Eco-restoration of IDL Lake, Kukatpally, Hyderabad

Situational Analysis & Feasibility Study

SaciWATERs
SOUTH ASIA CONSORTIUM FOR INTERDISCIPLINARY WATER RESOURCES STUDIES

Submitted to the Hinduja Foundation & GOCL Corporation Limited

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Executive Summary

Like many other urban lakes in India, once a healthy multiple-use ecosystem, the IDL Lake is now facing threat from all directions and calls for urgent action to restore it to its past glory. Prior to the commencement of any in-situ and ex-situ interventions, a situational analysis and feasibility study was conducted. The objectives of the situational analysis and feasibility study were to: (i) Understand the present status of the lake (baseline); (ii) Identify the root causes of lake degradation and their magnitude; and (iii) Develop the best feasible solutions (preferably nature based) to address the problems.

The detailed scientific study included various important research components such as Spatial analysis (GIS & remote sensing) of lake morphology & hydrology and catchment area analysis; water quality assessment and sediments analysis; biodiversity; pollution load; stakeholders & institutional analysis; nature-based solutions; and feasibility study. Findings from the study and a plan for eco-restoration of IDL Lake are presented in this report.

During present times when the news of reduced water levels and shrinkage of water bodies is widely acknowledged, the IDL Lake stands as a distinct contrast. The lake was classified as a dry lake (seasonal waterbody) as per 1975 toposheet. However, this seasonal lake has turned perennial with an increase in its overall area. However, the factors responsible for this are not something to be appreciated. With heavy inflow of untreated sewage, the IDL Lake floods the GOCL site throughout the year. The increased lake area is in dangerously proximity towards few of the company's workshops, causing serious safety concerns. The present scientific study clearly illustrates that the water spread area has increased by about 14 acres from the original area (i.e., its natural state). At full tank level, the present perimeter is 2690 m vis-à-vis 1790 m earlier.

The natural drainage system of the catchment has nearly disappeared with increase in built-up area or has been converted to open or underground sewage drains which are carrying the sewage to IDL Lake. In terms of residential area boundaries, a little amount of change is seen from 2003 to 2022 but in terms of built-up density all the very low, low, and medium density built up has been converted to high density built-up which has increased the sewage quantity manifold in the overall catchment. Lake morphology is flood prone and it is near to FTL throughout the year even during drought years. The catchment area since earlier

time has low bifurcation ratio of 2.48 which indicates that it is prone to flooding. Increase in high density built-up area is further aggravating the flooding situation.

The limnological study shows that the IDL lake ecosystem is unfit for aquatic life and human usages. It is heavily polluted with dead zones across the lake containing zero dissolved oxygen (DO). Limited number of aquatic macrophytes and birds were reported only along the shoreline (with birds feeding on solid waste). Given its present state, this lake can be labelled as a hyper-eutrophic water body with nutrient rich waters. The lake ecosystem is also polluted with toxic heavy metals (Cd, Pb, Zn, Cu, Ni and Cr).

The data from the flow measurements clearly indicates that the lake is at its full carrying capacity and the water balance is clearly seen (7.5 MLD of inflow and 7.1 MLD of outflow). A portion of water/wastewater enters the lake (5.5 MLD) directly and most of it goes through the screen channel into the pumping station (11.8 MLD).

Since the capacity of the existing STP is 5 MLD, a similar amount of wastewater is delivered for treatment through the pumping station and the remaining quantity is pumped out directly into the lake's outlet. The wastewater entering through the main inlet is heavily polluted with high values of COD, BOD, Nitrogen, Chlorides, Volatile solids, heavy metals and fecal coliform.

To ensure holistic rejuvenation of the water body, Various technical solutions (mostly nature-based) proposed in Two Phases, using a four-fold approach:

- Improving the quality of water in the lake
- Reviving the natural ecosystem
- Urban placemaking
- Sustainability of the initiative

The technical solutions include Dredging and Desilting of the lake; Vegetative Buffer Strip; Construction of Sedimentation Tank at the mouth of the Lake; Refurbishment of hydraulic structures; Installation of Floating Wetlands; Introducing solar aerators; and overwater wooden elevated walking track.

Considering the present situation of unnatural flooding and also that the final notification of FTL and Buffer zone for IDL Lake is yet to be issued, it is recommended that GOCL should approach the Lake Protection Committee (LPC) and concerned higher authorities with a request to reconsider the FTL demarcation. GOCL can share the present scientific study that clearly illustrates that the higher water spread area was

recorded during the 2013 FTL Survey due to unnatural flooding which resulted due to continuous heavy sewage inflow into the lake. If concerned authorities are convinced, the lake area can easily be brought back to its original or natural state through a weir. The weir has been installed near the outlet by the Irrigation Department to control the lake's water level. As mentioned earlier, as per the LPC's guidelines, FTL is maintained throughout the year to prevent any encroachments.

The IDL lake has been listed for Hyderabad Lake Conservation initiative under GHMC. IDL Lake has also been identified as one of the nine lakes to be restored (protection & beautification) in Kukatpally by GHMC under 'Mission Kakatiya'. The lake has been listed to be developed by GHMC under its CSR program. However, since the lake is situated in a prime location with high visibility, it has attracted direct investments from the government as well. The HMDA has already initiated the lake beautification work at IDL Lake since November 2022. Though all key government stakeholders are actively involved to speed up the lake development work, there seems to be a clear lack of coordination and communication among various stakeholders. Furthermore, the proposed project initiatives focus only on the beautification of the periphery regions around the lake, which has become a cesspool. There is no mention of reviving the lake ecosystem and protection of aquatic biodiversity.

Despite the above-mentioned challenges, the present situation is also offering new opportunities towards lake eco-restoration through multi-stakeholder participation. The policy environment is conducive for a PPP model for lake development. With proper communication and coordination, stakeholders can complement each other and contribute towards sustainable development of the lake. Fortunately, all necessary action plans and funds have been approved under various schemes.

1. HMDA is already working on the beautification and development of public infrastructure around the lake. The process of upgrading capacity of 5 MLD STP to 10 MLD has also started. Furthermore, diversion of additional wastewater is also proposed under Phase-2 of the restoration program.
2. GHMC: Involved in Solid waste management. It can plan an important role in promoting and supporting Housing associations and local industries/ commercial setups to treat, reuse and recycle their wastewater.

3. GOCL can contribute towards ecosystem rejuvenation by applying Nature-based solutions to improve lake water quality and habitat protection for biodiversity.
4. Local people have shown willingness to participate and can be engaged in regular lake protection activities such as cleaning of the lake (as volunteers for Swachh Bharat Abhiyan), plantation, eco-tourism, monitoring and evaluation of the project activities and awareness campaigns.

Urban wastewater is becoming a serious challenge for city administrative bodies and calls for holistic and sustainable approaches. To keep installing more and more STPs to treat the ever-growing volume of sewage doesn't seem to be the permanent solution in the long run. Rather, governmental policies should focus on addressing the root cause, which can be achieved through public participation. Housing associations and local industries/ commercial entities should be encouraged to treat, reuse, and recycle their wastewater at the source point. This will reduce the burden on both constructed and natural infrastructure and will bring both economic and ecological benefits to the city.

this site can possibly present a case for 'reuse pilot' within the city where water can be diverted, treated, and reused for various urban purposes. For any such proposal diversion of sewage inflows is necessary.

Chapter-1

Background

1. Background

Lakes are a highly important part of urban ecosystems. They play a significant role in providing environmental, social, and economic, aesthetic, and recreational services. These urban waterbodies at large also help in improving Climate Change resilience of the cities in three significant areas i.e., regulating groundwater, accommodating floodwater, and cooling cities.

Despite their ecological and economic benefits and associated cultural significance, wetlands degradation is a fact with losses far exceeding the loss rate of terrestrial ecosystems. The lakes in Hyderabad city have reduced due to rampant real estate and infrastructure development, high pollution levels, inefficient waste management, unplanned construction in catchment areas and encroachment.

Hyderabad was famous for its visionary sustainable water adaptation practices and included numerous natural and manmade wetlands, including reservoirs, barrages, rivers, streams, lagoons, aquaculture ponds, tanks, ponds, stepwells, and other human made water bodies that were designed, developed and maintained in harmony with nature as a remedy for both floods and drought. The city also earned a sobriquet as the “City of Lakes”. Unofficial oral records suggest that Hyderabad once had anything between 3000-7000 wetlands (both natural and human made). As of 2010, the Hyderabad Urban Development Authority (HUDA) listed 500 wetlands under its jurisdiction, which reduced to just 169 by 2018, with each water body having a surface area of > 10 hectares. It is estimated that Hyderabad has lost 55% of its wetlands (1970-2014), and dubiously ranks fourth among 22 cities in India that have lost wetlands in the last four decades, according to a study conducted by the Wetlands International South Asia (WISA). A prominent newspaper reported in 2021 that only 10 of the 185 lakes in the Greater Hyderabad Municipal Corporation (GHMC) limits that are on the list of the Telangana State Pollution Control Board (TSPCB) for regular water quality monitoring have Biochemical Oxygen Demand (BOD) levels within the prescribed standards. About 23 lakes in Hyderabad are as good as ‘dead’ due to almost zero levels of Dissolved Oxygen (DO).

Like many other lakes in Hyderabad, once a healthy multiple-use ecosystem, the IDL Lake is now facing threat from all directions, be it encroachments or direct discharge of untreated liquid waste and dumping of solid waste. The lake over time has developed hypereutrophic conditions because of the constant dumping of sewage in it. This highly degraded lake ecosystem calls for urgent action to restore it to its past

glory and to create a water secure and climate resilient community and ecosystem. To do so, it is essential to address the root cause of the problems.

Prior to the commencement of any in-situ and ex-situ interventions, a situational analysis and feasibility study was proposed.

The objectives of the situational analysis and feasibility study are to:

(i) Understand the present status of the lake (baseline)

(ii) Identify the root causes of lake degradation and their magnitude and

(iii) Develop the best feasible solutions (preferably nature based) to address the problems.

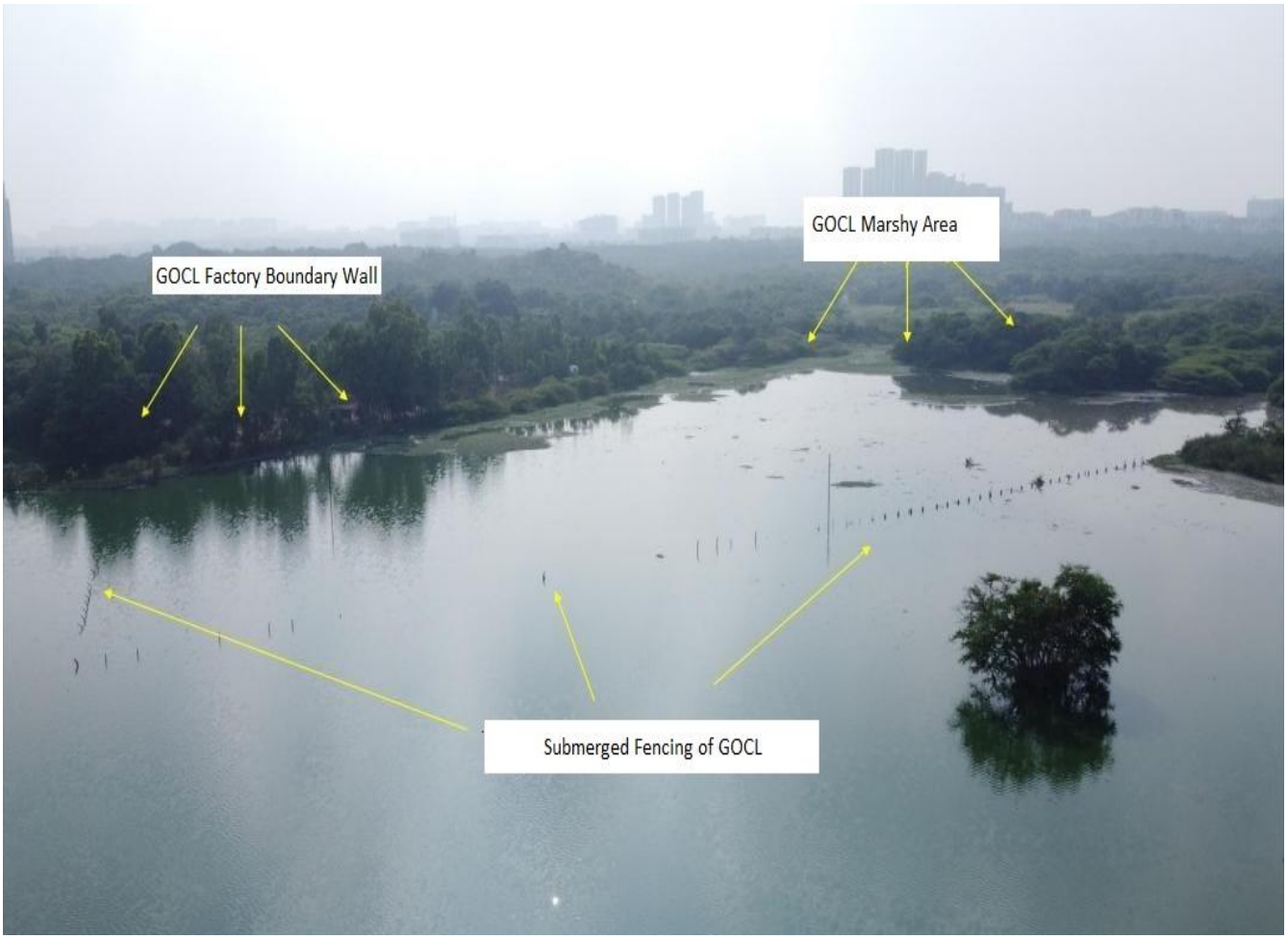
1.1 IDL Lake Kukatpally, Hyderabad

Rangadhamuni / Rangadhamini Kunta or Ranganayaka Cheruvu popularly known as IDL Lake, is located adjacent to the GOCL Corporation Limited (GOCL) facility, at Kukatpally, Balanagar Mandal in Malkajgiri revenue division of Medchal-Malkajgiri district in Telangana State (17^{o} 29' 23.641"N and 78^{o} 29' 44.59"E). It comes within the jurisdiction of the Greater Hyderabad Municipal Corporation (GHMC). The presence of the Mumbai National Highway and Kukatpally Housing Board has resulted in large-scale rise in retail activity and presently Kukatpally is a commercial hub in the Northwestern part of Hyderabad. The land prices of Kukatpally are higher than most parts of Hyderabad. It is one of the densely populated areas of the city.

The IDL Lake was originally a multiple use aquatic ecosystem, providing water primarily for irrigation and drinking to the local communities. The lake was also used for subsistence fishing by fisher folk. The lake also has a lot of cultural significance. There is an ancient temple of Lord Vishnu on the banks of the lake and the idol is believed to be "Swayambhu" (Swayambhu, a Sanskrit word means "self-manifested", "self-existing", or "that is created by its own accord"). In addition, this lake is a major destination for Visarjan (immersion of religious sacred items like idols and others), during Ganesh Chaturthi and Batukamma festivals, two of the major traditional festivals of Telangana. Once a healthy lake ecosystem, it has now turned into a grey colored and stinking cesspool with untreated liquid and solid waste directly released into the lake. Unnatural changes have occurred in its hydrological features due to heavy inflow of

untreated liquid waste, blocked natural outlets and encroachments. It has lost its biodiversity and Ecosystem Services due to heavy pollution.

The IDL lake is listed as Rangadhamuni Kunta (Lake ID 58) among 119 lakes Identified for Hyderabad Lake Conservation initiative under GHMC. The Lake Protection Committee included IDL Lake (Rangadhamini Kunta) in its 7th Phase Notification of FTL and Buffer in April 2014 (Rangadhamini Kunta, Lake ID 4808 - Annexure II). IDL Lake has also been identified as one of the nine lakes to be restored (protection & beautification) in Kukatpally by GHMC under 'Mission Kakatiya'. Since the lake is situated in a prime location with high visibility, it has attracted direct investments from the government as well. The lake is visible from the Metro rail and National Highway. Thus, although the lake has already been listed to be developed by GHMC under its CSR program, the HMDA has already initiated the lake beautification work at IDL Lake since November 2022. Unfortunately, the ongoing lake development project is focused only on the beautification work around IDL Lake, that presently is merely a dead cesspool. There have been no efforts made so far to revive its ecosystem and making it a 'Living Lake' again.



With heavy inflow of untreated sewage and natural rainwater, the lake in the recent past has been observed to be flooding the IDL site perennially and swelling towards few workshops of the company, which is a cause for serious safety concerns. A weir has been installed near the outlet by the Irrigation Department to control the water level of the lake. However, as per the Lake Protection Committee's guidelines, FTL is maintained throughout the year to prevent encroachments.

