up regions. The restoration has not yet completed which needs immediate attention to properly maintain the water body.

CURRENT THREATS (Refer Figure 25 and Plate 25)

a. Sewage and Agriculture inflow,
b. Fishing and local human disturbances
c. Improper maintenance.
d. Weed cover

PLATE 25


RESTORATION DEADLINE!!!
BANGALORE DEVELOPMENT AUTHORITY
NAME OF WORK: RESTORATION & OVERALL DEVELOPMENT OF RACHENAHALLI LAKE
COST OF ESTIMATE: 1900-00 LAKHS
NAME OF CONTRACTOR: % R.M.N. INFRASTRUCTURES Ltd
PERIOD OF COMPLETION: 12 MONTHS
DATE OF COMMENCEMENT: 17-07-2009
DATE OF COMPLETION: 16-07-2010.
DCF, BDA, B'lore

RESTORATION WORK – JUNE- JULY 2010

26. RAMAPURA LAKE

NAME OF THE LAKE	RAMAPURA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°2'50"N 77°41'23"E
AREA (2002/2010)	47.03/20.81ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	Rampura
STATUS	Highly polluted
RESTORATION	NO
WATER QUALITY	Poor

Figure 10 Google Earth image and area of Rampura Lake during 2002 and 2010 respectively.

WATER QUALITY

Table 10 Water quality of Rampura Lake and BIS standard limits

Sampling site	Rampura inlet (RPI1)	Rampura outlet (RPO1)	BIS standards for Surface waters
pH	6.85	7.2	6.5-9
Electric conductivity (µS/cm)	1930	1578	<1200
Total dissolved solids (ppm)	1050	1135	<700
Dissolved oxygen (mg/L)	0.00	0.00	>5
Biological oxygen demand (ppm)	67.93	78.24	<5
Chemical oxygen demand (ppm)	145.86	166.48	<30
Nitrates (ppm)	1.45	1.1	--
Inorganic phosphates (ppm)	2.3	2.41	--
Total hardness (mg/L)	401	382	<200
Calcium hardness (mg/L)	215.5	206	<80
Chlorides (mg/L)	429	420	<250
Total alkalinity (mg/L)	823	683	<600

Rampura water quality is listed in Table 26 which reflects severe pollution at both the sampling sites. Higher electric conductivity and dissolved solids was observed which ranged from 1578-1930 µS/cm and 1050- 1135 ppm at inlet and outlet respectively. Dissolved oxygen was found to be zero at both the sampling site because of no penetration of light as the whole lake is covered with water hyacinth. A part of city's sewage inflow could be observed at Rampura Lake's inflow region which is the main source of contamination of water.

CURRENT THREATS (Refer Figure 26 and Plate 26)

a. Local disturbances such as Dumping of solid waste,
b. Conversation of lake into land by filling up with soil,
c. Untreated sewage inflow,
d. Eutrophication,
e. Loss of Biodiversity

27. RAMASANDRA LAKE

NAME OF THE LAKE	RAMASANDRA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°56'44"N 77°27'29"E
AREA (2000/2009)	41.84/29.35 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Ramasandra
STATUS	Clean
RESTORATION	August 2009- August 2010 (Incomplete)
WATER CONDITION	Good.

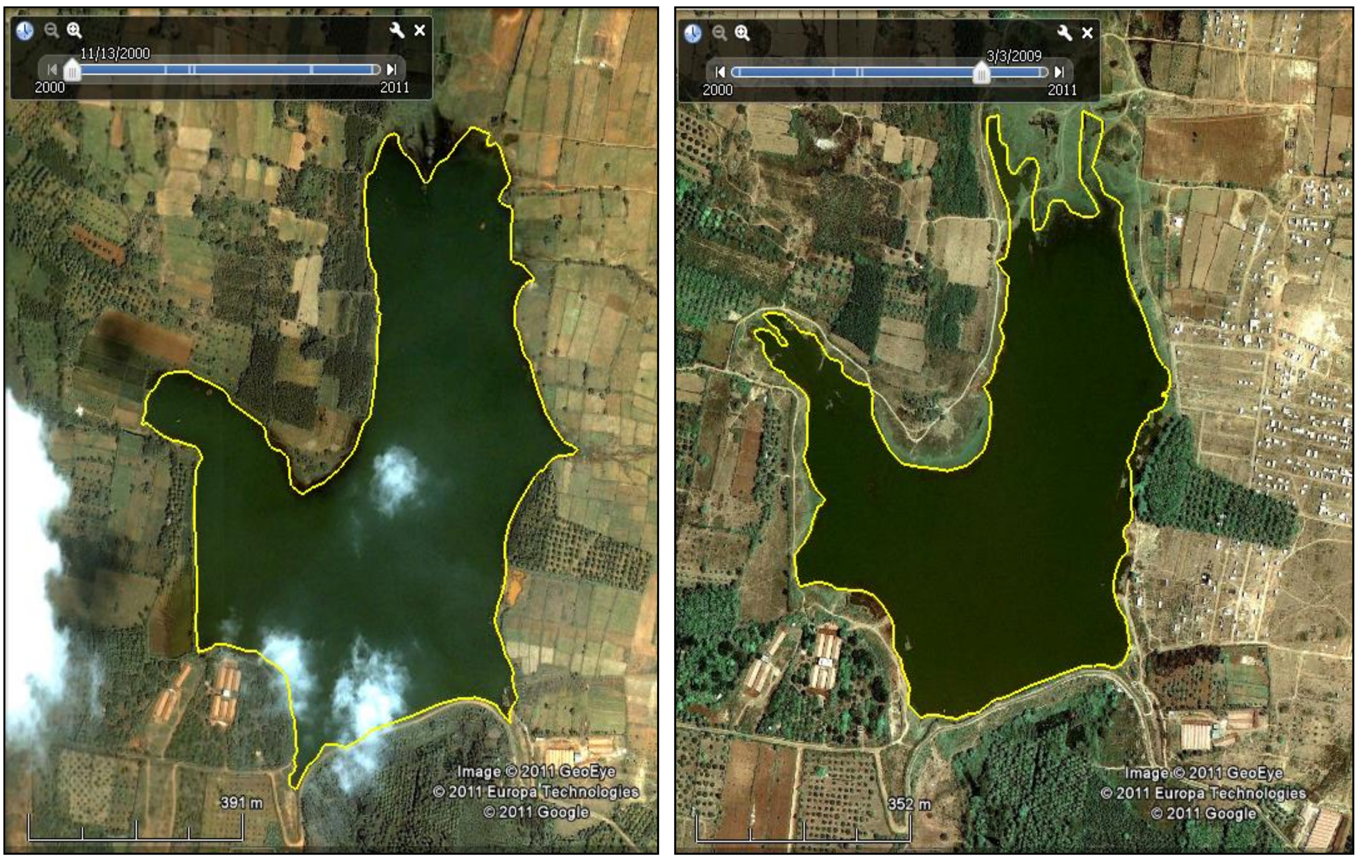


Figure 11 Google Earth image and area of Ramasandra Lake during 2000 and 2009 respectively.

WATER QUALITY

Table 11 Water quality of Ramasandra Lake with BIS standard limits

Sampling site	Ramasandra layout site (RMLY)	Ramasandra inlet (RMI1)	Ramasandra outlet (RMO1)	Ramasandra grazing (RMAG)	BIS standards for Surface waters
pH	8.88	8.85	8.60	8.96	6.5-9
Electric conductivity (µS/cm)	516.67	490.00	496.00	466.00	<1200
Total dissolved solids (ppm)	357.67	343.00	356.00	369.33	<700
Dissolved oxygen (mg/L)	6.21	6.67	7.06	6.05	>5
Biological oxygen demand (ppm)	10.68	14.23	13.33	8.88	<5
Chemical oxygen demand (ppm)	26.44	30.99	30.67	24.89	<30
Nitrates (ppm)	0.047	0.051	0.039	0.067	--
Inorganic phosphates (ppm)	0.014	0.001	0.020	0.004	--
Total hardness (mg/L)	112.67	113.33	164.00	129.33	<200
Calcium hardness (mg/L)	34.20	30.73	41.28	33.13	<80
Chlorides (mg/L)	65.13	59.92	100.82	61.53	<250
Total alkalinity (mg/L)	974.00	1088.67	744.00	788.67	<600

Chemical variation in water quality of Ramasandra Lake has been listed in Table 27. This lake is situated in less populated region and thus less influence of sewage on water quality could be observed. Electric conductivity and total dissolved solids ranged from 466- 516.67 µS/cm and 343- 369 ppm respectively. Least concentration of BOD and COD was observed at grazing sampling site (6.05 ppm and 8.88 ppm) while highest of 14.23 and 30.99 ppm at inlet site. Total hardness was highest at outlet site reasoning the utilization of water for washing, agricultural waste runoff and other human disturbances.

CURRENT THREATS (Refer Figure 27 and Plate 27)

Grazing, Fishing, Sand mining, Agricultural run-off, Local human disturbances.

PLATE 27

INCOMPLETE RESTORATION WORK December- January 2012

RAMASANDRA LAKE PRIOR TO RESTORATION: February 2009

28. RAYASANDRA LAKE

NAME OF THE LAKE	RAYASANDRA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°52'11"N 77°40'35"E
AREA (2004/2010)	-- / 28.59ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	Jigani
STATUS	Clean – Moderately polluted
RESTORATION	NO
WATER CONDITION	Clean – Moderate.

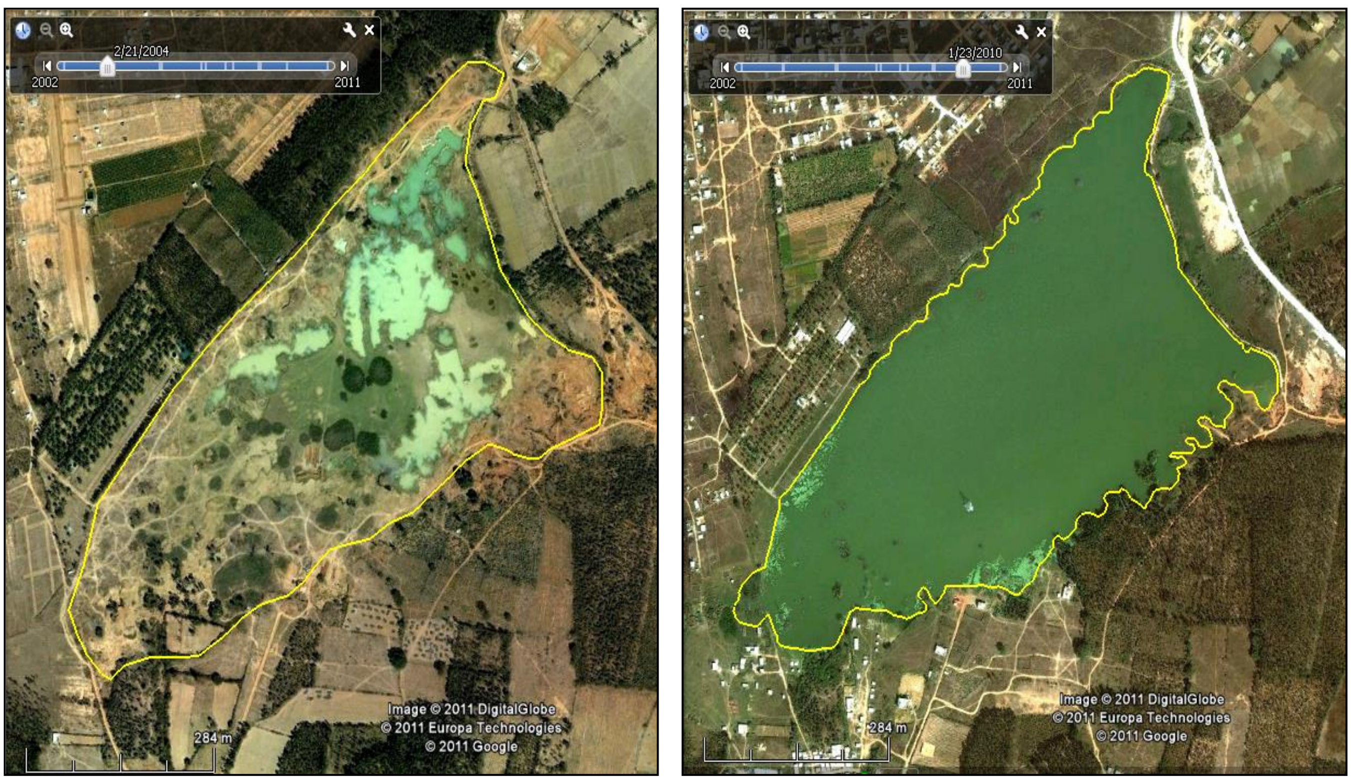


Figure 12 Google Earth image and area of Rayasandra Lake during 2004 and 2010 respectively.

WATER QUALITY

Table 12 Water quality variables of Rayasandra Lake with BIS limits

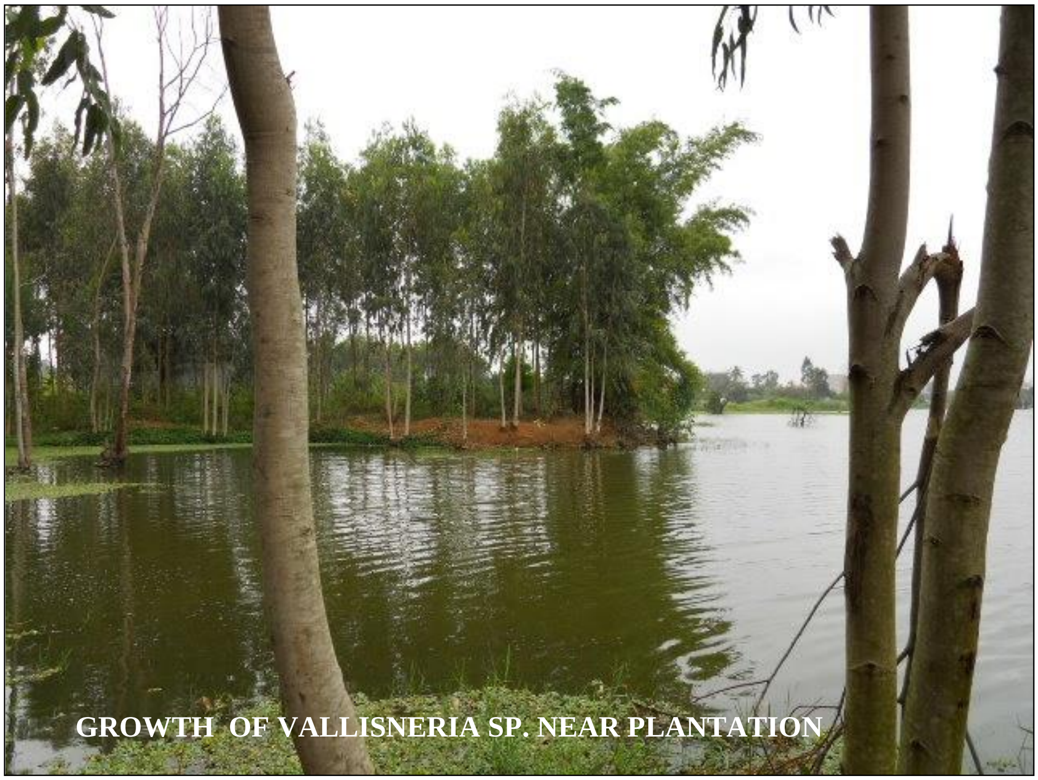
Sampling site	Rayasnadra site 1 (RYA1)	Rayasandra outlet (RYO1)	BIS standards for Surface waters
pH	9.12	9.58	6.5-9
Electric conductivity (µS/cm)	901	504.00	<1200
Total dissolved solids (ppm)	719	659.00	<700
Dissolved oxygen (mg/L)	4.63	7.12	>5
Biological oxygen demand (ppm)	14.63	6.54	<5
Chemical oxygen demand (ppm)	30.99	18.68	<30
Nitrates (ppm)	0.044	0.012	--
Inorganic phosphates (ppm)	0.18	0.160	--
Total hardness (mg/L)	135	189.30	<200
Calcium hardness (mg/L)	45.66	112.69	<80
Chlorides (mg/L)	112	95.31	<250
Total alkalinity (mg/L)	210	280.00	<600

Water quality of Rayasandra along with BIS limits is listed in Table 28. Both the sampling site revealed alkaline pH range. Ioinc level and dissolved solids concentration was slightly higher at site 1 when compared to outlet site while hardness of water was higher at outlet due to interruption of human disturbances. The water quality could be categorized as clean to moderate pollution as the pollution causing variables such as chlorides and organic concentration are well within the BIS surface water quality standards/

CURRENT THREATS (Refer Figure 28 and Plate 28)

a. Local disturbances,
b. Untreated sewage inflow

PLATE 28


GROWTH OF VALLISNERIA SP. NEAR PLANTATION

29. SANKEY TANK

NAME OF THE LAKE	SANKEY LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:**13°0'35"N 77°34'29"E
AREA (2000/2010)	11.97/12.93 ha
ORGANIZATION	BBMP
WARD/ VILLAGE NAME	Malleshwaram
STATUS	Clean – Moderately polluted
RESTORATION	Completed (Year)
WATER CONDITION	Clean – Moderate.