Chapter-2

Analysis of IDL Lake Catchment using spatial technologies

2. Analysis of IDL Lake Catchment using spatial technologies

2.1 Objective

The IDL Lake is a highly degraded lake ecosystem and calls for urgent action for restoration. To make a better restoration plan, understanding the overall morphology, hydrology, influence of climatic factors and land-use analysis of the catchment is important. Geographic Information System (GIS) with its capacity of querying, visualizing, analyzing, modelling, producing outputs, planning and monitoring has become a highly efficient tool for spatial analysis. This in-depth GIS study of IDL Lake is part of a larger objective to understand the factors causing degradation.

2.2 Detailed scope of work

- **Demarcating Lake and its catchment area, Lake morphology**

  The catchment area has been demarcated using a Toposheet. Also, its connectivity with nearby water bodies has been mapped. Recent satellite images are used to mark the lake's surface water spread.

- **Digital Elevation Model for the catchment area**

  The model prepared is based on contour information available on the toposheets. The accuracy of this model is higher than the 30 meter freely available DEM data. DEM is important to understand the height and slope characteristics of the area and is required for any kind of hydrological analysis.

- **Drainage mapping and marking disappeared channels.**

  Based on toposheet and satellite data, the historical and present drainage channels are marked. Marking of disappeared channels is also done with the support of ground truthing.

- **Rainfall data analysis**

  The analysis of rainfall data of the recent past is beneficial to conclude the impact of climatic factors in the catchment area.

- **Change in Groundwater levels**

  Based on secondary data, the ground water levels are compared with rainfall for better understanding of changes.

- **Landuse/Landcover change of catchment area**

A temporal pre and post monsoon analysis of the entire catchment area using satellite data was done for the last two decades at 10 year intervals to know the land use changes in the catchment which could be a major influencing factor in redefining the shape and size of IDL Lake.

2.3 Area Characteristics

Location

Rangadhamuni Cheruvu popularly known as IDL Lake (given its geographical proximity to IDL Explosives Limited (currently Gulf Oil Corporation Limited-GOCL), falls under Kukatpally Mandal of Medchal-Malkajgiri district in Telangana State (Fig 1). The geographical point coordinate of the lake are 17° 29' 23.641"N and 78° 29' 44.59"E. It comes within the jurisdiction of the Greater Hyderabad Municipal Corporation (GHMC) . It shares a long shoreline with GOCL complex boundary on the Southern and Western sides, with IDL access road on the Eastern side and residential complexes in the Northern side.

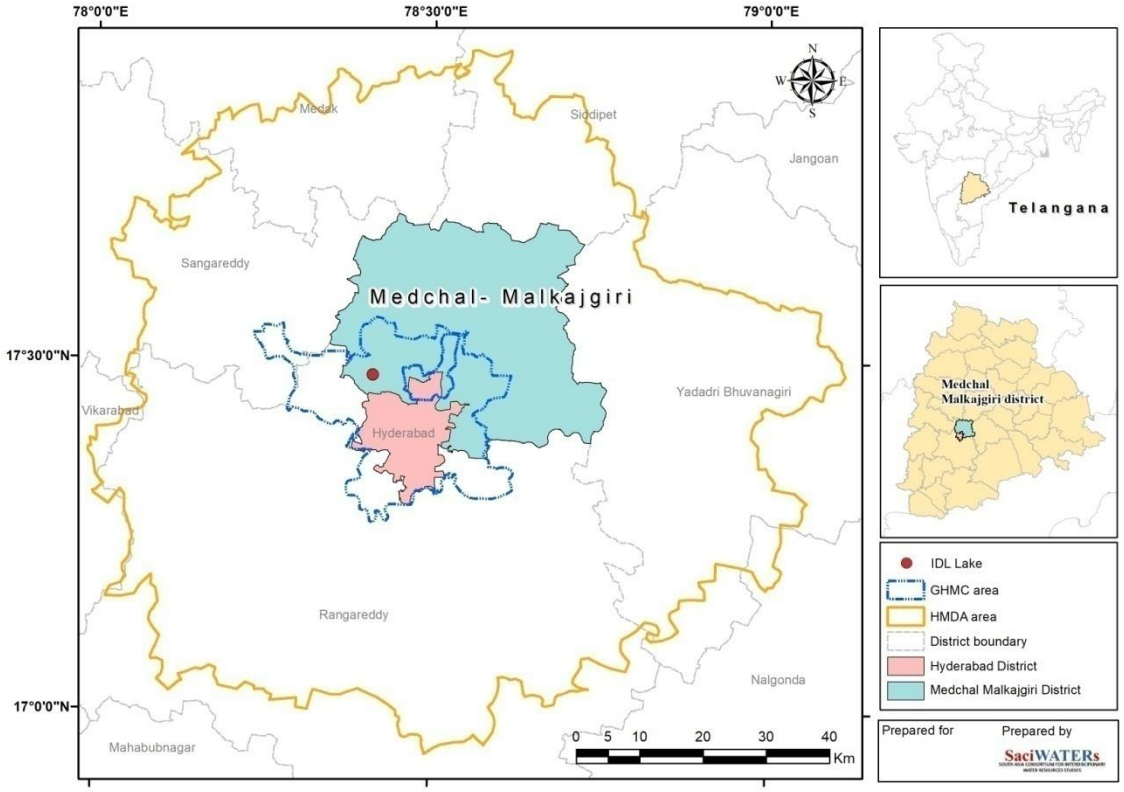


Fig 1: Location of stydy area

Demarcating Lake & its catchment area and Lake Morphology

As per the toposheet of 1975, the IDL Lake is clssifed as a dry lake (Fig. 2). This lake is connected with Yellamma Kunta Cheruvu in the North through a canal and to Hussain Sagar lake in the South to form a Tank Cascade System (TCS). The TCS is a type of traditional surface water infrastructure systems initially developed about 2000 years ago on Common Property Resources (CPR) for irrigation purposes in semi-arid Southern peninsular region of India. The application of TCS is not just limited to irrigation but covers domestic water supply, livestock management, retarding negative impacts from extreme events such as seasonal flooding and recurrent droughts (Srivastava, A., 2023).

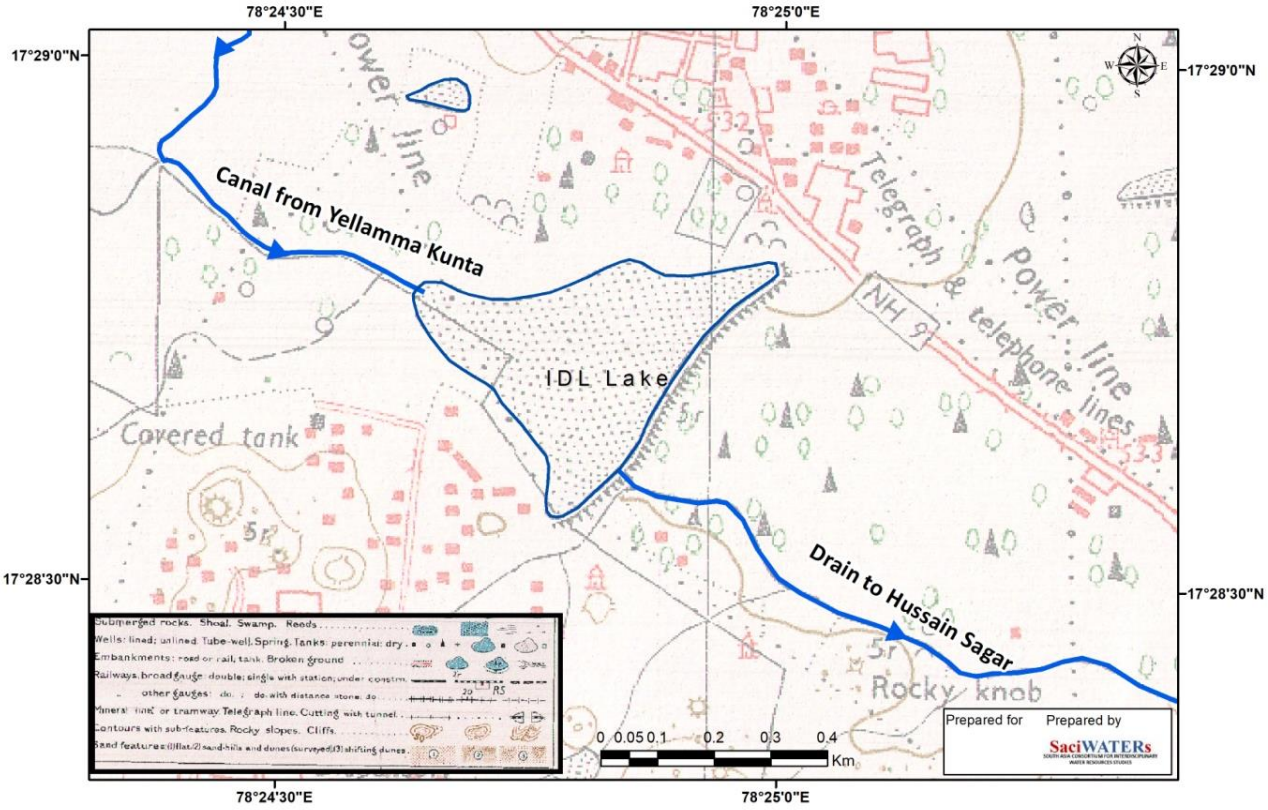


Fig 2: IDL lake marked as dry lake in the toposheet of 1975

IDL Lake is a shallow seasonal waterbody, which ideally shrinks during the summer and swells during the monsoon. However, presently this lake is filled with water throughout the year. The Lake waterspread area has been delineated using Google Earth historical images for the year 2003, 2010-11 and 2014-15 for both pre and post monsoon season (Table 1). During the pre-monsoon of 2003 i. e. May, the water spread area marked from the image was around 7.83 acres which swelled after the monsoon to 42.01 acres (Fig 3a and 3b). Similarly perimeter also changed from 1383 m to 2861 m. Hence, the shrinking of the lake size during summer and swelling post monsoon was confimed. However, while analysing pre and post monsoon images of 2010, it was noticed that there was no change in the water spread area. This pattern was repeated in 2014 pre-monsoon and 2015 post monsoon despite the years being consecutive drought years.

Table 1: Seasonal change in water spread area

Month Year	area (acres)	area (ha)	Peri-meter (m)
May-2003	7.83	3.17	1383
Dec-2003	42.01	17	2861
Apr-2010	43.74	17.7	2734
Jan-2011	43.74	17.7	2734
May-2014	43.24	17.5	2689
Dec-2015	43.24	17.5	2689

Fig 3a and b: Water spread area during June 2003 and December 2003

This seasonal change in water spread area wasn't noticed any year after 2005-06. Currently, not only the lake area but the bordering land of GOCL is also submerged under water throughout the year (Fig 4a and 4b).

Fig 4b and b: Negligible change in water spread area during May 2021 and December 2021

The lake is in highly degraded state and since it is the reflection of its catchment, it is important to demarcate and study the lake catchment thoroughly to have a fair idea about the factors influencing its characteristics. The lake condition is directly related to the condition of the lake's watershed. Moreover, whatever inputs are coming from the catchment, whether it is fresh water drainage or sewage, the same will get reflected in the lake water quality. The lake boundary has been drawn using the toposheet (no. 56K7/NE) at 1:25000 scale. The actual lake area as per toposheet is nearly 32 acres (13 ha). The latest lake map (Fig 5) and information from HMDA[1] is available for the year 2013.

[1] https://lakes.hmda.gov.in/SWC/rpt_lakes.aspx/

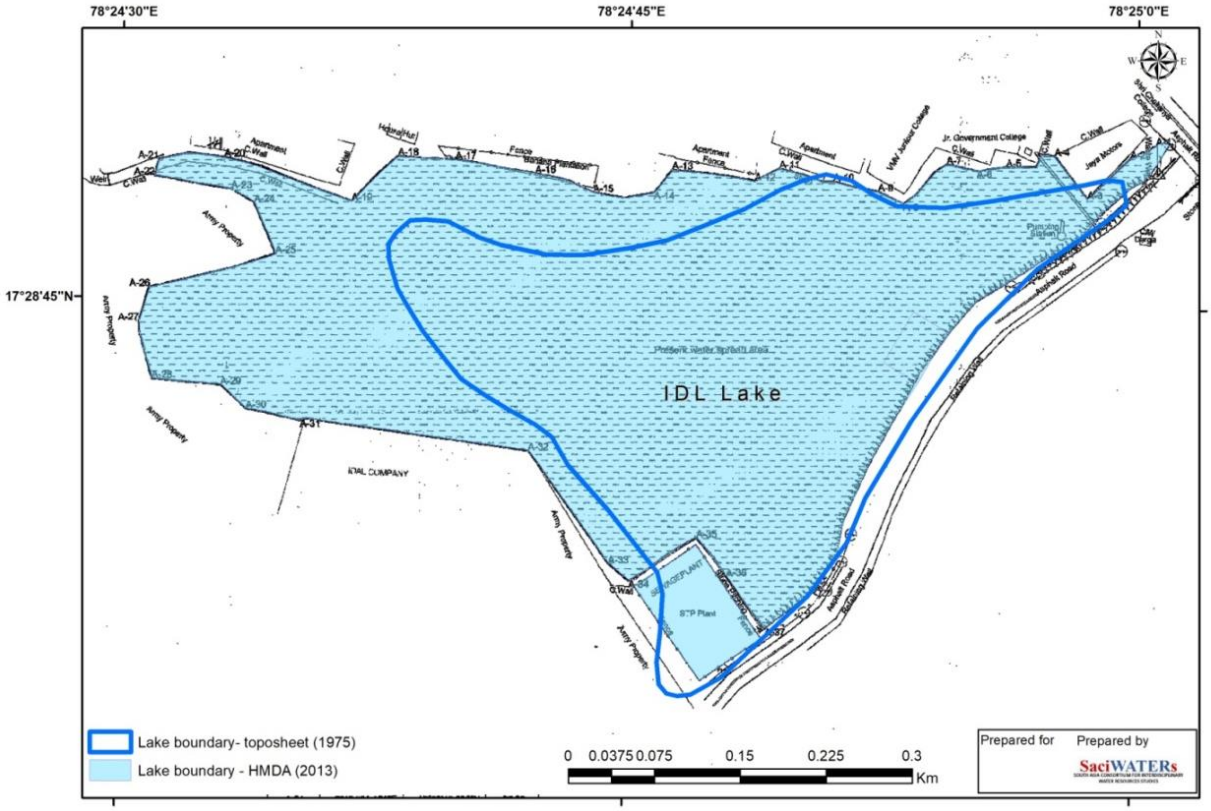


Fig 5: IDL lake boundary map, 2013 (source HMDA)

As per HMDA information, water spread area, the Full Tank Level and bund length etc. is given in Table 2. **It shows that the water spread area has increased by nearly 14 acres from the original area.** With full tank level the perimeter is 2690 m which was earlier 1790 m only.

Table 2: Lake details as on (21/09/2013)	
Water spread area	46.240 Acres
Area of the tank upto FTL	46.240 Acres
Water level	+99.900 m
Full tank level (weir top)	+100.000 m
Full tank level perimeter	2689.150m
Bund length	588.000 m

The catchment area of the lake was also demarcated using the toposheet. The watershed area spreads over North West region of the lake and covers approximately 830 ha. of land. A part of GOCL land is also submerged in the lake water. Earlier, till 2006, the land used to get inundated only during the monsoon, but afterwards a large portion of land is submerged under

the water throughout the year. GOCL poles can be seen in some satellite images and also the same are visible at the site partially submerged under water.