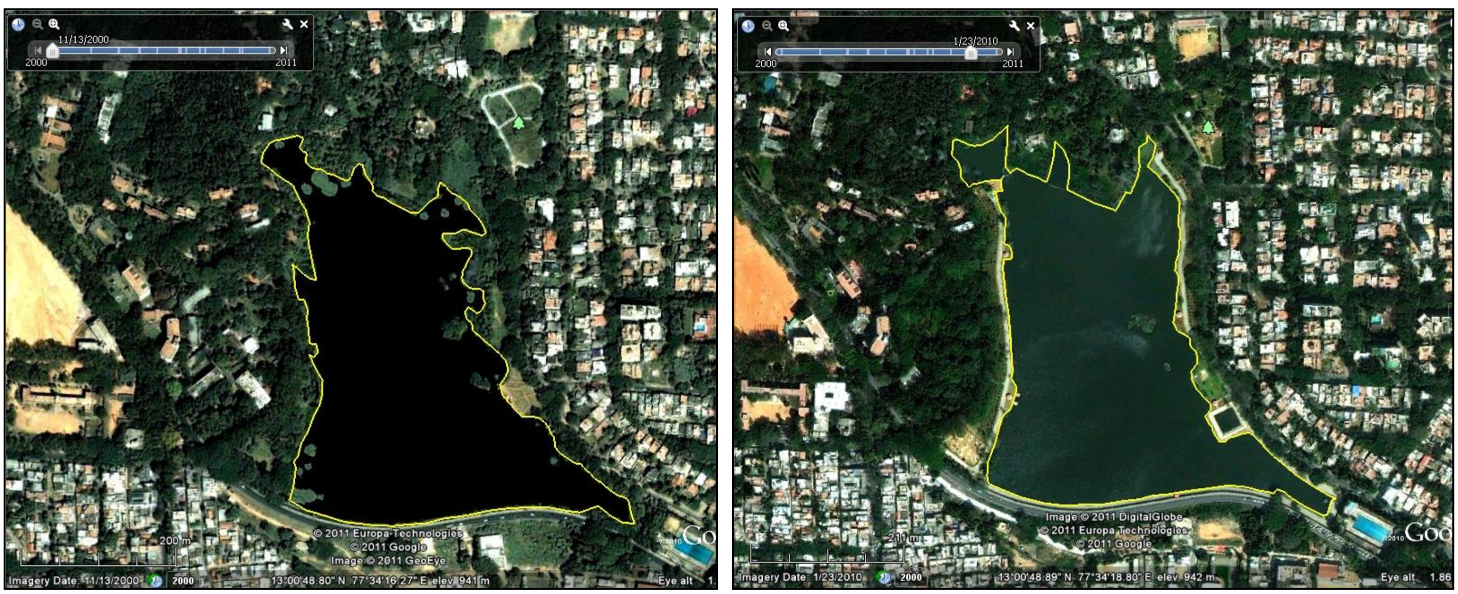


Figure 13 Google Earth image and area of Sankey tank during 2000 and 2010 respectively.

WATER QUALITY

Table 13 Water quality of Sankey tank and BIS standards

Sampling site	Sankey tank inlet (SNI1)	Sankey tank outlet (SNO1)	BIS standards for Surface waters
pH	9.66	9.45	6.5-9
Electric conductivity (µS/cm)	710	393	<1200
Total dissolved solids (ppm)	584	270	<700
Dissolved oxygen (mg/L)	6.91	8.94	>5
Biological oxygen demand (ppm)	10.2	10.54	<5
Chemical oxygen demand (ppm)	30.4	31.08	<30
Nitrates (ppm)	0.07	0.05	--
Inorganic phosphates (ppm)	0.56	0.73	--
Total hardness (mg/L)	134	123	<200
Calcium hardness (mg/L)	82	76.5	<80
Chlorides (mg/L)	129	102	<250
Total alkalinity (mg/L)	289	237	<600

Water quality of Sankey tank is listed dn compared with BIS permissible limits in Table 29. Even though this lake has been restored, the water quality reflects pollution status. Both the sampling sites had alkaline pH range. EC and TDS at inlet were higher than the outlet site i.e, 710 µS/cm and 584 ppm at inlet while, 393 µS/cm and 270 ppm at outlet. Except the calcium hardness, chlorides, total hardness and alkalinity were well within the required permissible limits. The inlet receiving untreated sewage was recorded which was also reflected through water quality at inlet site.

CURRENT THREATS (Refer Figure 29 and Plate 29)

a. Local human disturbances,
b. Untreated sewage inflow

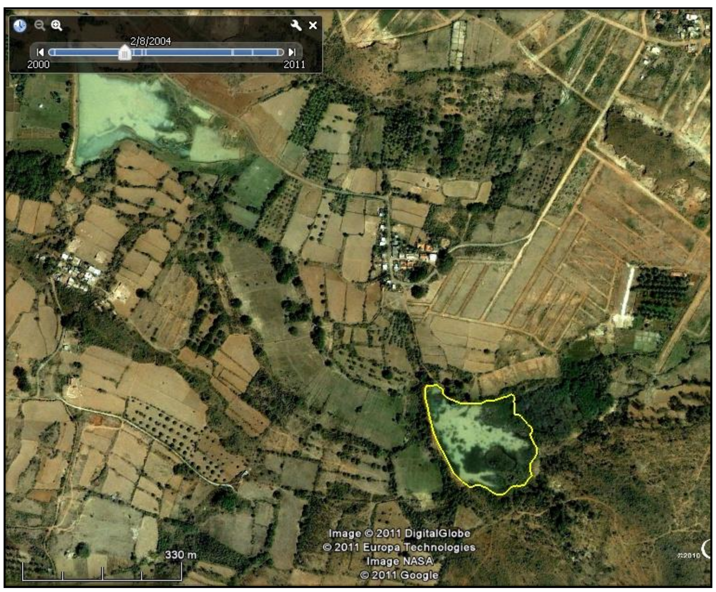
PLATE 29

EUTROPHIC WATER

ALGAL BLOOM NEAR INLET

30. SOMAPURA LAKE

NAME OF THE LAKE	SOMAPURA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:**12°52'27"N 77°29'54"E
AREA (2004/2011)	3.32/5.405 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Somapura
STATUS	Clean – Moderately polluted
RESTORATION	July 2009 – July 2010 (Completed)
WATER CONDITION	Clean – Moderate.



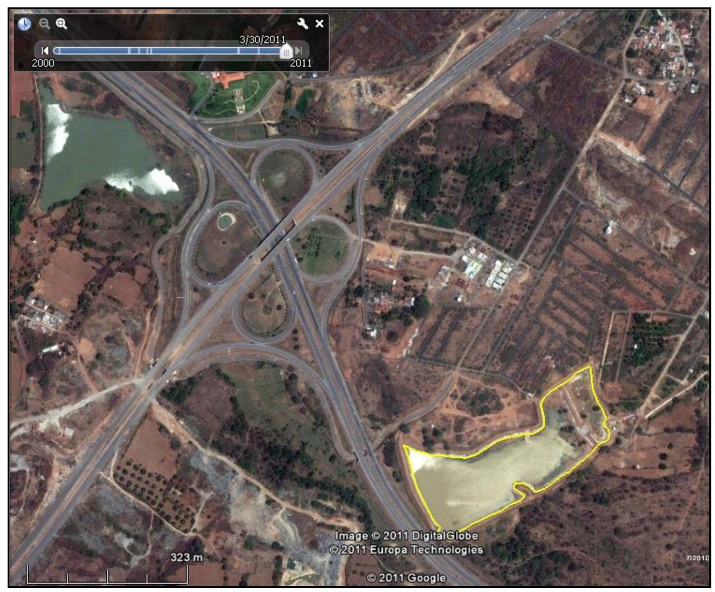


Figure 14 Google Earth image and area of Somapura Lake during 2004 an d2011 respectively

WATER QUALITY

Table 14 water quality variation in Somapura Lake with BIS limits

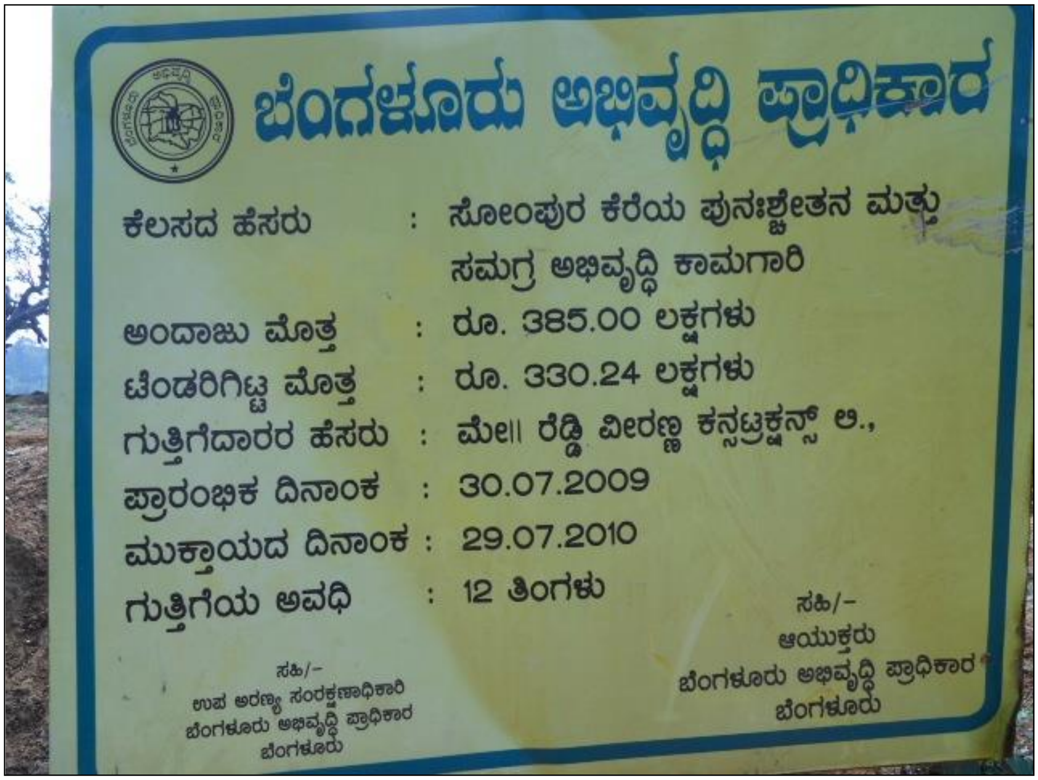
Sampling site	Somapura inlet (SMI1)	Somapura outlet (SMO1)	Somapura middle (SMM1)	BIS standards for Surface waters
pH	8.77	8.72	8.60	6.5-9
Electric conductivity (µS/cm)	1020.67	1024	1021.50	<1200
Total dissolved solids (ppm)	708.67	709.67	721.00	<700
Dissolved oxygen (mg/L)	6.69	6.29	7.56	>5
Biological oxygen demand (ppm)	12.88	4.31	5.98	<5
Chemical oxygen demand (ppm)	36.00	16.67	18.00	<30
Nitrates (ppm)	0.078	0.075	0.074	--
Inorganic phosphates (ppm)	0.044	0.046	0.042	--
Total hardness (mg/L)	112.67	109.33	112.00	<200
Calcium hardness (mg/L)	31.00	33.67	34.47	<80
Chlorides (mg/L)	120.70	82.36	115.02	<250
Total alkalinity (mg/L)	265.33	286.67	192.00	<600

Water quality of Somapura Lake has been listed in Table 30 which reflected clean to moderate water quality at all the sampling sites. Among all the variables recorded, electric conductivity was found to be high ranging from 1020.67- 1024 µS/cm which is slightly lesser than the BIS limits from surface standards. Apart from sewage inflow, the asphalted road in addition contributed to lake contamination with chloride concentration. Organic pollution was slightly higher at inlet with 12.88 ppm of BOD and 36 ppm of COD concentrations. The only pollution source found was sewage at inflow which if treated will help in balancing the ecosystem.

CURRENT THREATS (Refer Figure 30 and Plate 30)

a. Local disturbances
b. Untreated sewage inflow

PLATE 30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ಪ್ರಾರಂಭಿಕ ದಿನಾಂಕ : 30.07.2009
ಮುಕ್ತಾಯದ ದಿನಾಂಕ : 29.07.2010
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INFLOW REGION

Contents

31. SUBRAMANYA LAKE

NAME OF THE LAKE	SUBRAMANYA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:**12°53'45"N 77°32'33"E
AREA (2000/2009)	5.423/4.132 ha
ORGANIZATION	BDA
WARD/ VILLAGE NAME	Subramanyapura layout
STATUS	Highly polluted
RESTORATION	NO
WATER CONDITION	Polluted.

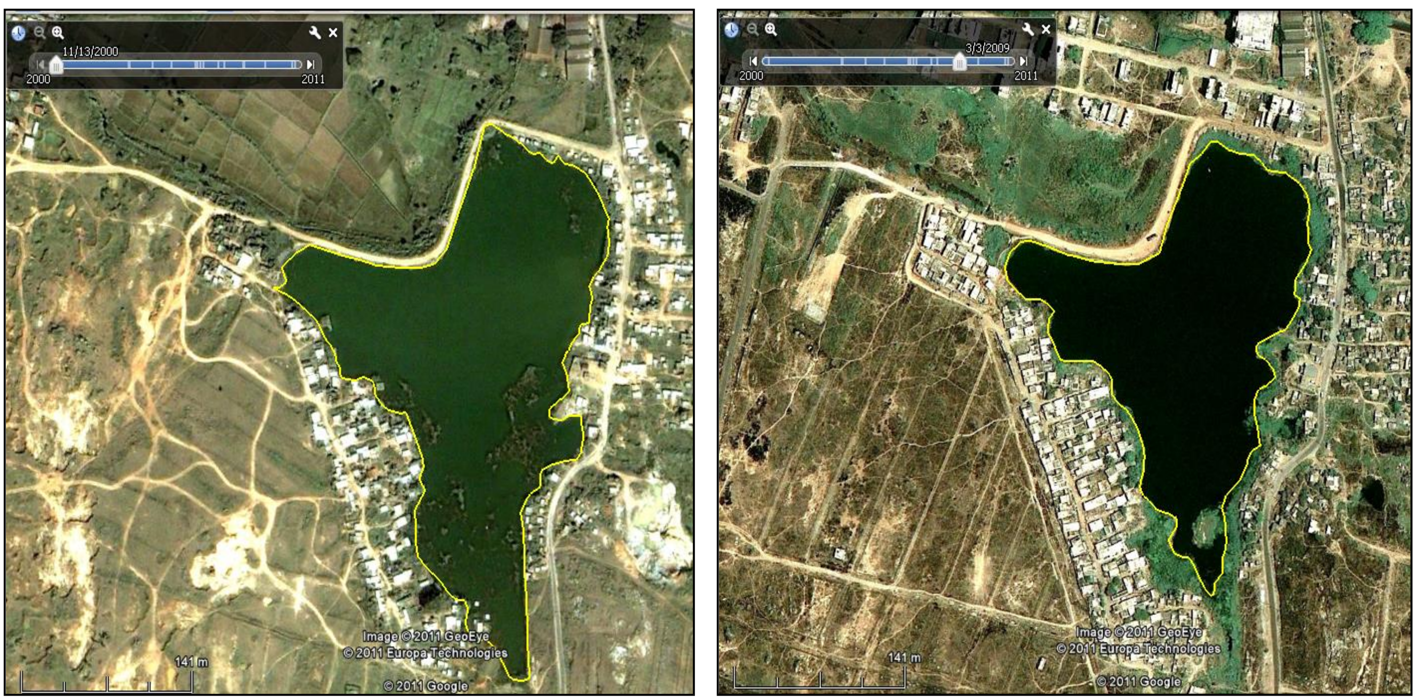


Figure 1 Google Earth image and area of Subramanya Lake during 2000 and 2009 respectively.

WATER QUALITY

Table 1 Water quality analysis of Subramanya Lake with BIS standards

Sampling site	Subramanya Lake inlet (SBI1)	Subramanya Lake outlet (SBO1)	BIS standards for Surface waters
pH	7.75	8.70	6.5-9
Electric conductivity (µS/cm)	2240.00	2290.00	<1200
Total dissolved solids (ppm)	1550.00	1570.00	<700
Dissolved oxygen (mg/L)	10.58	2.64	>5
Biological oxygen demand (ppm)	36.02	33.11	<5
Chemical oxygen demand (ppm)	96.00	76.67	<30
Nitrates (ppm)	0.309	0.725	--
Inorganic phosphates (ppm)	1.540	1.365	--
Total hardness (mg/L)	536.00	560.00	<200
Calcium hardness (mg/L)	435.92	459.92	<80
Chlorides (mg/L)	488.48	434.52	<250
Total alkalinity (mg/L)	1020.00	520.00	<600

CURRENT THREATS (Refer Figure 31 and Plate 31)

a. Local human disturbances
b. Untreated sewage inflow, Dumping of solid waste,
c. Buildings on lake bed

32. TALGHATTAPURA LAKE

NAME OF THE LAKE	**THALGHATTAPURA LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°51'55"N 77°31'59"E
AREA (2004/2011)	4.131/ 3.454 ha
ORGANIZATION	BDA
WARD/ VILLAGE NAME	Thalghattapura
STATUS	Moderate pollution
RESTORATION	August 2009- August 2010 (Incomplete)
WATER CONDITION	Moderate (2010) – Poor (2009 before restoration)

Figure 2 Google Earth image and area of Talghattapura Lake during 2004 and 2011 respectively.