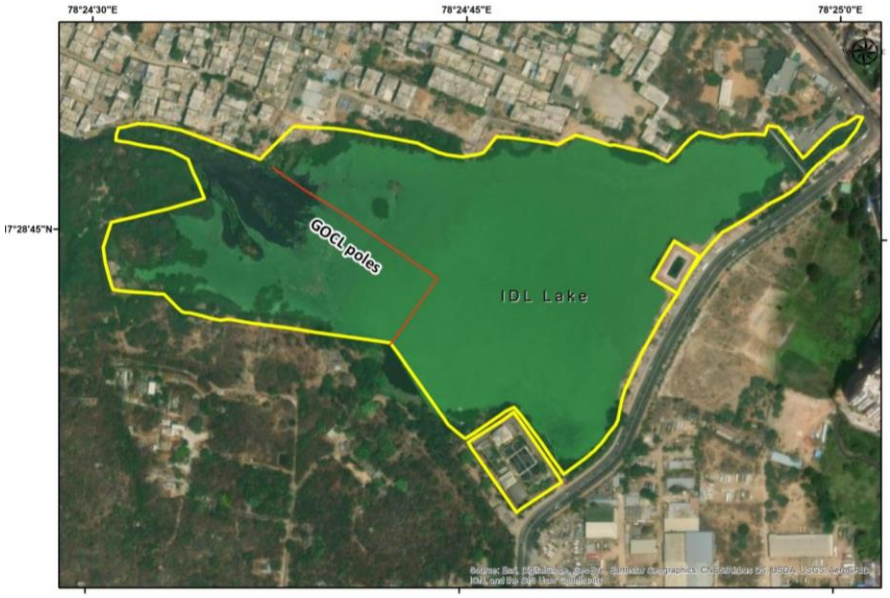


Fig 6: IDL lake boundary map, 2013 (source HMDA)

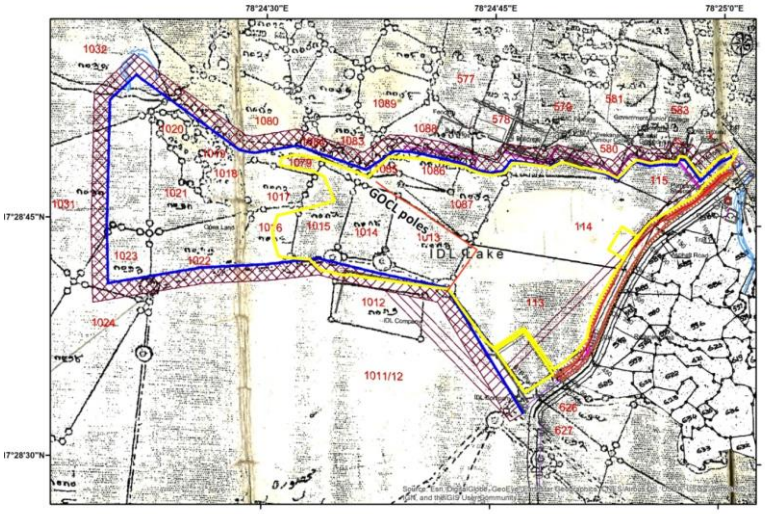


Fig 7: IDL lake cadastral map 2013– (FTL boundary -Yellow line drawn using the other map from HMDA, new FTL boundary.Blue line – modified by revenue department– 30 m buffer strip -Crossed hatched area of new FTL line which is much inside the GOCL boundary) source HMDA

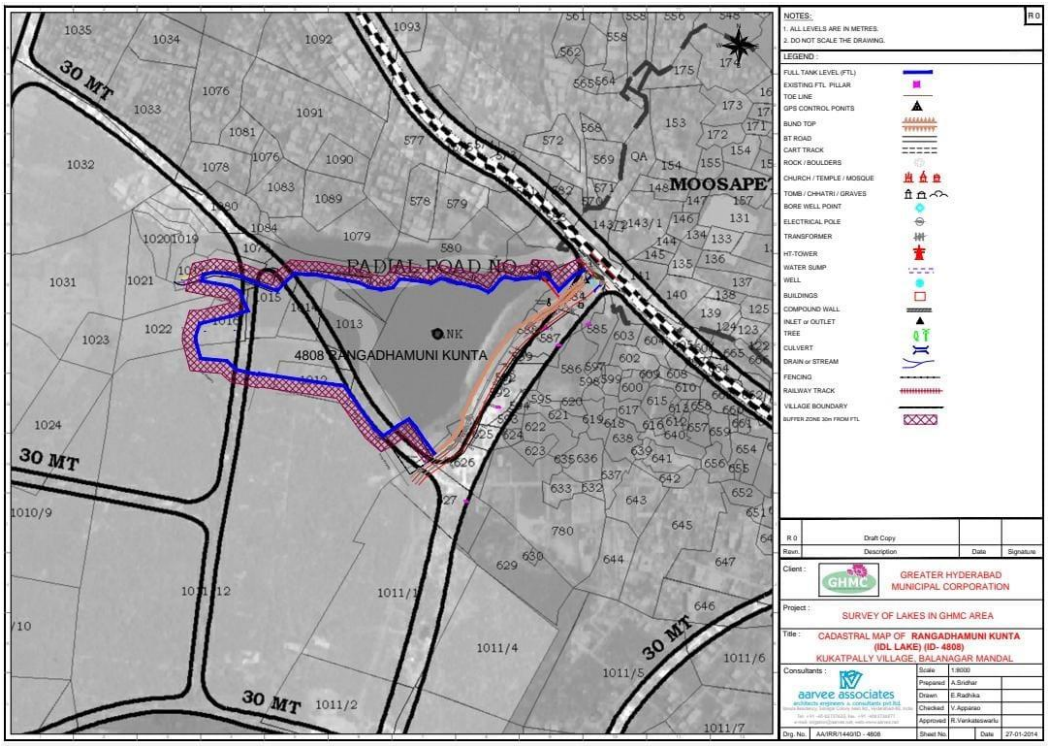


Fig. 7.1 The latest IDl Lake FTL map available on HMDA website

Digital Elevation Model for the catchment area

A Digital Elevation Model (DEM) is a representation of the bare ground topographic surface of the Earth excluding trees, buildings or any other surface objects. It is the representation of surface eleveation in three dimensions (3D). It is also required to calculated the slope in the watershed.

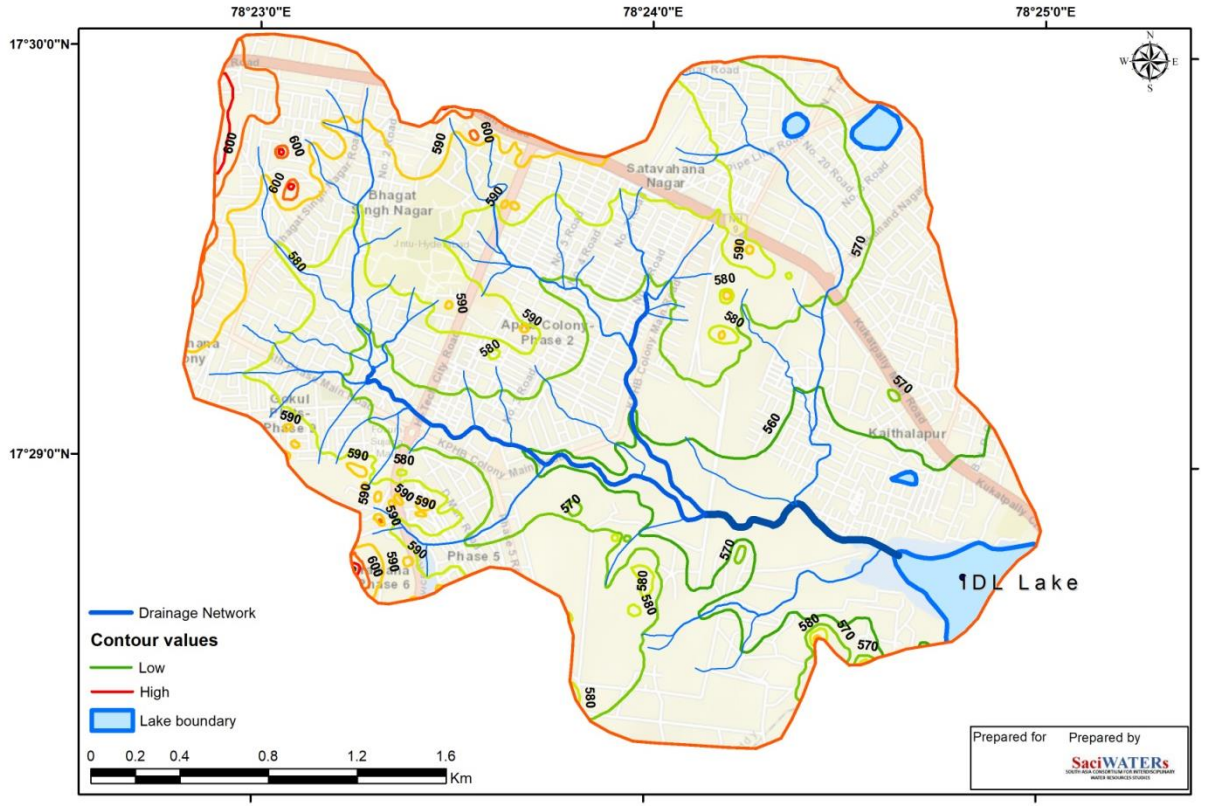


Fig 8: Elevation contours, drainage network and waterbodies in IDL lake catchment area

For the catchement of IDL Lake, the DEM is created by extracting and merging together the information from toposheet at 1:25000 scale in form of contours, spot height values, drainage, water bodies (Fig 8). The contour interval is 10 m. The lowest contour is 560 m MSL and highest is at 610 m MSL. The overall watershed area has a gentle slope. The western part of the basin is elevated and the first order drainage starts from there. The eastern part of the watershed has low land and the lake is also situated in the eastern part. The 3D representation of the land surface is given in Fig 9.

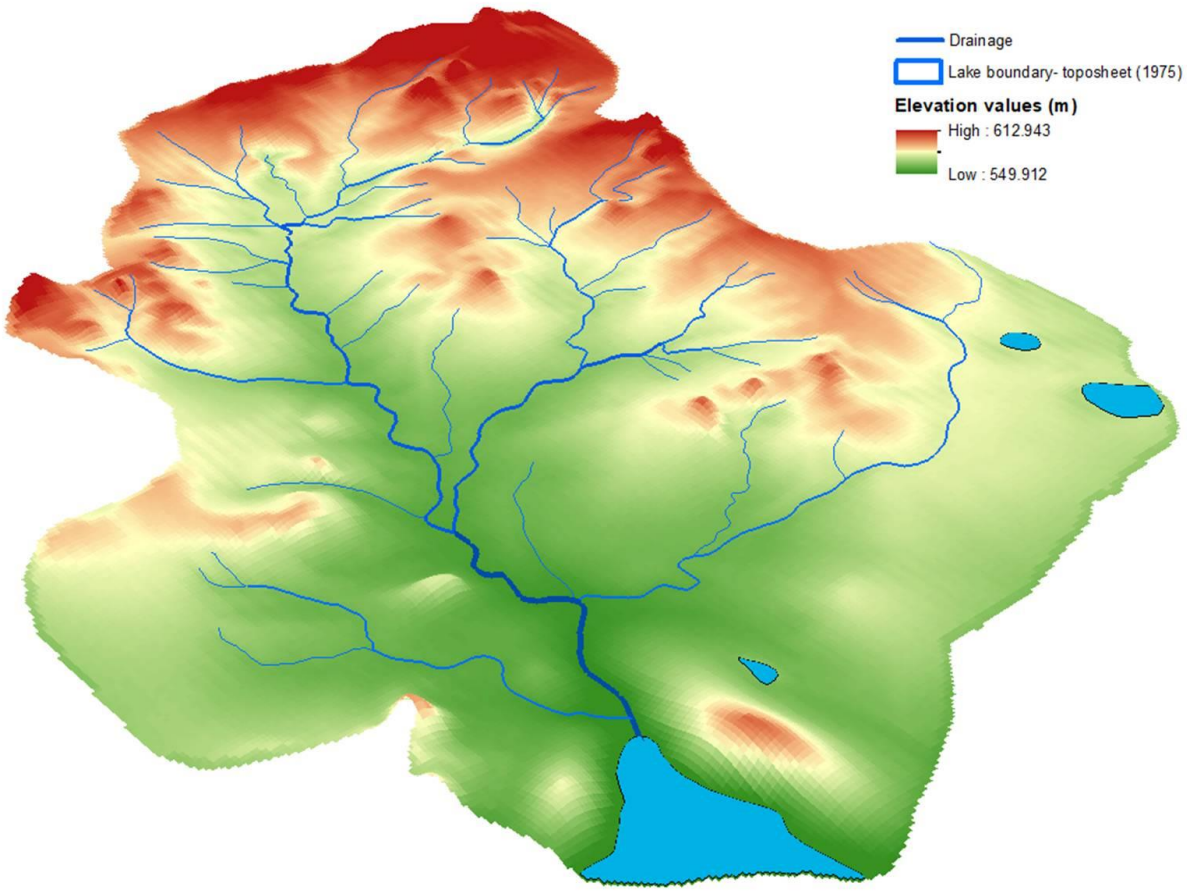


Fig 9: Digital Elevation Model of IDL catchment

Drainage morphometry and marking disappeared channels

The natural drainage channels are geomorphic features that convey the flow of water. Natural channels play a crucial role in maintaining the hydrological cycle of an area. The channel conveys this runoff to the lakes, ponds, or rivers and ultimately to the sea and ocean in the form of streams.

The historical drainage channels have been mapped in the area using toposheet (Fig 10). Stream ordering has been done using Strahler stream ordering method. Historically the area was drained by nearly 27000 m. length of streams. (Table 3).

Table 3: Drainage statistics (1975)

Stream order	Count	Total length in catchment (m)	Bifurcation ratio
1	46	15058	1.96
2	12	7699	2.44
3	3	3152	3.04
4	1	1038	

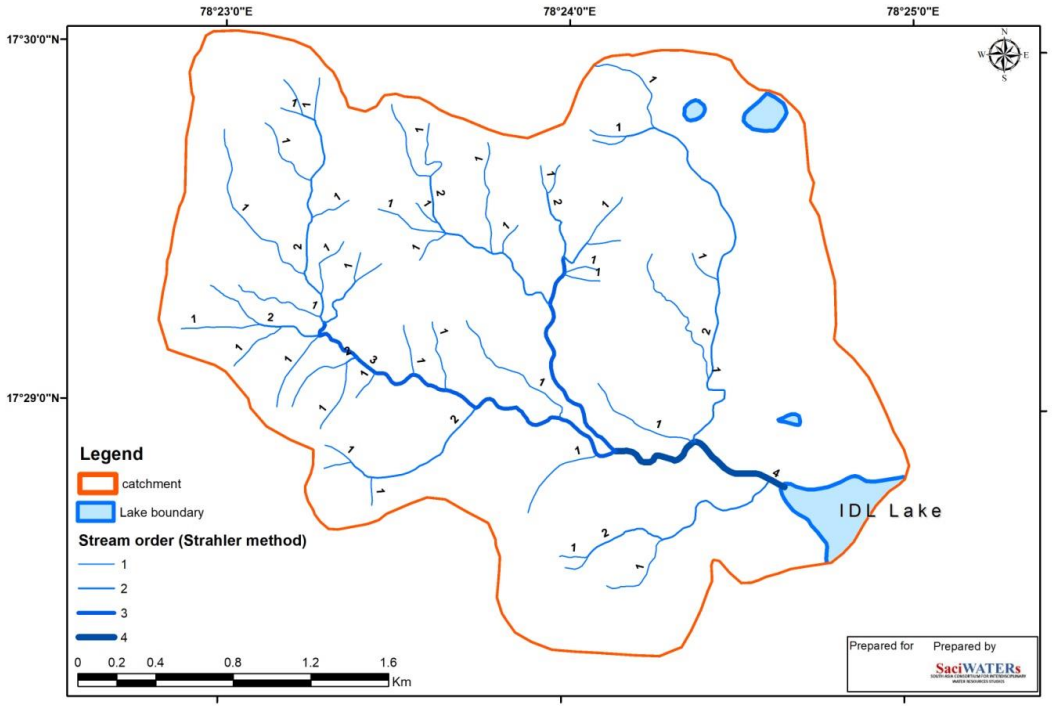


Fig 10: Drainage from toposheet and stream ordering

The total number of streams in each order is termed as the Stream Number. For the catchment area Stream number has been counted for each order. The Stream Number decreases with increasing order of streams (Table 2). In other words, stream number is inversely proportional to stream order. As per the 'Law of Stream Number', when Stream Number (taken in arithmetic scale) is plotted against Stream Order (taken in logarithmic scale), it gives a negative linear pattern (Fig. 11). It means number of streams from highest to lowest order in a particular basin tend to give a Geometric Series. The historical drainage shows this characteristic in the watershed.

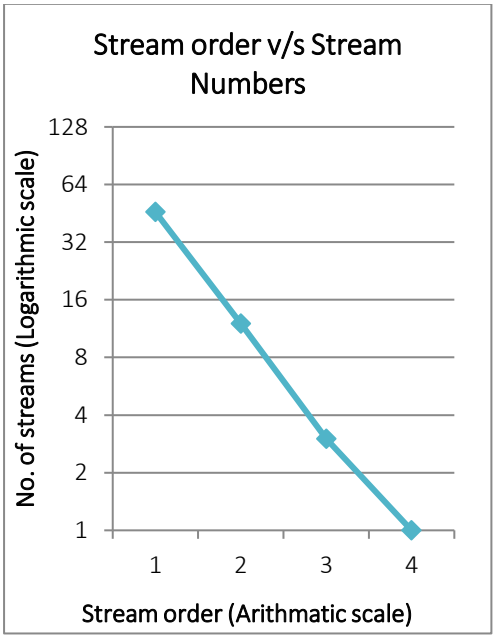


Fig 11: Stream order v/s stream number

Bifurcation Ratio of streams depends upon relief, rock type and dissection of rocks. Higher bifurcation ratio (> 5) shows that the drainage is controlled by geological structures. For a typical basin the mean bifurcation ratio ranges between 3 to 5. For this watershed area, the mean bifurcation ratio is 2.48 (Table 2) which is on the lower side. **It indicates high possibilities of flooding** as water tends to accumulate rather than spreading out. This information is with reference to the year 1975 and now the situation of the watershed has become further critical because number **of visible streams are reduced to just 18 in the year 2022 from the previous 62** (Fig 12). The drainage lines have been observed using satellite images for various recent years (2003, 2008, 2012, 2017 and 2022).

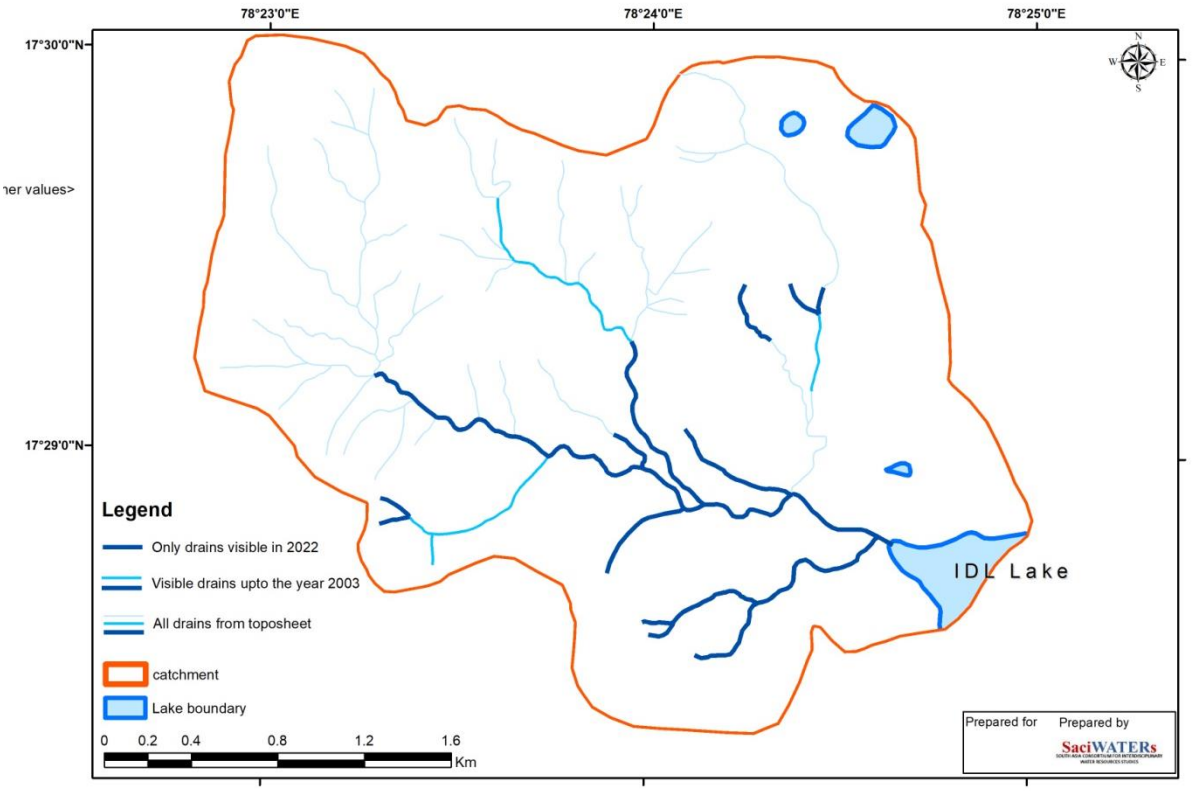


Fig 12:Decreased number of streams from 1975-2003-2022

It was observed that due to impact of urbanisation, the natural drains have disappeared at many places and at some they are nothing more than sewage carrying channels. (Fig 13a and 13b).

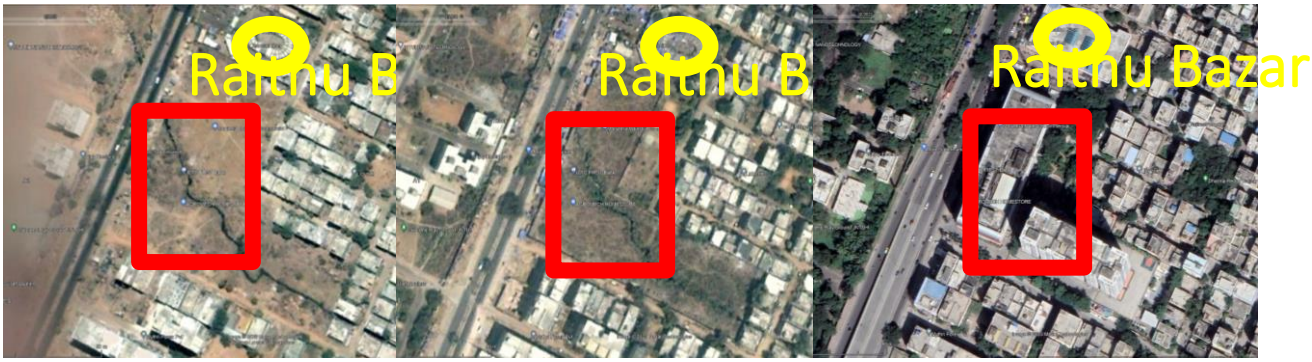


Fig 13a : Visible drainage line in 2003, 2008 but disappeared in 2022

Fig 13b: Visible drain in 2003 and properly managed in 2022.

Understanding influence of Rainfall

As per the long period average from 1999 to 2011, the average annual rainfall of the erstwhile Ranga Reddy district in which the study area falls is 833 mm, which ranges from Nil rainfall in January and December to 190 mm in July. According to this average, July is the wettest month of the year. The mean seasonal rainfall distribution is 652 mm in southwest monsoon (June-September), 114 mm in northeast monsoon (Oct-Dec).

The last five years (2018-2022) rainfall data analysis was also done for Kukatpally Mandal. The average monthly distribution of rainfall in the area is provided in Fig 14. The averages generally match with long-term averages.

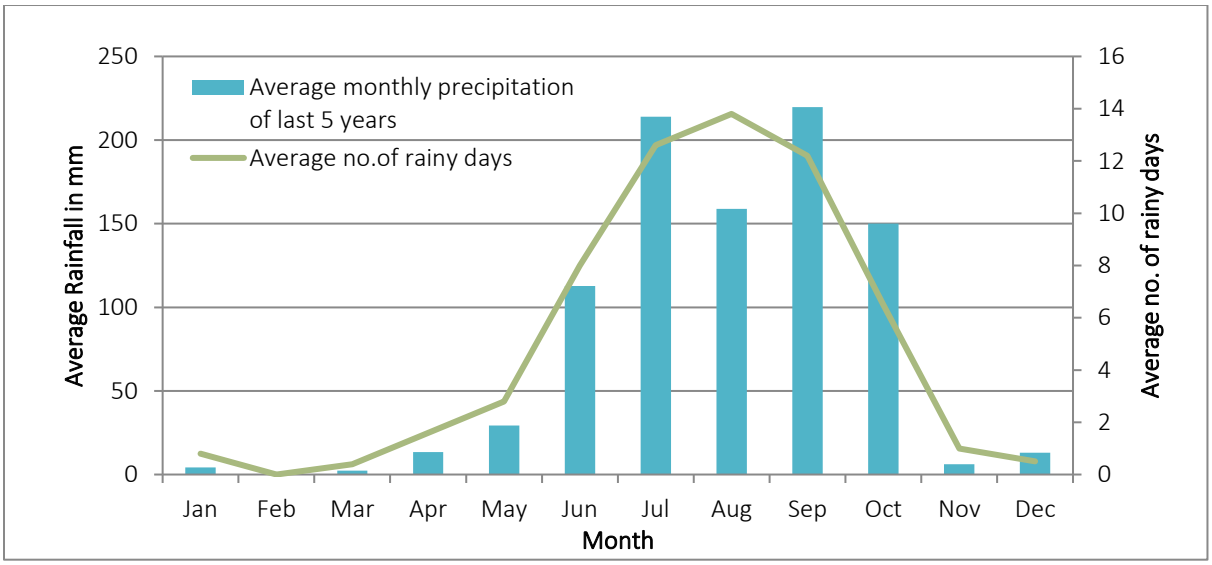


Fig 14 : Last five year(2018-2022)average monthly distribution of rainfall in Kukatpally

The rainfall in and around Hyderabad was highly variable during the last decade. An effort has been made to analyse monsoon period (June-September/October) data from the year 2004 to 2022 for Kukatpally mandal. The departure from the average were calculated (Table 4) and classified based on IMD rainfall categorisation scheme i. e. normal ranges between -19 to +19 %, deficit between -20 to -60, and excess between +20 to +60. Beyond 60 positive values are classified as large excess and negative values as large deficit. Six years data from 2004 and 2009 shows that there were five normal years of rainfall but in between 2010 and 2022 for a span of 13 years, there were only five normal rainfall years. This span has two large excess years (2010, 2020) and four deficit years (2011, 2014, 2015 and 2018). The deficit was reaching to large deficit in 2015 and for other years also it was more than 40%.

Table 4: Temporal Total of rainfall months					
Year	Rainfall total (July to Sep/Oct)	normal	% Departure	Cumulative % dep from normal	Remark
2004	411	743	-45	-45	Deficit
2005	792	743	7	-38	Normal
2006	707	743	-5	-43	Normal
2007	676	743	-9	-52	Normal
2008	707	743	-5	-57	Normal
2009	601	743	-19	-76	Normal
2010	1238	743	67	-9	Large Excess
2011	405	743	-45	-55	Deficit
2012	647	743	-13	-68	Normal
2013	791	743	6	-61	Normal
2014	408	743	-45	-106	Deficit
2015	325	743	-56	-163	Deficit
2016	1114	743	50	-113	Excess
2017	1174	743	58	-55	Excess
2018	443	743	-40	-95	Deficit
2019	834	743	12	-83	Normal
2020	1207	743	62	-21	Large Excess
2021	795	743	7	-14	Normal
2022	847	743	14	0	Normal

This analysis clearly shows that rainfall variability was very high in the region. Cumulative Rainfall Departure (CRD) from normal rainfall is a concept sometimes utilized to evaluate the temporal correlation of rainfall with surface water or ground water levels. The CRD has hydrologic meaning in the short term, as a generalized evaluation of either meagre or abundant rainfall, and when utilized in connection with a detailed water budget analysis can be used in a predictive fashion. Looking at cumulative % dep for the year 2022 it has become 0 so it can be said that rainfall pattern is cyclic in nature. Also, comparing these rainfall figures with groundwater levels are showing some strange co-relation (Fig 15). Till 2016, the average groundwater level curve was following the rainfall pattern but after 2016 there was a steep decline in grounwater levels. The ground water level is trending upwards from 2019 onwards.

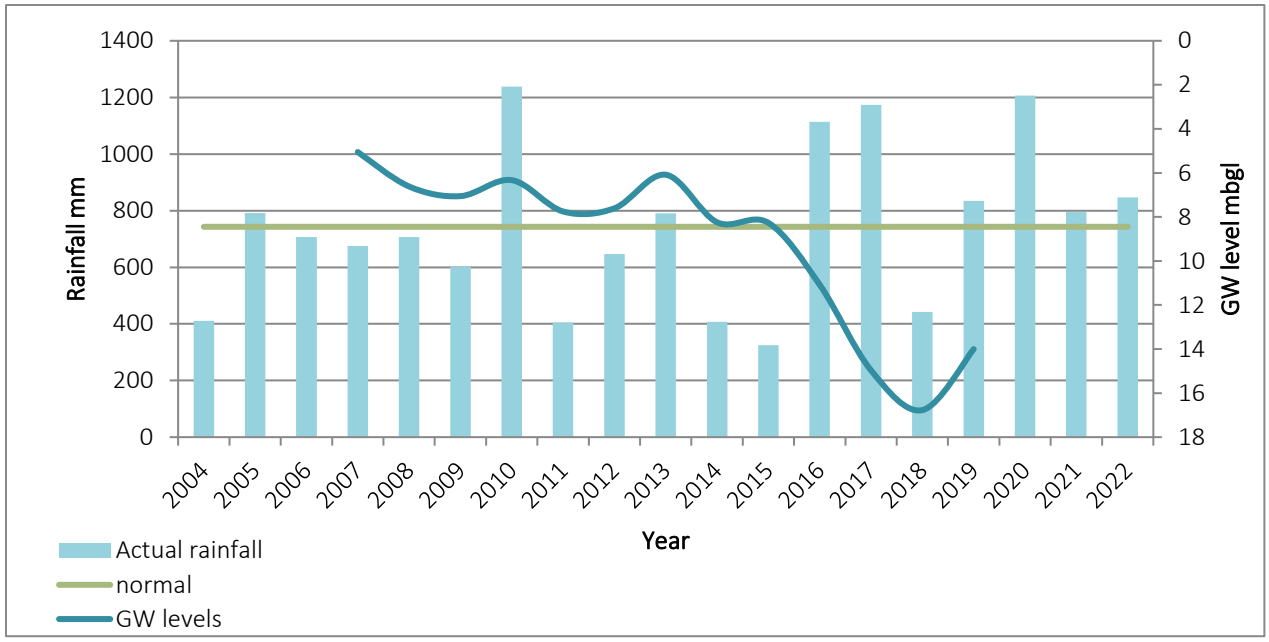


Fig 15 : Comparison of temporal rainfall and groundwater data for Kukatpally mandal.

Lake water spread area calculations done in the previous section, were correlated with rainfall data and it can be concluded that now **lake is not behaving as per the rainfall pattern**. **In 2014 and 2015 when the entire state was facing severe consecutive drought, the lake water spread area didn't change.** Also, in 2010 for both pre and post monsoon period, the lake water spread area was same.

The variable rainfall pattern with high intensity rainfall such as rainfall of 174.8 mm in a single day on 14 October 2020 and 106.6 mm on 23 July 2022 will have severe consequences in the surrounding environs as **the Lake morphology has become flood prone and it is near to FTL**. This situation is prevalent throughout the year including drought years.

Land Use/Land Cover change of catchment area

Several studies on Hyderabad Lakes summarize that lakes are either drying or are already dead. However, **IDL Lake is indicating a contradictory behaviour. Earlier it was classified as a dry lake but now it has become perennial.** To a large extent, urbanisation of the catchment area plays a crucial role. Hence a temporal analysis of the entire catchment area using satellite data was done for the past 20 years at an interval of 10 years to understand land use changes in the catchment and to ultimately conclude upon influencing factors in redefining the shape and size of IDL Lake. The change detection analysis was done

using a visual interpretation method using Google Earth and Sentinel temportal satellite image for the years 2003, 2012 and 2022. The roof area boundaries are modified using open street free buildings data. The major land-use classes in the catchment area are as follows:

- Built-up (very-low, low, medium and high density),
- Open land or Scrub,
- Agricultural crop land and plantation.
- Lake area (water spread, bund and dry area etc)

The land-use classes with respective to the area in hectares are presented in table 5.