WATER QUALITY

Table 2 Water quality of Talghattapura Lake with BIS limits

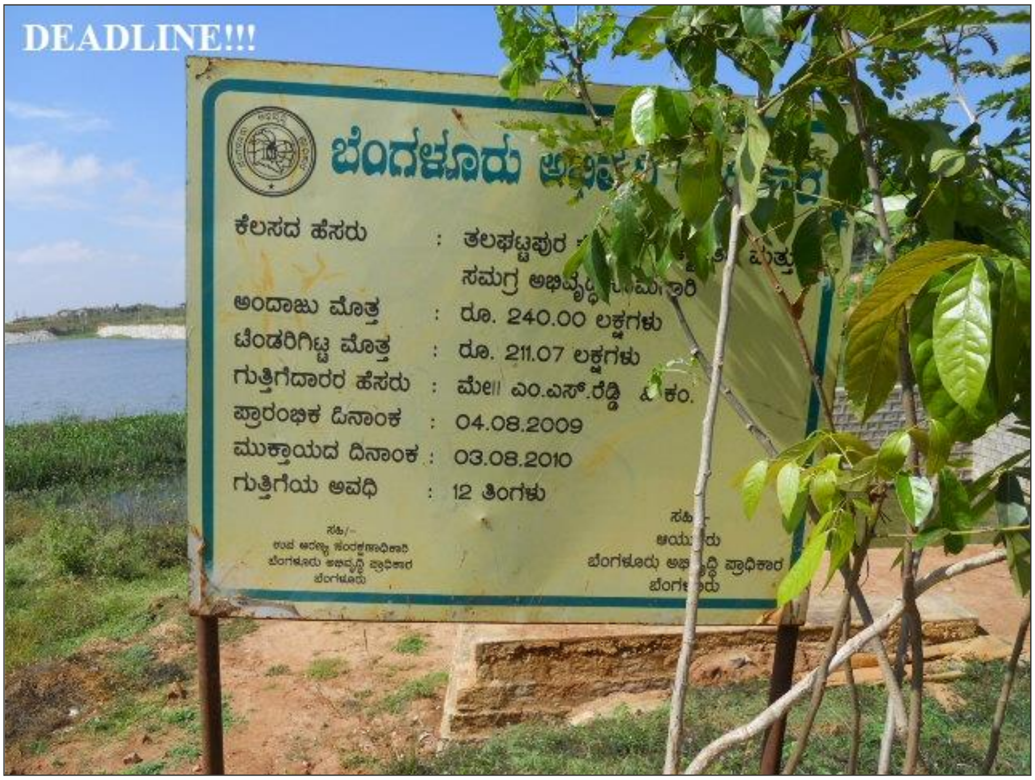
Sampling site	Talghattapura inlet (TAI2)	Talghattapura outlet (TAO1)	Talghattapura near inlet (TAI1)	BIS standards for Surface waters
pH	8.92	8.45	8.98	6.5-9
Electric conductivity (µS/cm)	788.50	790.50	779.00	<1200
Total dissolved solids (ppm)	548.00	670.00	536.00	<700
Dissolved oxygen (mg/L)	11.18	5.61	11.54	>5
Biological oxygen demand (ppm)	13.26	12.67	34.35	<5
Chemical oxygen demand (ppm)	34.00	30.00	70.00	<30
Nitrates (ppm)	0.058	0.043	0.048	--
Inorganic phosphates (ppm)	0.054	0.049	0.045	--
Total hardness (mg/L)	190.00	180.00	178.00	<200
Calcium hardness (mg/L)	29.66	36.87	36.87	<80
Chlorides (mg/L)	187.44	184.60	185.31	<250
Total alkalinity (mg/L)	293.00	163.00	252.00	<600

CURRENT STATUS (Refer Figure 32 and Plate 32)

a. Sewage inflow and dumping of waste near inlet
b. Local human disturbances such as swimming, washing clothes, etc
c. Improper restoration
d. Massive growth of aquatic weeds

PLATE 32

INCOMPLETE / IMPROPER RESTORATION



33. ULLALU LAKE

NAME OF THE LAKE	ULLALU LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°57'41"N 77°28'54"E
AREA (2000/2010)	8.237/ 7.635 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	130- Ullalu
STATUS	Pollution
RESTORATION	July 2009- July 2010 (Incomplete)
WATER CONDITION	Moderate to poor

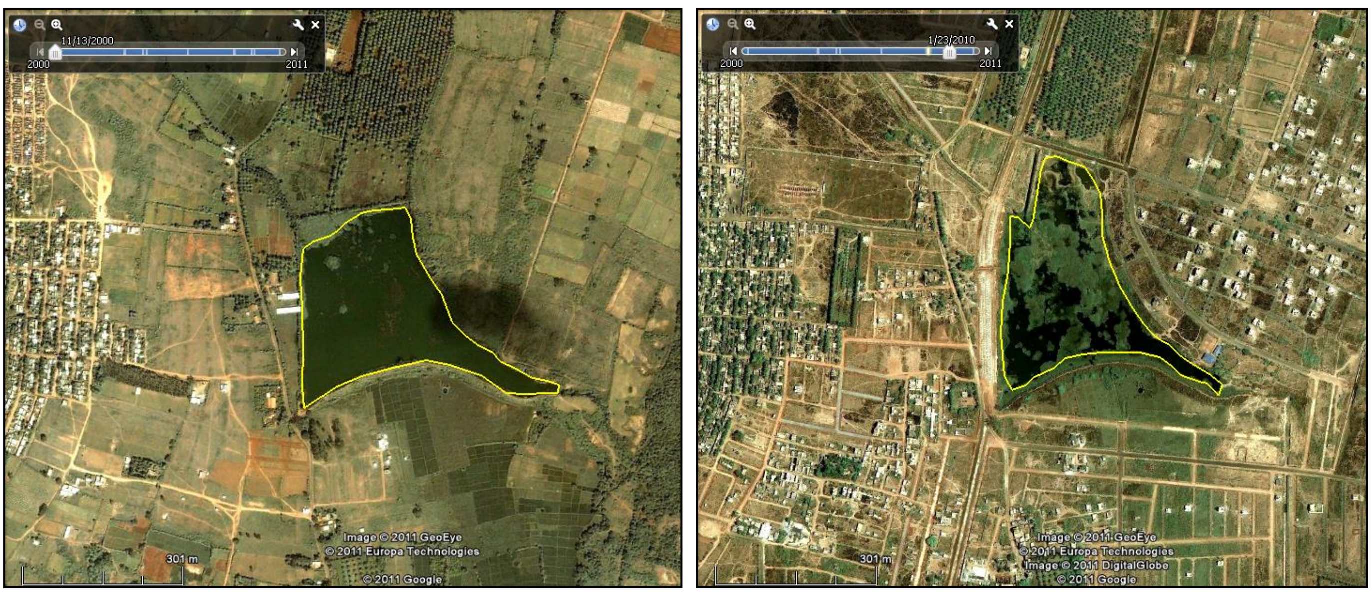


Figure 3 Google Earth image and area of Ullalu Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 3 Water quality variables of Ullalu Lake with BIS standards

Sampling site	Ullalu middle (ULM1)	Ullalu outlet (ULO1)	Ullalu inlet (ULI1)	BIS standards for Surface waters
pH	8.70	8.97	8.80	6.5-9
Electric conductivity (µS/cm)	605.00	587.00	747.50	<1200
Total dissolved solids (ppm)	495.00	416.50	514.00	<700
Dissolved oxygen (mg/L)	7.24	6.59	7.03	>5
Biological oxygen demand (ppm)	10.69	14.91	16.50	<5
Chemical oxygen demand (ppm)	22.00	42.00	46.00	<30
Nitrates (ppm)	0.057	0.078	0.092	--
Inorganic phosphates (ppm)	0.026	0.041	0.037	--
Total hardness (mg/L)	255.40	224.00	298.00	<200
Calcium hardness (mg/L)	25.65	20.04	23.25	<80
Chlorides (mg/L)	88.89	80.94	80.94	<250
Total alkalinity (mg/L)	297.00	210.00	315.00	<600

CURRENT THREATS (Refer Figure 33 and Plate 33)

a. Sewage inflow (before and after restoration)

b. Fragmentation of lake

c. local human disturbances

d. No shoreline and aquatic habitat availability

PLATE 33 RESTORATION OF LAKE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ಪ್ರಾರಂಬಿಕ ದಿನಾಂಕ : 23.07.2009
ಮುಕ್ತಾಯದ ದಿನಾಂಕ : 22.05.2010 (ಮಳೆಗಾಲವನ್ನು ಹೊರತು ಪಡಿಸಿ)
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ಆಯುಕ್ತರು
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ಬೆಂಗಳೂರು

34. ULSOOR LAKE

NAME OF THE LAKE	ULSOOR LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°58'56''N 77°37'9''E
AREA (2000/2010)	40.84/39.35 ha
ORGANIZATION	BBMP
WARD / VILLAGE NAME	90- Halsoor
STATUS	Pollution
RESTORATION	Completed (2003)
WATER CONDITION	Poor