Table 5: Land-use classes and area in hectare and percentages

Landuse classes/Years	Area in Hectare			Area in Percentage		
	2003	2012	2022	2003	2012	2022
Agriculture	28.38	8.27	8.27	3.41	0.99	0.99
Plantation	12.79	4.95	4.95	1.54	0.60	0.60
Open Scrub	270.17	227.70	227.70	32.50	27.39	27.39
STP	0.00	0.86	0.86	0.00	0.10	0.10
Bund	0.48	0.48	0.48	0.06	0.06	0.06
Drain	0.54	0.54	0.54	0.07	0.07	0.07
Lake Area	18.10	4.71	4.71	2.18	0.57	0.57
Water spread	5.09	17.85	17.85	0.61	2.15	2.15
Built-up-very low density	14.01	20.97	20.97	1.68	2.52	2.52
Built-up-low density	142.06	47.30	47.30	17.09	5.69	5.69
Built-up-medium density	339.77	56.64	56.64	40.87	6.81	6.81
Built-up high density	0.00	441.13	441.13	0.00	53.06	53.06
Total area	831.39	831.39	831.39	100.00	100.00	100.00

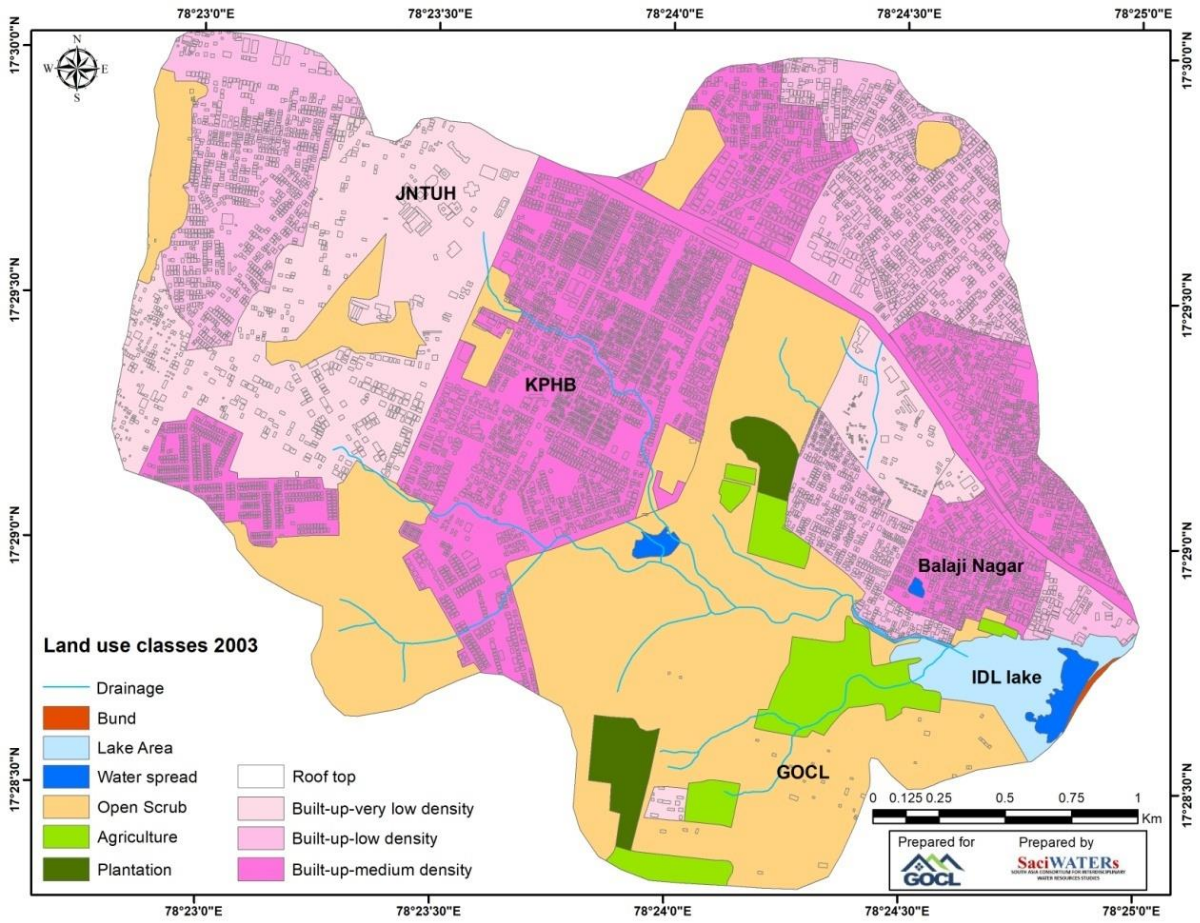


Fig 16: Land-use map of IDL catchment for the year 2003

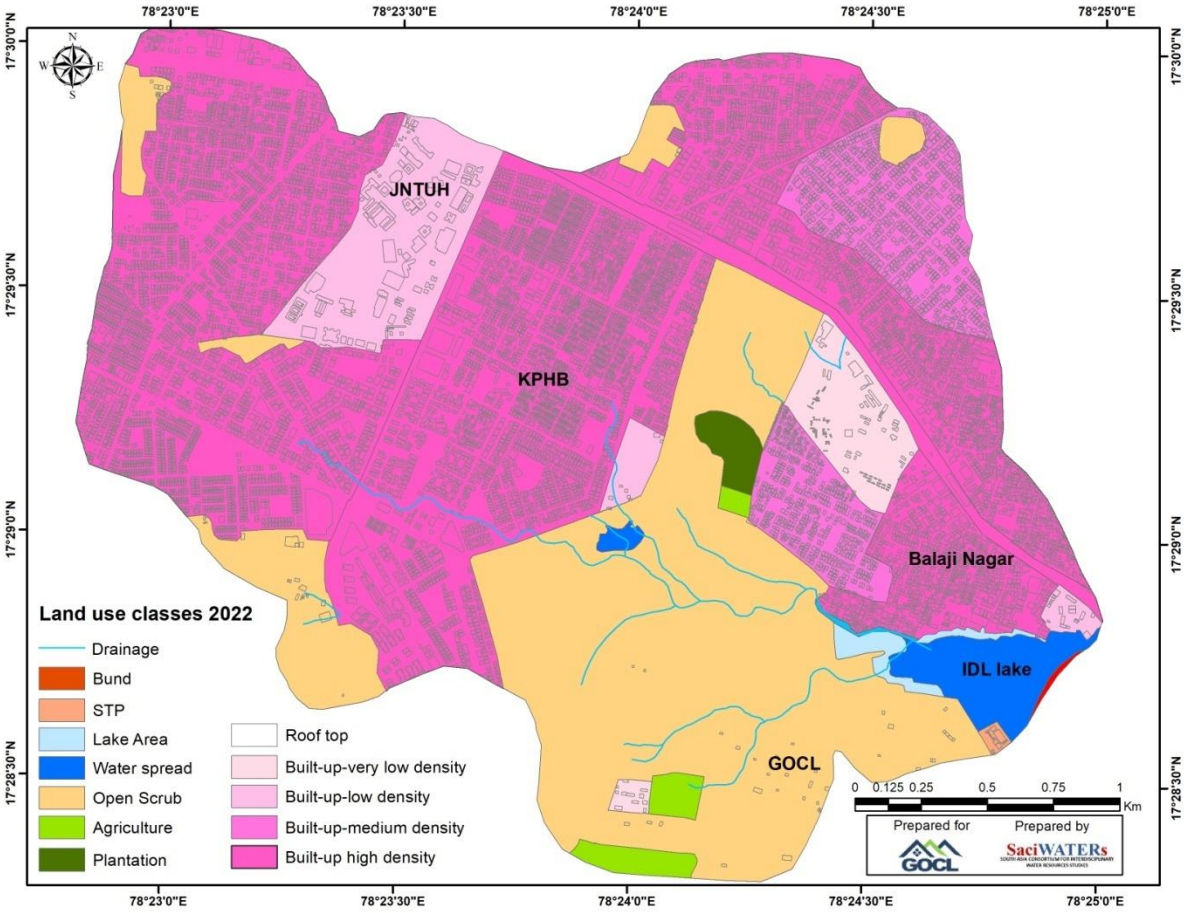


Fig 17: Land-use map of IDL catchment for the year 2012

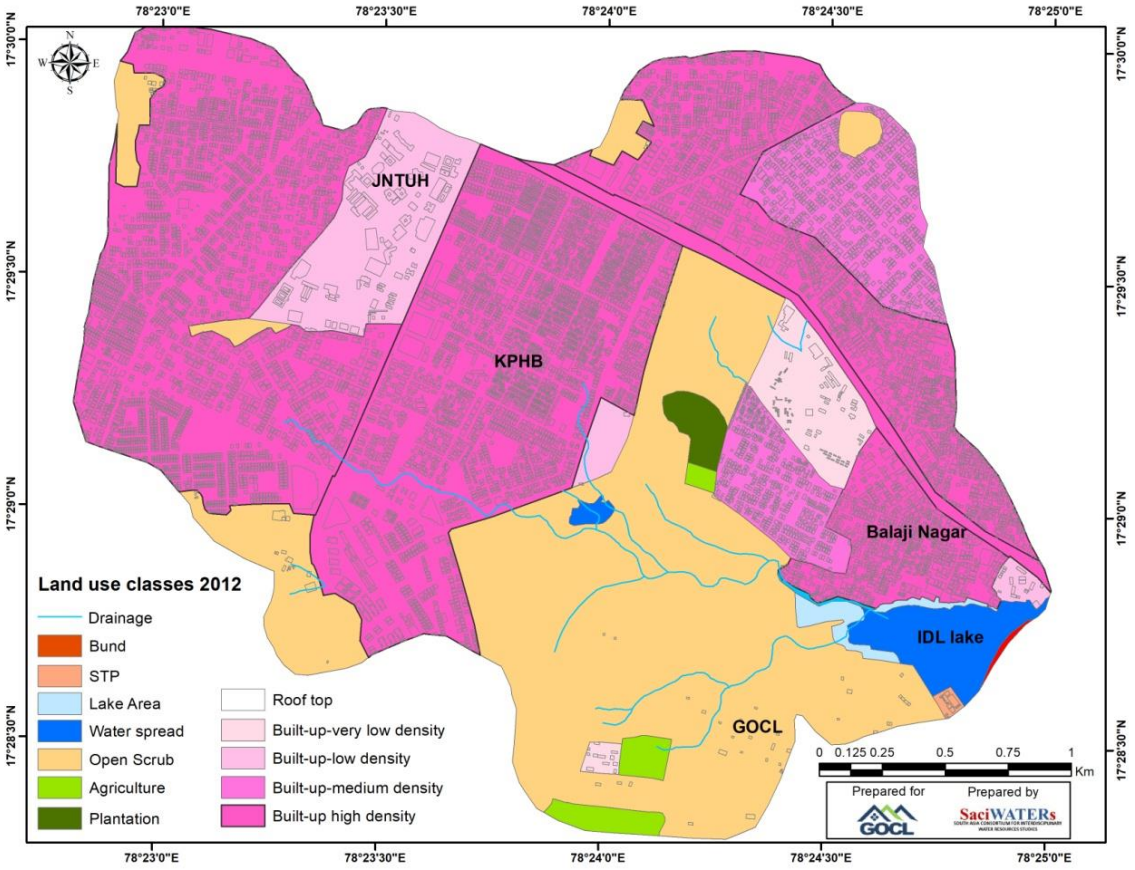


Fig 18: Land-use map of IDL catchment for the year 2022

Landuse interpretation for different years has been done for the dry season i.e. April or May months. Conclusions from landuse interpretations are as follows:

- Landuse changes happened during 2003 and 2012 and has not changed much between the years 2012 and 2022.
- Built-up area covered 60% of the catchment during 2003 which increased by nearly 8% in 2012 and remained same in 2022.
- In 2003, the total built up area was classified as very-low, low and medium density built-up. The area under all these classes substantially reduced and the new class high-density built up covered 88% of the built-up area.

- Agricultural and plantation area also reduced substantially.
- The open scrub in the south-west quadrangle reduced and got converted into builtup area.
- The water spread area for dry season has increased in both the years of 2012 and 2022 in comparison to 2003.

2.4 Summary and key observations

- The lake was classified as dry lake as per 1975 toposheet but now it has become perennial as water is available in the lake throughout the year. The seasonal water spread shrinking and swelling phenomenon has gone away after the year 2005.
- The natural drainage system of the catchment nearly disappeared with increase in builtup area or has been converted to open or underground sewage drains which are carrying the sewage to IDL Lake.
- The catchment area since earlier time has low bifurcation ratio of 2.48 which indicates that it is prone to flooding. Increase in high density builtup area is further aggrevating the flooding situation.
- The variable rainfall pattern with high intensity rainfalls such as 174.8 mm in just one day on 14 October 2020 and 106.6 mm on 23 July 2022 will have severe consequences in the surroundings because Lake morphology is flood prone and it is near to FTL throughout the year even during drought years.
- In terms of residential area boundaries, a little amount of change is seen from 2003 to 2022 but in terms of built-up density all the very low, low and medium density builtup has been converted to high density builtup which has increased the sewage quantity manifold in the overall catchment.
- Considering a runoff co-efficient of 0.7 because 68% area in the catchment is builtup so less amount of percolation, with rainfall intensity of 1 inch per hour, sudden flow of nearly 40 cubic

meter of water per day in addition to current average sewage flow of nearly 300 cubic meter per day would definitly lead to inundation in low lying areas.

- Since built up area is covering nearly 68% of the catchment area and generating a huge quantity of wastewater, managing sewage is a cause of conern. Hence, eco-friendly technologies such as Vision Earthcare's 'CAMUS-SBT'[2] can be explored for recycling wastewater at various sources.

2.5 References

Srivastava, A., Chinnasamy, P. (2023). Tank Cascade System in Southern India as a Traditional Surface Water Infrastructure: A Review. In: Chigullapalli, S., Susha Lekshmi, S.U., Deshpande, A.P. (eds) Rural Technology Development and Delivery. Design Science and Innovation. Springer, Singapore. https://doi.org/10.1007/978-981-19-2312-8_15

Ramachandraiah *C.* and Prasad, S. (2004), Impact of urban growth on water bodies: The case of Hyderabad, Centre for Economic and Social Studies, Hyderabad Working Papers, Centre for Economic and Social Studies, Hyderabad, India

[2] http://www.visionearthcare.com/technology/wastewater-treatment

Chapter-3

Limnological Study of IDL Lake

3. Limnological study of IDL Lake

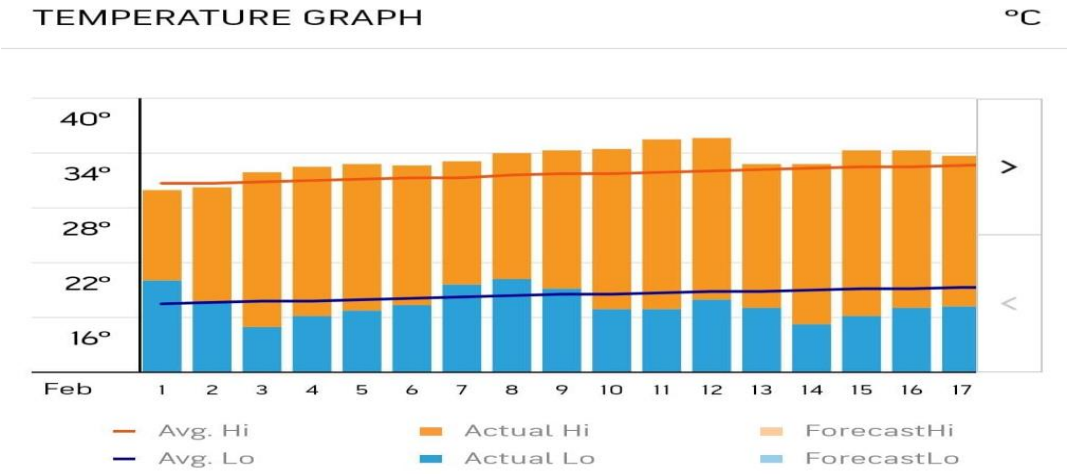
A study of physico-chemical lake indicators was undertaken to determine health of the water body prior to the commencement of in-situ and ex-situ interventions as part of the Lake restoration Project. Physico-chemical parameters analysed included pH, Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Calcium (Ca) Hardness, Magnesium (Mg) Hardness, Sodium (Na), Chloride (Cl), Potassium (K), Phosphates (PO4-P), Total Nitrogen and Heavy Metals (Cadmium as Cd; Lead as Pb**;** Zinc as Zn**;** Copper as Cu**;** Arsenic as As**;** Nickel as Ni**;** and Total Chromium as Cr. Biotic parameters recorded during the study were Total Coliform & Ecoli bacteria, aquatic plants (macrophytes) and birds.

The present study indicates that the IDL is a hyper-eutrophic water body with dead zones across the lake, subjected to heavy pollution. The untreated lake water is unfit for drinking, bathing and other domestic purposes. The causes of pollution appear to be continuous inflow of untreated wastewater from the catchment area and dumping of solid waste. No previous studies on any of these aspects of IDL Lake could be found for comparative analysis and to understand the ecological patterns. The degradation has severely impacted lake's floral and faunal diversity. Results of the study and detailed discussions are presented in the following sections.

3.1 Climatic Conditions:

Kukatpally, Hyderabad has a tropical Semi-arid (Steppe) climate. June to November are the monsoon months, which are accompanied by rains. The climate of this region is largely characterized by a hot summer, a mild winter and a moderate monsoon season with unreliable rains. Parthasarthy (1983) divided the annual cycle of the region into following four seasons.