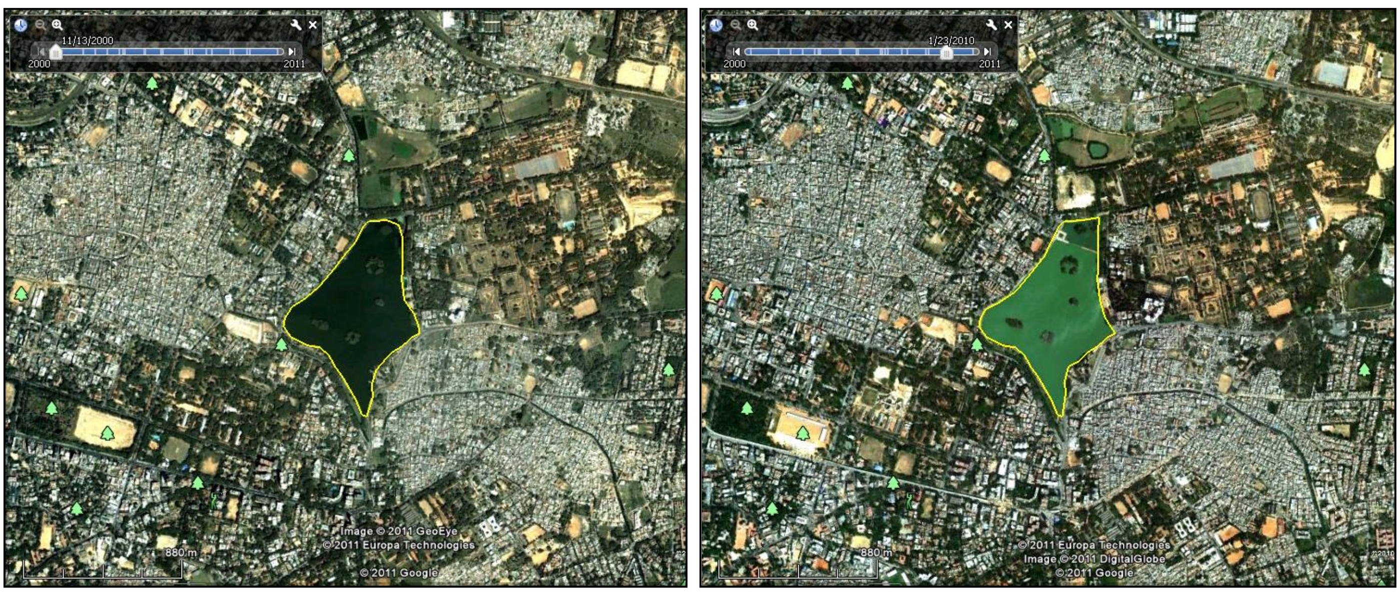


Figure 4 Google Earth image and area of Ulsoor Lake during 2000 and 2010 respectively.

WATER QUALITY

Table 4 Water quality with BIS standards of Ulsoor Lake

Sampling site	Ulsoor park side (USR1)	Ulsoor road side (USR2)	BIS standards for Surface waters
pH	9.48	9.38	6.5-9
Electric conductivity (µS/cm)	705	609	<1200
Total dissolved solids (ppm)	624	525	<700
Dissolved oxygen (mg/L)	1.63	4.07	>5
Biological oxygen demand (ppm)	16.98	15.96	<5
Chemical oxygen demand (ppm)	43.96	41.92	<30
Nitrates (ppm)	0.27	0.18	--
Inorganic phosphates (ppm)	1.89	2.01	--
Total hardness (mg/L)	265	243	<200
Calcium hardness (mg/L)	147.5	136.5	<80
Chlorides (mg/L)	397	355	<250
Total alkalinity (mg/L)	403	549	<600

CURRENT THREATS (Refer Figure 34 and Plate 24)

a. Eutrophication due to Untreated sewage into lake inflow,
b. improper restoration,
c. No shoreline region and habitat availability, hence loss of Biodiversity (Fish, birds, Insects, Butterflies),
d. No aquatic plants for Bird nesting,
e. Anthropogenic activities and degraded ecosystem.

PLATE 34 EUTROPHICATION IN ULSOOR LAKE

GREEN WATER

ISLANDS

35. VADERAHALLI LAKE

NAME OF THE LAKE	VADERAHALLI LAKE/ CHUDAHALLI RESERVOIR
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°50'19"N 77°32'0"E
AREA (2004/2010)	16.51/ 40.14 ha
ORGANIZATION	Forest department
WARD / VILLAGE NAME	Vaderahalli
STATUS	Clean / Less pollution
RESTORATION	NO
WATER CONDITION	Good- Moderate.

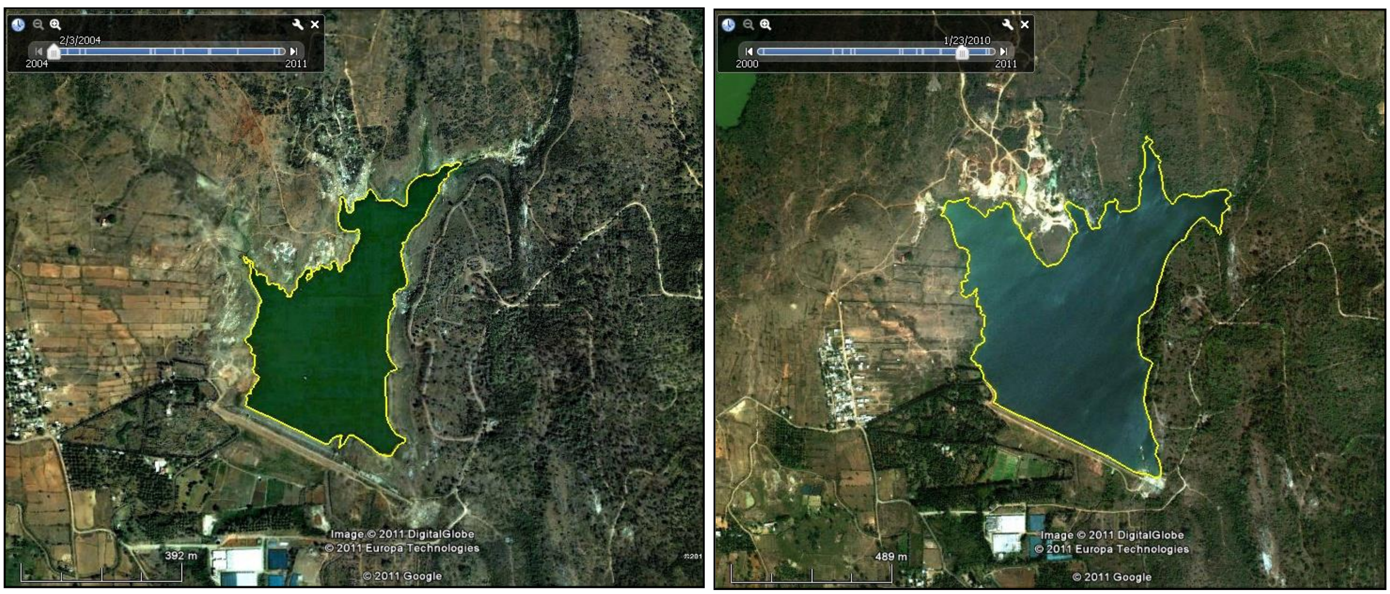


Figure 5 Google Earth image and area of Vaderahalli Lake during 2004 and 2010 respectively.

WATER QUALITY

Table 5 Water quality variables and BIS surface water standards for Vaderahalli Lake

Sampling site	Vaderahalli inlet (VDI1)	Vaderahalli outlet (VDO1)	BIS standards for Surface waters
pH	9.28	9.91	6.5-9
Electric conductivity (µS/cm)	529.00	582.00	<1200
Total dissolved solids (ppm)	614.00	419.00	<700
Dissolved oxygen (mg/L)	10.16	7.97	>5
Biological oxygen demand (ppm)	10.83	8.93	<5
Chemical oxygen demand (ppm)	35.30	21.44	<30
Nitrates (ppm)	1.652	2.397	--
Inorganic phosphates (ppm)	0.750	0.720	--
Total hardness (mg/L)	160.00	168.00	<200
Calcium hardness (mg/L)	115.96	111.96	<80
Chlorides (mg/L)	130.64	130.64	<250
Total alkalinity (mg/L)	280.00	320.00	<600

CURRENT THREATS (Refer Figure 35 and Plate 35)

a. Inflow of sewage and Industrial waste,
b. Massive fish death in November 2010 due to increased organic matter and decreased oxygen level.
c. Local human disturbances
d. Recreational activities

PLATE 35

DEAD FISH IN THE LAKE

36. VALLEY SCHOOL LAKE

NAME OF THE LAKE	VALLEY SCHOOL LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 12°51'6"N 77°30'18"E
AREA (2004/2010)	1.088/0.892 ha
ORGANIZATION	Valley school, Forest department
WARD / VILLAGE NAME	Valley school
STATUS	Clean water
RESTORATION	NO
WATER CONDITION	Good

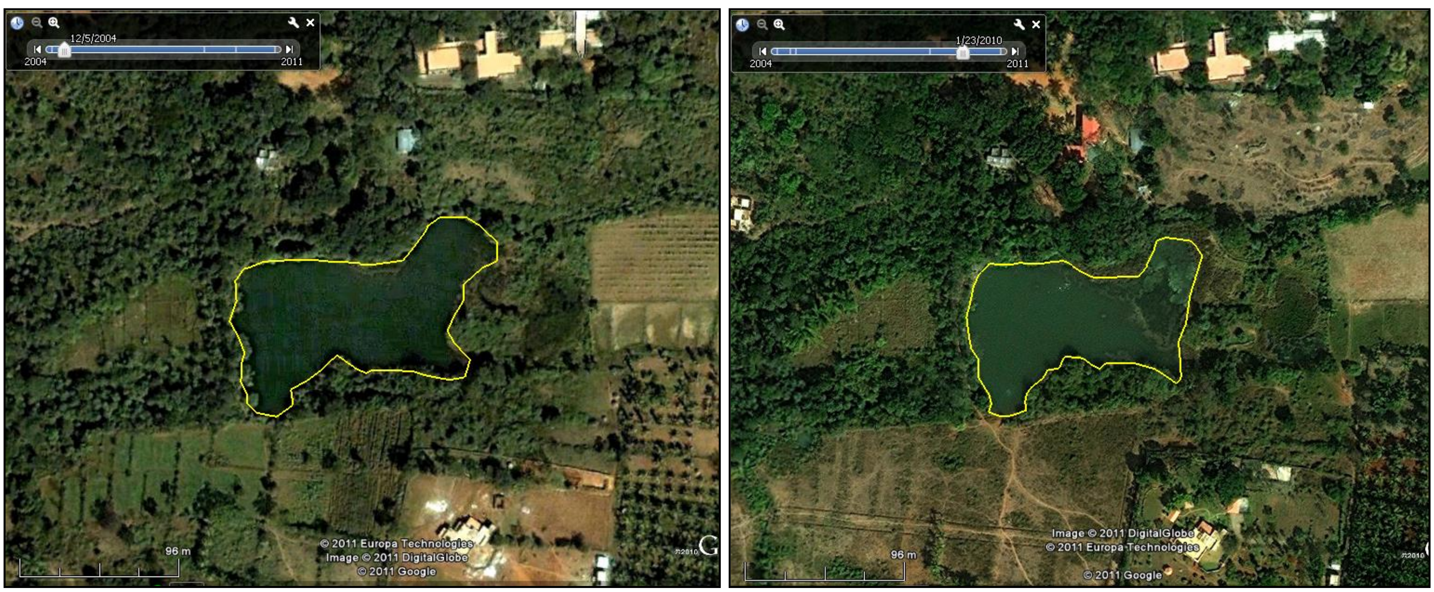


Figure 6 Google Earth image and area of Valley school during 2004 and 2010 respectively.

WATER QUALITY

Table 6 Water quality variables with BIS surface water standards for Valley School Lake

Sampling site	Valley school inlet (VLS1)	Valley school outlet (VLS2)	BIS standards for Surface waters
pH	9.91	9.40	6.5-9
Electric conductivity (µS/cm)	1160.00	1245.00	<1200
Total dissolved solids (ppm)	836.00	875.00	<700
Dissolved oxygen (mg/L)	10.57	9.35	>5
Biological oxygen demand (ppm)	17.81	14.93	<5
Chemical oxygen demand (ppm)	43.56	45.64	<30
Nitrates (ppm)	1.922	0.935	--
Inorganic phosphates (ppm)	0.680	0.590	--
Total hardness (mg/L)	360.00	288.00	<200
Calcium hardness (mg/L)	343.99	259.98	<80
Chlorides (mg/L)	156.20	144.84	<250
Total alkalinity (mg/L)	620.00	720.00	<600

CURRENT THREATS (Refer Figure 36 and Plate 36)

a. Inflow of sewage waste
b. local human disturbances (washing, swimming)

PLATE 36

37. VARTHUR LAKE

NAME OF THE LAKE	VARTHUR LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:**12°56'53"N 77°43'28"E
AREA (2004/2010)	132.4/89.45 ha (EXCLUDING WATER HYACINTH COVER)
ORGANIZATION	BBMP
WARD / VILLAGE NAME	Varthur
STATUS	Highly Polluted
RESTORATION	NO
WATER CONDITION	Poor

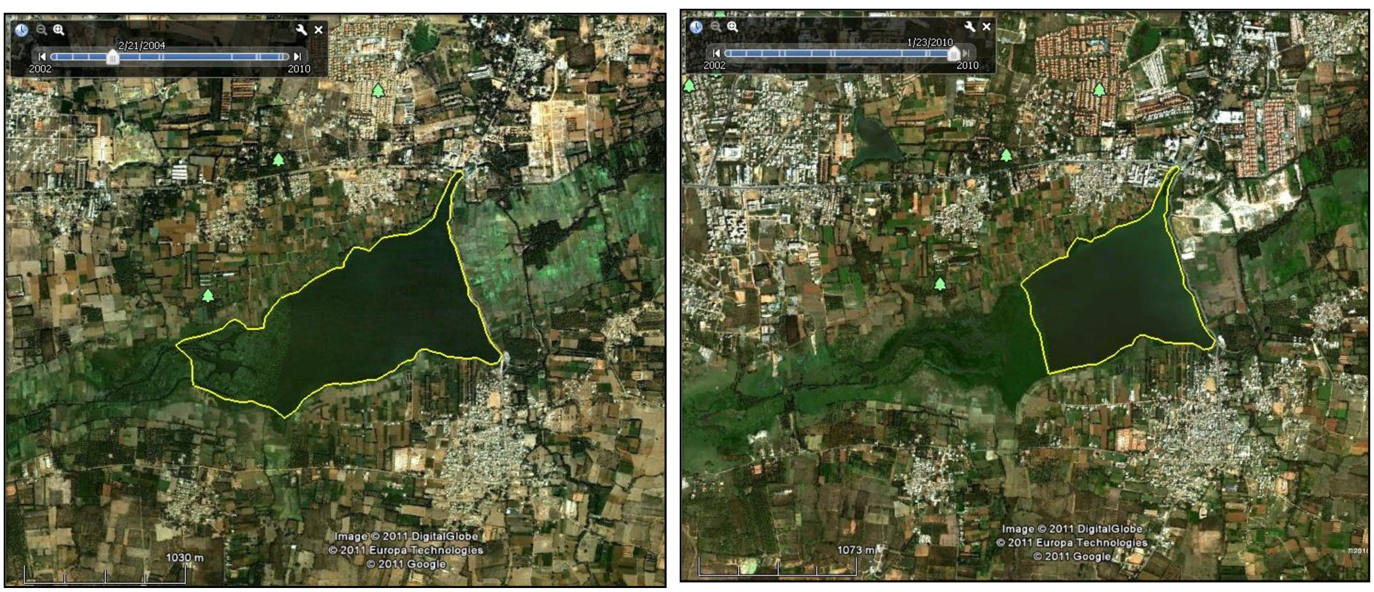


Figure 7 Google Earth image and area of Varthur Lake during 2004 and 2010 respectively

WATER QUALITY

Table 7 Water quality and BIS surface standards for Varthur Lake

Sampling site	Varthur inlet (VRI1)	Varthur outlet (VRO1)	BIS standards for Surface waters
pH	7.16	6.93	6.5-9
Electric conductivity (µS/cm)	1238.00	1253.00	<1200
Total dissolved solids (ppm)	857.00	873.00	<700
Dissolved oxygen (mg/L)	5.93	0.00	>5
Biological oxygen demand (ppm)	35.92	32.63	<5
Chemical oxygen demand (ppm)	84.00	78.67	<30
Nitrates (ppm)	0.392	0.449	--
Inorganic phosphates (ppm)	1.850	1.583	--
Total hardness (mg/L)	276.00	260.00	<200
Calcium hardness (mg/L)	183.93	131.90	<80
Chlorides (mg/L)	184.60	190.28	<250
Total alkalinity (mg/L)	480.00	520.00	<600

CURRENT THREATS (Refer Figure 37 and Plate 37)

a. Inflow of sewage and industrial waste
b. Local pollution such as washing clothes, defecation, swimming etc.
c. Agricultural field and plantation run-off,
d. Macrophyte cover

PLATE 37

OUTLET

MACROPHYTE COVER


BLACK WATER

38. VENKATTESHAPURA LAKE

NAME OF THE LAKE	VENKATESHAPURA LAKE
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°5'36"N 77°37'49"E
AREA (2002/2009)	1.504/1.756 ha
ORGANIZATION	BDA
WARD / VILLAGE NAME	Jakkur
STATUS	Clean / No / Less pollution
RESTORATION	July 2009- August 2010 (Incomplete)
WATER CONDITION	Good.

Figure 8 Google Earth image and area of Venkateshapura Lake during 2002 and 2009 respectively.