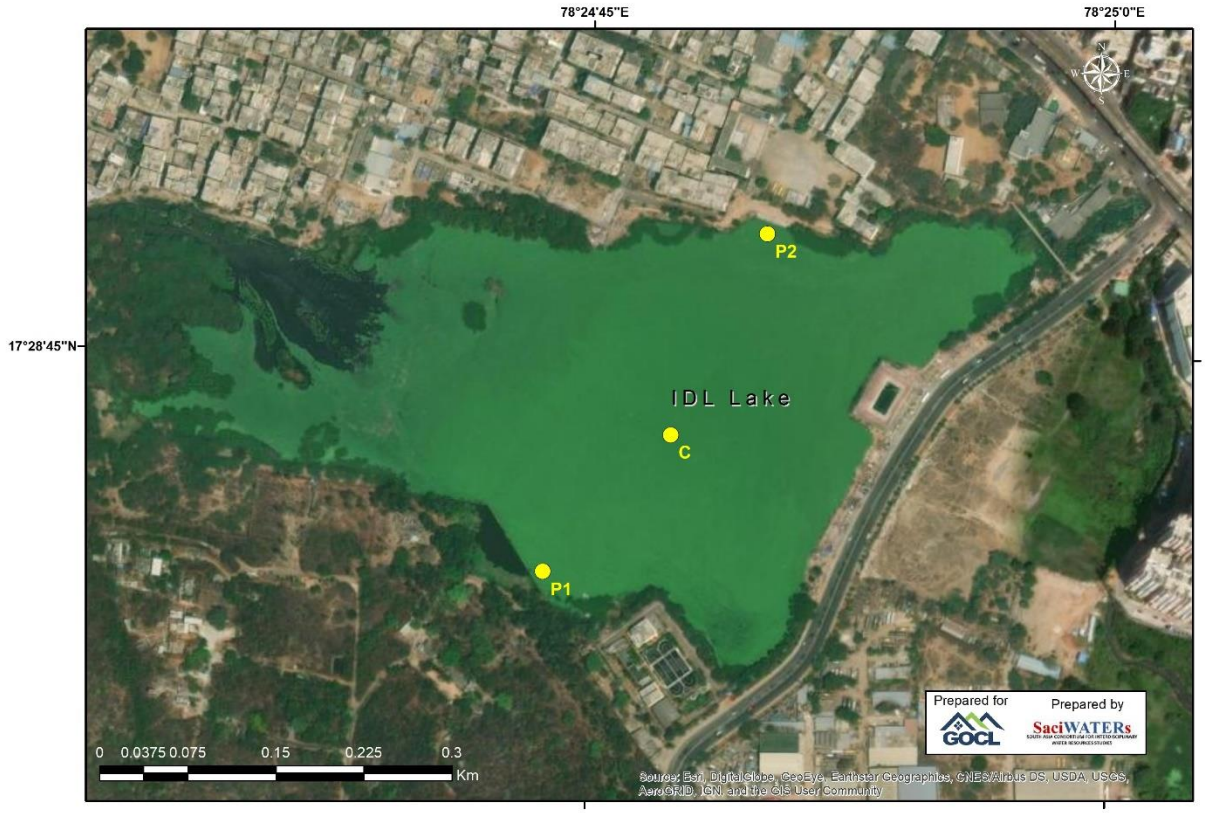
- Winter: December to mid-February
- Summer: Mid-February to May
- Monsoon: June to September
- Retreating Monsoon: October to November



3.2 Material and Methods

Sampling stations were selected to represent the water and sediment quality at three different points. **Station P1** located near the periphery towards GOCL; **Station C** located at the centre – the point which represents general lake water quality (Fig. 1) and **Station P2**. The sampling was done in the morning hours at around 10 am on 4 February 2023.

Water samples for determining physico-chemical parameters to be carried out in the field were collected in clean five (5) liters capacity plastic containers. The surface sediment samples were collected using long-handled stainless-steel scoop in clean polyethylene zip-lock bags. The collected water and sediment samples were immediately transported to EPTRI, Hyderabad for analysis. Macrophytes were also identified during the field visit.



Map.2: Sampling Stations

3.3 Results and Discussion

3.3.1 WATER QUALITY

1. PHYSICO-CHEMICAL PARAMETERS

Physico-chemical parameters studied include pH, , Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Calcium (Ca) Hardness, Magnesium (Mg) Hardness, Sodium (Na), Chloride (Cl), Potassium (K), Phosphates (PO_4-P) and Nitrates (NO_3-N) (Please refer Table 1).

Table.1 Results of Physico-Chemical Analysis of Water.

S. No.	Parameter	Method (APHA, 23rd Edition, 2017	Units	Sample P-1	Sample P-2	Sample C
1.	pH	Electrometric	-	7.5	7.7	7.5
2.	DO	Winkler with azide modification	Mg/L	NIL	1.5	NIL
3.	BOD	5 day-BOD test	Mg/L	160	90	150
4.	COD	Dichromate method	-	350	170	320
5.	Total Dissolved Solids (TDS)	2540. D, (Gravimetric)	mg/L	1066	956	973
6.	Total Suspended Solids (TSS)	2540. D, (Gravimetric)	mg/L	185	123	157
7.	Magnesium Hardness (Mg)	Titrimetric	mg/L	30	28	30
8.	Sodium (Na)	APHA 3500 Na B	mg/L	131.9	113.5	115.6
9.	Chloride (Cl)	APHA Cl B	mg/L	171	154	161
10.	Potassium (K)	APHA K B	mg/L	20	20	19
11.	Phosphates (PO4-P	APHA PC	mg/L	3.7	4.1	3.3
12.	Total Nitrogen (TN)	By Calculation	mg/L	24	16	19
13.	Cadmium as Cd	3120-B (ICP- OES)	mg/L	BDL	BDL	BDL
14.	Lead as Pb	3120-B (ICP- OES)	mg/L	BDL	BDL	BDL
15.	Zinc as Zn	3120-B (ICP- OES)	mg/L	0.23	0.14	0.42
16.	Copper as Cu	3120-B (ICP- OES)	mg/L	0.07	BDL	0.10
17.	Arsenic as As	3120-B (ICP- OES)	mg/L	BDL	BDL	BDL
18.	Nickel as Ni	3120-B (ICP- OES)	mg/L	BDL	BDL	BDL
19.	Total Chromium as Cr	3120-B (ICP- OES)	mg/L	BDL	0.06	BDL

1.1. pH: Potential of hydrogen, is the measure of concentration of hydrogen ions. It provides the measure of acidity or alkalinity of a solution. pH is generally considered as an index for suitability of the environment. Freshwater lakes, ponds and streams usually have a pH of 6-8 depending on the surrounding soil and bedrock[21]. The pH of IDL Lake water samples indicated that the lake water is neutral to slightly alkaline. pH of water sample was recorded as **7.5** at **Station P-1**, **7.7 at P-2** and **7.5** at **Station C.** pH levels of IDL Lake were within the limits set for protection of aquatic life, (6.5-9.0; USEPA, 1975), Irrigation (5.5-9.0; ISI, 1981) and Domestic Use (7.0-9.0; ICMR, 1975).

1.2. **Total Suspended Solids (TSS) & Total Dissolved Solids (TDS):** Solids refer to suspended and dissolved matter in water. They are very useful parameters and describe the chemical constituents of water and can be considered as a general indicator of edaphic relations that contribute to productivity within the water body (Goher, 2002). Total Dissolved Solids (TDS) was recorded as **1066** at **Station P-1**, **956 at P-2** and **973** at **Station C .**Total Suspended Solids (TSS) were **185** at **Station P-1**, **123 at P-2** and **157** at **Station C.** The existing levels of TDS and TSS make it unfit for human consumption

1.3. **Dissolved Oxygen (DO)**: A great variety of gases are found dissolved in natural waters. Out of these gases, Oxygen is the most significant one because it regulates metabolic processes of the organisms and also the community as a whole. Vital to aquatic life, oxygen enters the water by diffusion from the atmosphere or through plant photosynthesis. DO content indicates health and ability of the water body to purify itself through biochemical processes. DO value for **Station P-1 was NIL, 1.5 at P-2** and **NIL** at **Station C indicating Dead Zones within IDL Lake**. Aquatic habitats with little dissolved oxygen are called dead zones (Hypoxic areas) because nothing can live there except some microbes (Kirchman, 2021). Hypoxia occurs when dissolved oxygen (DO) concentration falls to or below 2 mg of O_2/liter (Dempsey 2014),

0-4 ppm	4-6.5 ppm	6.5-9.5 ppm	9.5-12 ppm
All fish are dead.	Very few fish can live	Most Big Fish can live but some small fish can not	All fish can live

1.4. **Biochemical Oxygen Demand (BOD):** Biochemical Oxygen Demand is defined as the amount of oxygen required by bacteria in stabilizing the decomposable organic matter. BOD gives an idea about the extent of organic pollution. BOD values reported in the lake were 160 mg/L at **Station P-1, 90 at P-2** and **150** at **Station C. Very** high values of BOD indicate dumping of organic wastes into the lake. A BOD level of 1-2 ppm is considered very good. There will not be much organic waste present in the water supply. A water supply with a BOD level of 3-5 ppm is considered moderately clean. In water with a BOD level of 6-9 ppm, the water is considered somewhat polluted because there is usually

organic matter present and bacteria are decomposing this waste. Waters with BOD levels above 10 ppm are considered organically polluted. At BOD levels of 100 ppm or greater, the water supply is considered severely polluted with organic waste (CIESE, 2015)

1.5. **Chemical Oxygen Demand (COD):** Chemical Oxygen Demand (COD) of the lake was at **350** mg/L **Station P-1, 170 at P-2** and **320** at **Station C**. COD is the oxygen required by the organic substances in water to oxidise them with a strong chemical oxidant. This shows the oxygen equivalent of the organic substances in water that can be oxidised by a strong chemical oxidant such as potassium dichromate in acidic solution. The determination of COD values are of great importance where the BOD values cannot be determined accurately due to the presence of toxins and other such unfavourable conditions for growth of microorganisms the COD usually refers to the laboratory dichromate oxidation procedure. Overall, COD in the lake is high and the lake water shows substantial pollution through dumping of waste.

1.6. **Magnesium (Mg):** Magnesium was reported as **30** at **Station P-1, 28 at P-2** and **30** at **Station C**. Magnesium was found within acceptable levels.

1.7. **Sodium (Na):** Sodium content in waters of IDL Lake was recorded as **132** at **Station P-1, 114 at P-2** and **116** at **Station C**. Sodium is one of the most abundant elements and is a common constituent of natural waters. The increased pollution of surface and groundwater results in a substantial increase in the sodium content. Sodium is often associated with chloride. It finds its way into lakes from road salt, fertilizers, human and animal waste. (Deem *et al*., 2007). Sodium levels in the sample waters are high.

1.8. **Chloride (Cl):** Chloride Content of the lake was **171** at **Station P-1, 154 at P-2** and **161** at **Station C**. Chlorides in waters are generally due to the salts of sodium, potassium and calcium. Chloride levels in the waters are within permissible limit.

1.9. **Potassium (K):** Potassium content in waters of IDL Lake **30** at **Station P-1, 28 at P-2** and **30** at **Station C**. Though found in small quantities (<20mg/L) it plays a vital role in the metabolism. Since natural

levels of sodium and potassium ions in soil and water are low, their presence may indicate lake pollution caused by human activities. Potassium is the key component of commonly used potash fertilizer, and is abundant in animal waste (Deem *et al.*, 2007).

1.10. **Phosphates (PO4-P):** Phosphate levels in the lake were **3.7 mg/l at Station P-1, 4.1 mg/l at P-2 and 3.3 at C**. Phosphorus is essential to the growth of organisms and can be the nutrient that limits the primary productivity in water. Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. The increased application of fertilizers, use of detergents and domestic sewage greatly contribute to the heavy loading of phosphorous in the water. The BIS (Bureau of Indian Standard) suggested the limit of phosphate is 0.1mg/l (Rajan and Pradeep Kumar, 2012). Phosphate levels were very high in all the sampling sites leading to hyper-eutrophication.

1.11. **Total Nitrogen (TN) mg/l:** TN content in waters of IDL Lake was recorded as **24 at Station P-1, 16 at P-2** and **19** at **Station C.** High levels TN levels indicate refuse dump runoff or contamination with human or animal wastes (World Health Organization, 2011).

1.12. **Heavy metals (Cd, Pb. Zn, Cu, As, Ni, Cr):** Zn, Cu and Cr were reported in the lake. The levels were within permissible limits.

2. FECAL CONTAMINATION:

Table.2. MPN count of Total Coliform

Sl. No	Test Parameter(s)	Unit	Test Method [APHA, 23rd Edition, 2017)	P-1	P-2	C1
2.1	*Escherichia Coli*	MPN/100mL	9221 F	23000	11000	17000

MPN count of Total Coliform ranged from 11000-23000/ 100 ml Sample-A (Periphery). The high readings show heavy fecal contamination of lake water. Very high level of contamination makes it unfit for drinking, domestic and recreational purposes.

3.3.2 LAKE SEDIMENTS:

The chemical parameters studied include heavy metals and plant nutrients (NPK) to understand pollution and eutrophication levels.

Table.3 Results of Physico-Chemical Analysis of Sediments:

S. No	Parameter(s)	Unit	Test Method	P1	P2	C
1	Cadmium as Cd	mg/Kg	EPA SW-846-6010B/ 3050B	4	3	4
2	Lead as Pb	mg/Kg	EPA SW-846-6010B/ 3050B	37	17	53
3	Zinc as Zn	mg/Kg	EPA SW-846-6010B/ 3050B	85	36	255
4	Copper as Cu	mg/Kg	EPA SW-846-6010B/ 3050B	27	13	71
5	Arsenic as As	mg/Kg	EPA SW-846-6010B/ 3050B	BDL	BDL	BDL
6	Nickel as Ni	mg/Kg	EPA SW-846-6010B/ 3050B	12	7	17
7	Chromium as Cr	mg/Kg	EPA SW-846-6010B/ 3050B	14	9	23
9	Total Nitrogen	mg/Kg	As per CPCB Manual Method	1008	1232	1120
10	Total Potassium	mg/Kg	As per CPCB Manual Method	161	92	176
11	Total Phosphates	mg/Kg	As per CPCB Manual Method	7.9	10.2	8.3

Lake degradation by anthropogenic activities has become a serious threat to the aquatic ecosystem due to the presence of a high concentration of toxic heavy metals and other pollutants. The present study aimed to find the extent of contamination by heavy metals for designing appropriate remediation and preventive measures to restore the lake quality and its ecosystem.

The heavy metals i.e. Cd, Pb, Zn, Cu, Ni and Cr were detected in the sediment samples. The chemical contamination in the sediments is evaluated by comparing them with the Heavy metal guidelines for sediments (mg/kg) proposed by USEPA. The lake sediments are heavily polluted by Zn and Cu and moderately polluted by Cd and Pb. The sources of heavy metals appear to be urban runoff, vehicular deposits, and idol components such as paints and decorative.

The results suggest that the high amount of NPK is being added to the lake through untreated urban sewage that is increasing its eutrophication level. These nutrients are being added to the lake from secondary sources from catchment area leading to eutrophication of the lake.

Dredging is recommended to remove these polluted surface sediments from the lake.

3.3.3 AQUATIC BIODIVERSITY:

The dead zones detected across the lake due to heavy pollution have made it unfit to support a healthy ecosystem. Limited number of aquatic macrophytes and birds were reported only along the shoreline.

1. **Aquatic Macrophytes:** Only rooted emergent macrophytes and toxic algal blooms were reported. The five dominant species of macrophytes were:

i) *Ipomea aquatic*

ii) *Ipomoea carnea*

iii) *Typha angustata*

iv) *Cyperus compressus*

v) *Enydra fluctuans*

These macrophytes were found in limited patches along the lake shoreline (except near the under-construction waterfront). There is no previous data available to compare the status.

Pic: Patches of *Ipomea aquatic, Ipomoea carnea ,Typha angustata* growing together

Pic: *Growth of an Aquatic creeper, Enydra fluctuans*

Pic: Toxic algal blooms in the lake near the bridge

2. **Birds:** Seven species of birds were spotted in limited number near the solid waste dumping site at the periphery of the lake near the outlet:

i) Purple Moorhen-Grey headed swamphen

ii) Indian Pond Heron

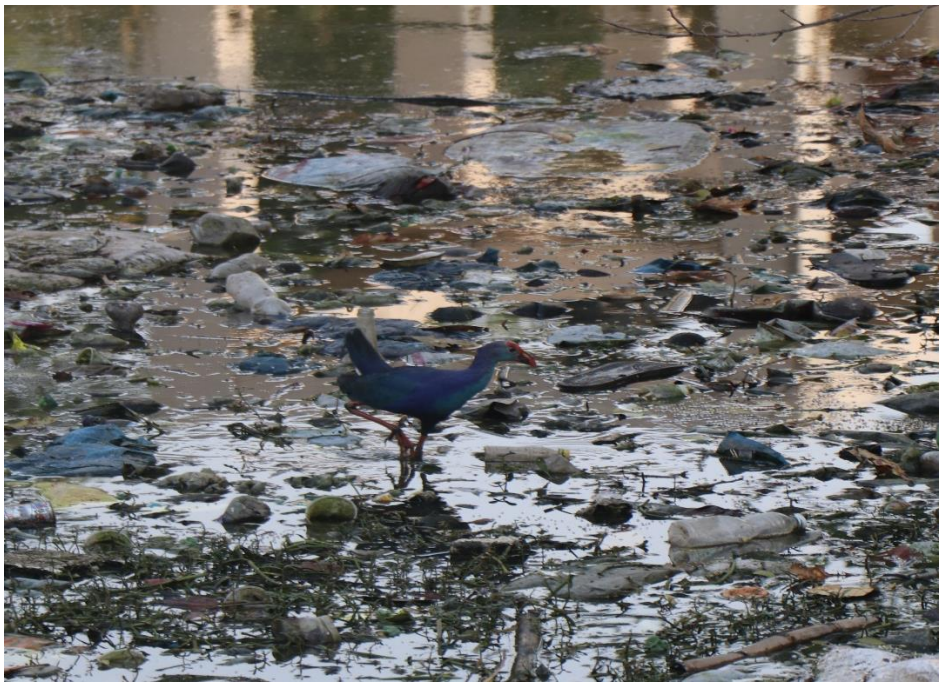
iii) Cattle Egret

iv) Little Egret

v) White-breasted Kingfisher

vi) Common Kingfisher

vii) Green Bee-eater



Pic. 'The sorry state of the birds': Purple Moorhen feeding on garbage near the Outlet of the lake

Pic: The Indian Pond Heron near the bridge

3.3.4 ECOSYSTEM SERVICES PROVIDED BY RANGADHAMUNI KUNTA (IDL LAKE)

The very many benefits (goods and services) provided by nature for sustenance and wellbeing of human society are collectively referred to as "Ecosystem services". However, only a healthy ecosystem and healthy ecosystem functioning can provide the necessary ecosystem services. In this regard it is necessary to understand what the potential ecosystem services are provided by a certain ecosystem and how such systems are getting impacted from anthropogenic activities and interests.

Provisioning Services (ecosystem goods): These services are referred to as the food/water/ and raw materials provided by any ecosystem for the wellbeing of human society. The Rangadhamuni Cheruvu (IDL Lake), was the main source of irrigation and drinking water in this region, especially to the village which is located close to the lake. Besides being the main source of irrigation and drinking water, the lake has a lot of cultural significance. There were also artisanal fisher folks practicing fishing in the lake for subsistence.

Regulating Services: These are the functions performed by an ecosystem in terms of purification of water/air, groundwater recharge, carbon sequestration, detoxification, climate regulation, biological pest, and disease control, and most importantly in the case of IDL lake flood protection and resilience. In a fillip to wetland conservation in India, the government of India recently announced the "Amrit Dharohar Scheme" with an aim to conserve wetlands by encouraging their optimal use. The scheme will be implemented in the next three years, with an intent to increase eco-tourism, and carbon stock, and contribute to improvement of livelihoods of the local communities.

With regards to the mention of 'carbon stock' in the said scheme, it is however, necessary to take note that studies on 'Blue Carbon' have been confined to oceans and coastal wetlands, excluding inland wetland ecosystems. On the other hand, studies have analysed carbon sequestration potential of man-made wetlands like the paddy fields, based on the usage of different organic nutrients, but the same is not conducted for inland wetlands. The lack of research focus on Inland wetlands could hamper the progress of designing the appropriate carbon market mechanisms and carbon market-based livelihood opportunities for the local communities. The Rangadhamuni Cheruvu (IDL Lake), provides a unique opportunity to conduct research studies in this direction.

Cultural Services: These services include historical, spiritual, recreational, cultural, therapeutic, social, science and educational, among others provided by an ecosystem. Rangadhamuni Cheruvu (IDL Lake), has historical and cultural significance. There is an ancient temple of Lord Vishu on the banks of the lake and the idol of Lord Vishu of the temple was believed to be “Swayambhu” (Swayambhu is a Sanskrit word means "self-manifested", "self-existing", or "that is created by its own accord"). In addition, this lake is the major destination for visarjan (immersion of sacred items), of sacred idols and other items of Ganesh Chaturthi and Batukamma festivals, two of the traditionally major festivals of Telangana.

Habitat Services: These are referred to as the living spaces provided for flora and fauna, and help in maintenance of biodiversity, which in turn contribute to provisioning, regulating, and cultural services provided by an ecosystem. The degradation of the natural habitat directly results in disappearance of biodiversity.

Present Status of the Ecosystem services provided by the IDL lake:

Ecosystem Services	Healthy	Degraded	Lost
Provisioning Services (ecosystem goods e.g. food/water/ and raw materials)			
Regulating Services (purification of water/air,/ carbon sequestration, detoxification, climate regulation/ flood control,)			
Cultural Services (historical, spiritual, recreational, cultural, therapeutic, social, science and educational)			
Habitat Services (living spaces provided for flora and fauna/ Biodiversity)			

CONCLUSION

Based on the present evidence, this study concludes that IDL Lake is heavily polluted with dead zones across the lake. Given its present state, it can be labelled as a hyper-eutrophic water body with nutrient rich waters. The lake is also polluted with heavy metals. The IDL lake ecosystem is unfit for aquatic life and human usages.

Remarks:

3. It is strongly recommended to record the 'seasonal' patterns of all major limnological parameters to establish the lake's ecological status.
4. The purpose of the study is to record crucial limnological parameters to understand the ecological status of the lake prior to the initiation of the second phase i.e. cleaning and plantation. Due to the paucity of time and resources, detailed analysis on certain other parameters was not possible.

REFERENCE:

Kirchman, David. 2021. Dead Zones: The Loss of Oxygen from Rivers, Lakes, Seas, and the Ocean The Loss of Oxygen from Rivers, Lakes, Seas, and the Ocean. 10.1093/oso/9780197520376.001.0001.

Dempsey, Caitlin.2014 | Physical Geography Realm https://www.geographyrealm.com/aquatic-dead-zones/#:~:text=Aquatic%20dead%20zones%20are%20bodies,water%20becomes%20a%20biological%20desert.

Chapter-4

Assessment and quantification of pollution load

4 Assessment and quantification of pollution load

4.1 Objectives:

This report is part of a study aimed to offer technical assistance to GOCL (Gulf Oil Corporation Limited) towards developing a rejuvenation plan for the IDL Lake in Hyderabad, which is one of the oldest lakes of Kukatpally village. In order to provide technical assistance, undertaking a wastewater quantity assessment of all inlets of the lake is necessary. This chapter outlines the results of the following field work activities that were undertaken at specific points near the IDL lake:

- Quantity Assessments to measure flow of water within the channels entering IDL lake: Conducted on the 24th and 25th of January 2023.
- Quality Measurements to measure flow of water within the channels entering IDL lake: Site visits undertaken on 27th January 2023 & test results shared on 6th February 2023.

4.2 Scope of Work

Quantity and quality assessment of wastewater inflow as articulated below:

- Quantitative analysis to assess the volumes of wastewater flowing into the lake:
    - To conduct a 24-hour flow rate analysis at sewage entry points into the IDL lake to provide us peak hour discharge and normal discharge of wastewater into the lake. The flow measurement was conducted at 5 inlet points, 3 inlets at the IDL road and 2 inlets at the deep drain.
- Qualitative analysis to assess the concentration of wastewater entering the lake:
    - The quality assessment was conducted through a grab sampling approach. Grab sampling refers to a small representative subset of a larger quantity or concentration of effluent that is taken at a specific time.
    - The quality assessment was analyzed the three different characteristics within the collected sample of wastewater viz. biological characteristics, Chemical characteristics and pathogens.

4.3 Quantity Assessment to gauge flow into IDL lake

4.3.1 Approach & Methodology

For the measurements to be undertaken, the points for quantity assessment were first decided based on a reconnaissance visit undertaken on the 3rd of January with the GOCL team. The points selected for measurement were those sections, which allowed the team to ascertain the channel discharging the total flow into the lake. These sections were the portions where the flow from all prior channels would culminate into. These points are shown in Figure 1 below (The figure here indicates the location of the quantity (flow) sampling points in satellite image).

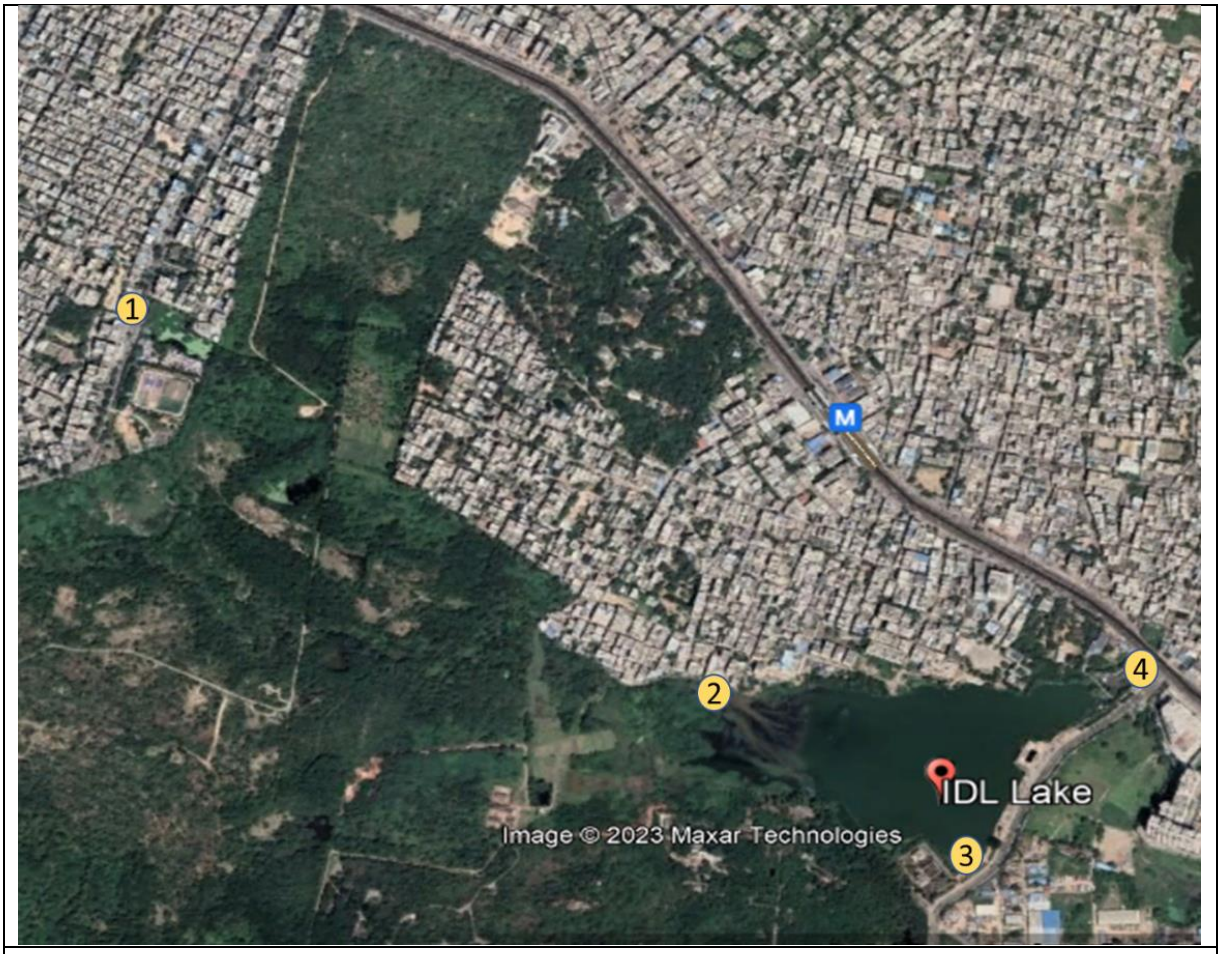


Figure 1: Sampling points identified for detailed quantity measurements

The tool used for undertaking the flow measurement was a 'Hach FH950 Handheld Flow Meter' which is illustrated here. The basic method adopted using this flow meter is to gauge the velocity of the water flowing in the each of the drain using a staff. The Tapes/Staff is used to measure the cross section (B*D) of the open channel. **The flow (m^3/s) is measured using.**

$$Flow = Velocity\ (\frac{m}{s}) \times Cross\ section(m2)$$

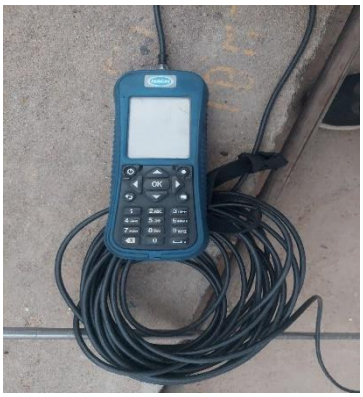


Figure 2: The 'Hach FH 950 Handheld Flow Meter'

4. 3.2 Sample Point Locations

There are majorly 4 points are identified and 24 hours duration measurements were carried out with minimum of 2 hours intervals. 3 out of the 4 points are inlets into the lake and 1 is the main outlet of the lake. Details of these sample points are below:

Inlets	Outlets
1. Channel from Balaji Nagar opposite to HDFC Bank 2. Inlet Channel of the STP 3. STP outlet channel	4. Outlet of Lake (near the gate)

4.3.3 Site specific images of the Sampling Points

Figure 3: This image shows Point-4 demarcated on Figure 1 (Identified as the Lake Outlet). Single Point measurement was collected on an hourly basis.

Figure 4: This image again shows Point 4 demarcated on Figure 1 (Identified as the Lake Outlet)

Figure 5: This image shows Point 3 demarcated on Figure 1 (Identified as the STP Outlet). Single Point measurement was collected on an hourly basis

Figure 6: This image also shows another view of the STP outlet, i.e., Point 3 demarcated on Figure 1 (Identified as the STP Outlet).

Apart from the above 2 areas, where measurements were collected at single points, at the following two locations multiple point measurements were collected to average the flow:

- At the Point 2 (illustrated in figure 9 and 10), 8 points were measured along this channel on an hourly basis and averaged.
- At point 1 (illustrated in figure 7 and 8), four points were measured along this channel on an hourly basis and averaged.

Measurements were taken to constitute an entire day of hourly samples at the following points. All the details of measurements collected are provided in the Annexure I but the final output is shared within these main sections of the report.

Figure 7: This image shows measurement being done at Point 1 (identified as Channel from Balaji Nagar opposite to HDFC Bank). Measurements were collected at four points in this channel on an hourly basis

Figure 8: This image shows another view of Point 1 (identified as Channel from Balaji Nagar opposite to HDFC Bank).

Figure 9: This image shows Point 2 demarcated on Figure 1 (Identified as the STP inlet). Point measurements were undertaken for eight points on an hourly basis.

Figure 10: This image shows another view of Point 2 demarcated on Figure 1 (Identified as the STP inlet).

4.3.4 Results of Flow measurements

The results of the data collected through the flow meter and its analysis is presented in the table below.

Sample Point:	Sample point description:	Flow (MLD):
	Inlet Channels:	
1.	**Channel from Balaji Nagar opposite to HDFC Bank**	7.76
2.	**a. Inlet Channel to the lake**	5.50
	b. Inlet of the STP	11.80
3.	**STP outlet channel**	2.01
Total In Flow into the Lake (2a + 3)		**7.51**
Outlet Channels:		
4.	**Outlet of Lake (near the gate)**	**7.10**

Important Notes:

- Sample point 1 (channel from Balaji Nagar opposite to HDFC Bank) converges into a common channel to Sample point 2 (Intel channel to lake) therefore the flow measurement is discounted from the overall inflow into the lake.

Flow from Sample point 2b is entering inro a collection well at pumping station and is manually pumped into the STP for treatment therefore it is excluded from the total inflow calculation into the lake.

- The outlet of the STP is connected to the lake so its flow is considered to calculate the total inflow into the lake. Also, it has to be noted that the flow measured is dependent on the operations of STP on that given day.

Note: Detailed flow measurements at every location and each cross-section of the channels are presented in Annexure 1 for reference.

Figure 11: Flow data measured at all the inlets and outlet

4.3.5 Inferences

Several field visits and consultation with various stakeholders from GHMC, HMWSSB and GOCL have confirmed that the water/wastewater flowing into the lake from various intel points converge at Balaji Nagar on the northern side of the lake (Sample Point 2). Water/wastewater from here is diverted through a manmade water management structure (check dam + screened intel channel) as shown in the picture below. A portion of water/wastewater enters the lake (5.5 MLD) directly and the majority of it goes through the screen channel into the pumping station (11.8 MLD).

Since the capacity of the existing STP is 5 MLD, a similar amount of wastewater is delivered for treatment through the pumping station and the remaining quantity is pumped out directly into the lake's outlet.

Treated water from the STP is let out into the lake. In delivering treated wastewater, a gap of 3 MLD was observed on the day of measurement from the STP, and this could be because of operational reasons (varying operational hours, under maintenance etc.). The Sankey diagram below shows flow of water/wastewater into the lake and its outflow.