WATER QUALITY

Table 8 Water quality and BIS standard for Venkateshapura Lake

Sampling site	Venkateshapura inlet (VNI1)	Venkateshapura outlet (VNM1)	BIS standards for Surface waters
pH	8.54	8.41	6.5-9
Electric conductivity (µS/cm)	342.00	346.50	<1200
Total dissolved solids (ppm)	239.00	243.50	<700
Dissolved oxygen (mg/L)	8.13	7.40	>5
Biological oxygen demand (ppm)	3.11	3.02	<5
Chemical oxygen demand (ppm)	26.88	20.33	<30
Nitrates (ppm)	0.020	0.021	--
Inorganic phosphates (ppm)	0.022	0.057	--
Total hardness (mg/L)	122.00	130.00	<200
Calcium hardness (mg/L)	63.33	64.00	<80
Chlorides (mg/L)	45.44	35.50	<250
Total alkalinity (mg/L)	100.00	80.00	<600

CURRENT THREATS (Refer Figure 38 and Plate 38)

a. Inflow of sewage,

b. Regional pollution such as washing clothes, defecation, swimming etc.

c. Agricultural field and plantation run-off

d. Quarry

PLATE 38

39. YELAHANKA LAKE

NAME OF THE LAKE	**YELAHANKA LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°6'52"N 77°35'31"E
AREA	115.8 ha
ORGANIZATION	BBMP
WARD NAME	1- Kempegowda ward
STATUS	Polluted/ Eutrophic water
RESTORATION	NO
WATER CONDITION	Poor.

Figure 9 Google Earth image and area of Yelahanka Lake during 2004 and 2010 respectively.

WATER QUALITY

Table 9 Water quality variables and BIS standards for surface water limits for Yelahanka Lake.

Sampling site	Yelahanka outlet (YLO1)	Yelahanka inlet (YLI1)	BIS standards for Surface waters
pH	9.06	9.33	6.5-9
Electric conductivity (µS/cm)	1220	1350	<1200
Total dissolved solids (ppm)	1105	1132	<700
Dissolved oxygen (mg/L)	4.63	2.76	>5
Biological oxygen demand (ppm)	21.94	26.385	<5
Chemical oxygen demand (ppm)	53.88	62.77	<30
Nitrates (ppm)	0.19	0.26	--
Inorganic phosphates (ppm)	1.34	1.61	--
Total hardness (mg/L)	266	284	<200
Calcium hardness (mg/L)	148	157	<80
Chlorides (mg/L)	360	498	<250
Total alkalinity (mg/L)	504	628	<600

CURRENT THREATS (Refer Figure 39 and Plate 39)

a. Inflow of sewage and Industrial waste from surrounding area
b. Regional pollution such as fishing, defecation, swimming etc.
c. Field and plantation run-off,
d. Massive macrophyte cover.
e. No/ less oxygen availability and hence Loss of Biodiversity (Only African catfish is available)

PLATE 39

40. YELLAMALLAPPA CHETTY LAKE

NAME OF THE LAKE	**YELLAMALLAPPA CHETTY LAKE**
GEOGRAPHIC DETAILS	**LAT/LONG:** 13°1'38"N 77°43'44"E
AREA (2002/2010)	128.3/114.2 ha
ORGANIZATION	Irrigation department
WARD / VILLAGE NAME	K R Puram
STATUS	Polluted/ Eutrophic water
RESTORATION	NO
WATER CONDITION	Poor.

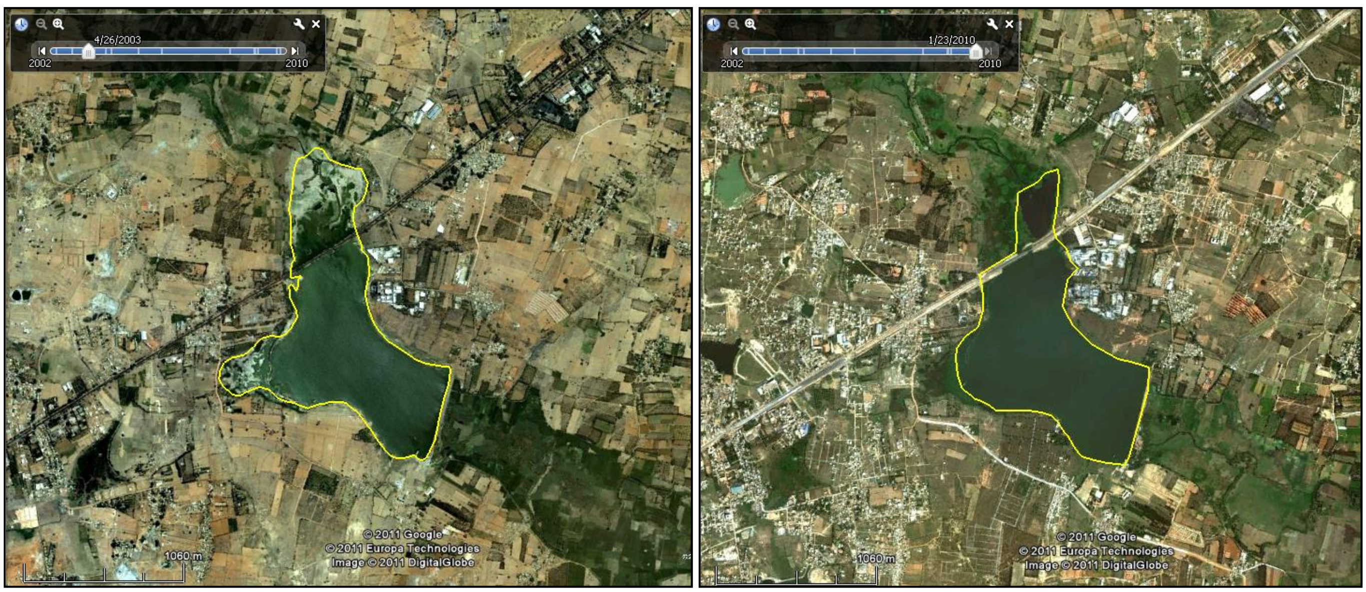


Figure 10 Google Earth image and area of Yellammalappa Lake during 2002 and 2010 respectively.

WATER QUALITY

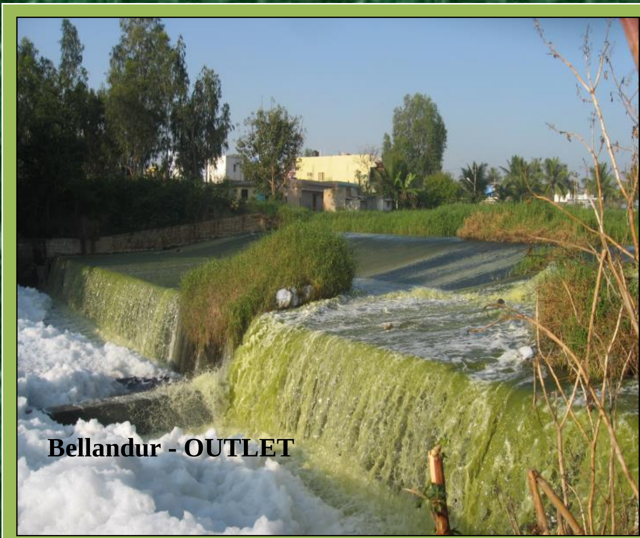
Table 10 Water quality and BIS standard values for Yellammallappa chetty sampling sites.

Sampling site	Yellamallappa chetty outlet (YLO1)	Yellamallappa chetty inlet (YLI1)	BIS standards for Surface waters
pH	7.36	7.40	6.5-9
Electric conductivity (µS/cm)	1691.00	1883.00	<1200
Total dissolved solids (ppm)	1178.00	1309.00	<700
Dissolved oxygen (mg/L)	9.73	0.00	>5
Biological oxygen demand (ppm)	63.18	65.82	<5
Chemical oxygen demand (ppm)	174.67	180.00	<30
Nitrates (ppm)	0.418	0.167	--
Inorganic phosphates (ppm)	2.896	2.581	--
Total hardness (mg/L)	384.00	388.00	<200
Calcium hardness (mg/L)	259.90	259.90	<80
Chlorides (mg/L)	142.00	514.04	<250
Total alkalinity (mg/L)	560.00	680.00	<600

CURRENT THREATS (Refer Figure 40 and Plate 40)

a. Inflow of sewage and Industrial waste from surrounding area,
b. Regional pollution such as fishing, defecation, swimming etc.
c. Field and plantation run-off,
d. More macrophyte cover,
e. Loss of Biodiversity (Only African catfish is available)

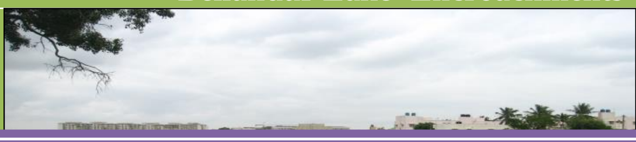
PLATE 40



Evergreen - Froth

Construction debris, Solid waste

Bellandur Lake- Encroachments – Lake bed, storm water drains,..



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