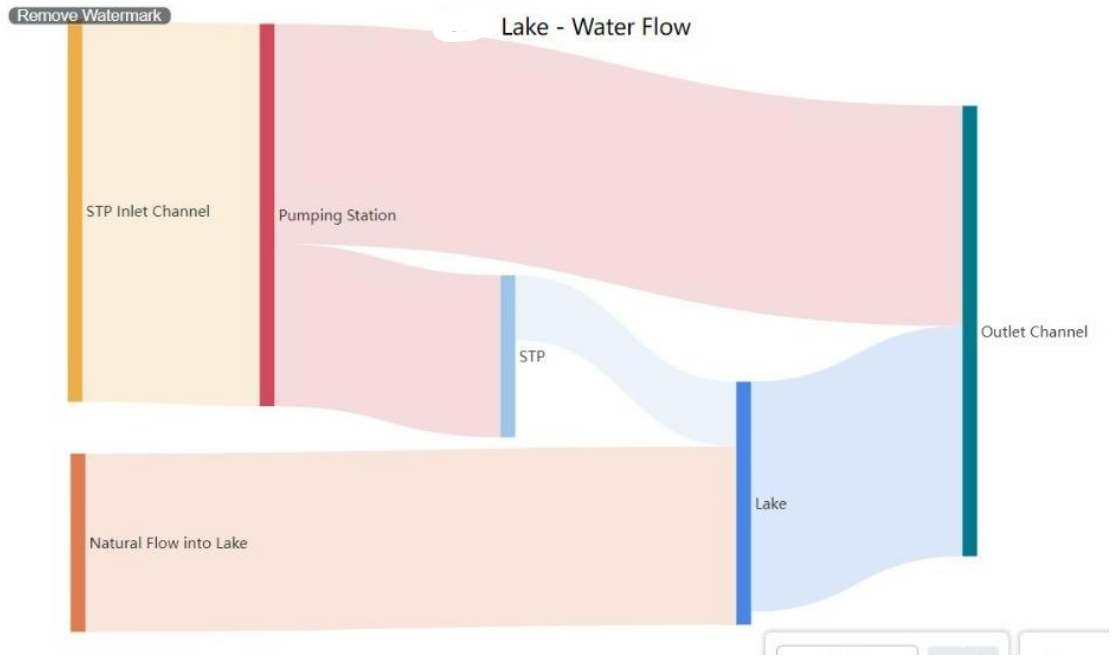


Figure 12: Flow of water/wastewater in and out of IDL Lake (Numbers in the image are represented by MLD in units)

The data from the flow measurements clearly indicates that the lake is at its full carrying capacity and the water balance is clearly seen (7.5 MLD of inflow and 7.1 MLD of outflow).

Figure 13: Water divertion structure at Balajinagar (Sample Point 2a and 2b) – The channel on the left carrys water directly into the lake and the one on the left screens solid waste and conveys water to the pumping station

Figure 14: 5 MLD Sewage Treatment Plant (STP) established and operations along the bank of the lake

Figure 15: Sewage Pumping Station near the Lake

Figure 16: Outlet of the STP into the Lake

4.4 .Quality Assessment

4.4. 1 Approach & Methodology

While wastewater sampling is generally performed by one of two methods, grab sampling or composite sampling; in this assignment, a grab sampling approach was adopted. Grab sampling is just what it sounds like; all of the sample effluent which is collected at one time (though this is repeated every hour). As such, a grab sample reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected. The tests were done with support from the NABL accredited lab of the Environment Protection Training and Research Institute (EPTRI).

4.4.2 Sample points

The samples for testing the quality parameter of the water/wastewater entering the lake, in the lake and exiting the lake were measured at 7 different locations. The details of the locations are:

Inlets of the Lake	From within the Lake-bed	Outlets of the Lake
1. KPHB – 1 Play Park (S5) 2. Balajinagar inlet flow to lake (S2) 3. Balajinagar inlet flow to STP screening (S3) 4. IDL Lake HMWSSB STP outlet (S6)	5. Near Watching tower inside GOCL (S4) 6. IIDL Lake Bathukamma Kunta (S7)	7. Outlet channel near Decathlon (S1)

Figure 17: The figure above indicates the location of the quality sampling points in satellite image.

Photographs showing the team collecting wastewater samples for analysis

Figure 18: IIDL Lake Bathukamma Kunta (S7)

Figure 19: Balaji Nagar inlet flow to STP screening (S3)

Figure 20: Balaji Nagar inlet flow to lake (S2)

Figure 21: Outlet channel near Decathlon (S1)

4.4.3 Results:

The key 'Physical Characteristics' of wastewater are:

Table 1: Physical characteristics of wastewater sample collected at 7 points along the IDL Lake

Test parameters	S2 - Balaji Nagar inlet flow to lake	S3 - Balaji Nagar inlet flow to lake screening	S5 KPHB – 1 Play Park	Average of inlets	S6 IIDL Lake HMWSSB STP outlet	S4 Near watching Tower	S7 IDL Lake Bathukamma kunta	Average of Lake Water	S1 Outlet channel near Decathlon	NGT standards for disposal into water bodies (2019) - Mega and Metropolitan cities
pH (25°C)	7.00	7.10	7.00	**7.03**	7.20	7	7.6	7.3	7.1	5.5 -9.0
Electrical Conductivity	1,310.00	1,330.00	1,520.00	**1,386.67**	1,540.00	1350	1430	1390	1420	-
Total Suspended Solids	180.00	118.00	108.00	**135.33**	28.00	129.00	97.00	113.00	94	50
Volatile Suspended Solids (VSS)	130.00	85.00	87.00	**100.67**	16.00	100.00	65.00	82.50	73	-
Dissolved Oxygen	NIL	NIL	NIL	**NIL**	2.50	NIL	7.10	7.10	1.8	-
Temperature	25.4	25.5	25	**25.30**	25.1	25.70	25.30	25.50	25.1	-
Total Dissolved Solids at 180 ºC	764	776	886	**808.67**	898	788.00	834.00	811.00	826	-
Total Alkalinity as $CaCO_3$	420	400	355	**391.67**	430	410.00	400.00	405.00	465	-
Chemical Oxygen Demand	288.00	244.00	230.00	**254.00**	80.00	200	160	180	140	50
Biochemical Oxygen Demand (3 days at 27°C)	156.00	135.00	130.00	**140.33**	48.00	130.00	70.00	100.00	65	10
Total Kjeldahl Nitrogen as N	19	13	16	**16.00**	3.6	16.00	11.00	13.50	13	10
Ammoniacal Nitrogen as N	15	9	13	**12.33**	2	11.00	8.00	9.50	7.8	-
Total Phosphates as PO4	2.1	1.4	1.5	**1.67**	0.2	1.80	1.20	1.50	0.8	1

Test parameters	S2 - Balaji nagar inlet flow to lake	S3 - Balaji nagar inlet flow to lake screening	S5 KPHB – 1 Play Park	Average of inlets	S6 IIDL Lake HMW SSB STP outlet	S4 Near watching Tower	S7 IDL Lake Bathukamma kunta	Average of Lake Water
Chlorides as Cl-	141	139	175	**151.67**	167	139.00	153.00	146.00
Fluoride as F-	0.53	0.53	0.56	**0.54**	0.49	0.54	0.54	0.54
Phenolic Compounds as C_6H_5OH	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Cyanide as CN-	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Arsenic as As	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Mercury as Hg	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Lead as Pb	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Cadmium as Cd	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL
Total Chromium as Cr	0.12	BDL	0.09	**0.11**	0.13	0.09	0.11	0.10
Copper as Cu	0.11	0.09	0.07	**0.09**	0.11	0.13	0.15	0.14
Zinc as Zn	0.18	0.08	0.07	**0.11**	0.11	0.15	0.15	0.15
Nickel as Ni	BDL	BDL	BDL	**BDL**	BDL	BDL	BDL	BDL

The key 'Biological Characteristics' of wastewater are:

Table 2: Biological characteristics of wastewater sample collected at 7 points along the IDL Lake

Test parameters	S2 - Balaji Nagar inlet flow to lake	S3 - Balaji Nagar inlet flow to lake screening	S5 KPHB – 1 Play Park	Average of inlets	S6 IIDL Lake HMW SSB STP outlet	S4 Near watching Tower	S7 IDL Lake Bathukamma kunta	Average of Lake Water	S1 Outlet channel near Decathlon	NGT standards for disposal into water bodies (2019) - Mega and Metropolitan cities
Total Coliforms	130,000.00	94,000.00	79,000.00	**101,000.00**	46,000	94,000.00	79,000.00	86,500.00	70000	-
Faecal Coliforms	79,000.00	21,000.00	14,000.00	**38,000.00**	20,000	21,000.00	46,000.00	33,500.00	20000	Desirable - 100, Permissible -230
Escherichia coli	33,000.00	14,000.00	11,000.00	**19,333.33**	11,000	14,000.00	26,000.00	20,000.00	11000	-

4.4.4 Inferences

The key inferences from evaluating the physical, chemical and biological characteristics of the flow collected from the sampling points are as follows:

- The COD (chemical oxygen demand) in the inlet (considering the average measurements captured from the inlets in the table above) is above desired level of 50 and in the range of 240-250, which indicates the presence of pollutants which are harmful for aquatic and human life.
- The BOD (biological oxygen demand) in levels of above 120 in each of the inlet indicates inflow of wastewater with high organic content. The organic content induces the microbial growth which in turn consumes the oxygen and reduces the Dissolved oxygen making the water toxic for aquatic life.
- The high nitrogen values indicate the influx of urine into the water. The high nutrient value results in eutrophication, eutrophication is accumulation of algae which in turn reduces the dissolved oxygen and makes water unfit for aquatic life.
- The chloride levels of up to 250 mg/l is desirable. High levels of Chlorides increase the corrosivity of the water and result of corrosion in water distribution systems. The high levels of chloride in water are harmful for aquatic levels. In the lake the chlorides level is optimum.
- The fecal coliform level (38,000 considering the average at the inlets) is at high value in the water indicating the potential health risks when human are exposed to this water.
- The volatile solids content is very high (100.67 considering average at inlets), indicating organic content which can be further degraded using microorganisms. Need treatment options to reduce the level to less than 20 to removal the organic content. Organic content indicates the presence of carbonaceous components which is the food for the microorganism growth in wastewater.
- There is no DO in the water samples tested, which indicates that the water quality is not fit for aquatic life and is harmful when human beings come in contact. The absence of DO indicates the deterioration of water quality and the need for intervention for improving the water quality using different treatment options.

Chapter-5

Stakeholders Analysis

5 Stakeholder Analysis:

Active and efficient stakeholder engagement in a complex socio-ecological system is a fundamental prerequisite for successful participatory water resource management and governance. A clear understanding of the roles and contributions of the different stakeholders is essential for successful planning. Stakeholder analysis is a basic tool for achieving this understanding. In this context, the primary objective of this chapter is to provide a mapping of stakeholders, their interests in and impact on natural resource use, management, and governance of the IDL lake. It describes the stakeholders' profiles based on desk research, key informant interviews, focus group discussions, and stakeholders' meeting.

The IDL lake restoration project identifies a list of primary stakeholders, and they can be divided into different groups:

1. Institutional Stakeholders
    a. Hyderabad Metropolitan Development Authority (HMDA)
    b. Greater Hyderabad Municipal Corporation (GHMC)
    c. Irrigation & CAD Department
    d. Hyderabad Metropolitan Water Supply and Sewage Board (HMWSSB)
    e. Revenue Department (Mandal Revenue Office)
    f. Telangana Housing Board
    g. Telangana Pollution Control Board
    h. Police Department
    i. Telangana State Road Transport Corporation
2. Commercial Stakeholders
    a. Safai Karamchari/Contractors
    b. Educational Institutions
    c. Shopping complexes
    d. Poultry Industry
    e. Hotels/Restaurants
    f. Street Vendors
    g. Hospitals
3. Community-based groups
    a. Washerman Association
    b. Resident Welfare Association
    c. Civil Society groups
    d. Environmental Activists

The table -1 analyses each stakeholder under the three parameters namely,

- Authority: an ability of a stakeholder to impose their will on lake restoration project
- Interest: the level of the concern in a project and its outcome
- Impact: the ability to make a positive contribution to project's success.

Table -1: Stakeholder analysis matrix

S.No.	Name of the Stakeholder	Roles and Responsibilities	Authority	Interest	Impact
1.	Hyderabad Metropolitan Development Authority (HMDA)	- This is the most powerful stakeholder of IDL Lake. - HMDA is a Town Planning Agency. Its jurisdiction covers (7) Districts, (70) Mandals, 1032 Villages including Greater Hyderabad Municipal Corporation consisting of 175 Villages and 40 Municipalities / Nagar Panchayats consisting of 138 villages and remaining 719 Villages under jurisdiction of the HMDA. - HMDA was set up for the purpose of planning, co-ordination, supervising, promoting, and securing the planned development of the Hyderabad Metropolitan Region. - HMDA, which covers seven districts, plays a crucial role in urban development under the direct supervision of Municipal Administration and Urban Development Minister Mr. K.T. Rama Rao. - Has rules prohibiting building and development activities on the bed of the water bodies.	HMDA has statutory powers and an executive body and requires an approval of government for any proposal. Thus, it has comparatively less authority than GHMC. However, HMDA has emerged as the most active and influential stakeholder of late. HMDA has entirely taken up the IDL lake development project following the instructions provided by Municipal Administration and Urban Development Minister Mr. K.T. Rama Rao and Mr. Madhavaram Krishna Rao, MLA	IDL Lake is situated at the prime location in Kukatpally. It is visible from the highway and metro train as well. Thus, it has a very high interest in the IDL restoration project Most of the infrastructure related planning is spelt out by HMDA.	HMDA is directly involved in planning and implementation of the lake development project. Also, the procedure and process to approve the FTL maps, rests with HMDA, besides the operation of STP, it has a high impact on the success of the project.

		- Metropolitan Commissioner, HMDA heads the Lake Protection Committee. - HMDA has taken up the lakefront development with an estimated cost of Rs 9.80 crore. Project was launched on 2nd December 2022 by K.T. Rama Rao. The project is expected to wrap up by June 2023. The following are the main features of the project: Bund strengthening, walkway and cycling track, a children's play area, illuminating the recreational place, setting up a food court, and develop a seating area. To further beautify the place, sculptures will be installed, and softscape will come up on the main bund. Other required amenities will be developed so that people enjoy the lakefront. It also aims to develop it as one of the important sites for Bathukamma festival. - Has planned to fill water bodies to Full Tank Level.	Kukatpally Assembly Constituency.		

		- Nodal agency for providing final approval for FTL maps and keeping them in the public domain on its website. - Operates three major STPs in the Hussain Sagar Lake catchment area including a 5 MLD STP at the IDL Lake.			
2.	Greater Hyderabad Metropolitan Corporation (GHMC)	- GHMC is responsible for administering and providing basic infrastructure to the city: Building and Maintenance of roads (implements SRDP projects that would cross IDL lake), streets, and flyovers; Public municipal schools; street lighting; Maintenance of parks and open spaces; **Garbage disposal and street cleanliness**; Urban development and city planning of new areas; **Health and Sanitation; work with Strategic Nala Development Programme (SNDP).** - GHMC-CSR initiative to synchronize with civic bodies and private corporations. - authority to constitute municipal funds and special	Of all the institutions, GHMC has a very high authority over this project. As, it has a major role in providing amenities, waste disposal, besides having financial powers. It is also an elected agency and hence has a political authority to complete this project.	Being a democratically elected stakeholder, it has a very high political interest to complete the project, in order to win over the people.	Co-ordination with this stakeholder, will make a high positive contribution as most of the decision-making powers lie with it, especially in terms of water quality improvement and waste management.

		funds under The Greater Hyderabad Municipal Act. - Coordination with the Pollution Control Board to conduct defoaming spray to curb the foam from overflowing. - Lake Protection Committee has identified IDL Lake among 119 lakes in Hyderabad for conservation under GHMC (IDL lake/Rangadhamuni Kunta; Lake ID 58). - IDL Lake has also been identified as one of the nine lakes to be restored (protection & beautification) in Kukatpally by GHMC under 'Mission Kakatiya'. - GHMC is given a responsibility to Supervises the following proposed activities in coordination with HMDA: cleaning of water hyacinth and biological wetland treatment, floating wetland plantation, diversion of sewerage, setting up garbage bins, installation of aerators, signage boards to discourage littering, fencing,			

		silt removal and arranging securities.			
3.	Irrigation and CAD Department (ICADD) (North Tank Division)	- Gives NOC for any development work that would be taken around the lake. - Prepares FTL boundary maps and submits them to HMDA and Lake Protection Committee - Coordinates with GHMC and revenue department to register criminal cases against encroachers.	High authority as they had to give NOC for any operation to be taken around lake.	High Interest as they are responsible for maintain and protecting the lake in coordination with the coordination of GHMC	High impact because of the direct involvement in maintaining FTL at IDL Lake.
4.	Hyderabad Metropolitan Water Supply Sewage Board (HMWSSB)	- Supply of potable water - Sewerage, Sewage Disposal, and sewerage treatment work including planning, design, construction, maintenance, operation & management of all sewerage and sewerage treatment works. However, in the case of IDL Lake, the 5 MLD STP and sewerage system are under the control of HMDA. As Minister of Municipal Administration and Urban Development, Mr. K. T. Rama	At present, HMWSSB's main role is to supply potable water.	At present, no direct involvement in Sewerage, Sewage Disposal, and sewerage treatment work around IDL Lake.	As sewage flowing into IDL lake is one of the major problems, any step taken by HMWSSB in its catchment area might have a high impact on the success of the project in the future, if involved in the diversion of the untreated sewage directly entering the IDL Lake.

		Rao has announced that Hyderabad will be the first city in India to have hundred per cent sewerage facilities by April-May 2024. HMWSSB will have a major role to play at the city level.			
	Mandal Revenue Office, Kukatpally	- provides the interface between the government and public within his jurisdiction. He initiates welfare measures within his jurisdiction. The MRO assists the higher authorities in collecting information and conducting inquiries. - responsible for updating and issuing Land Pattas (Records of rights). - As per directions of the Lake Protection Committee, assists HMDA, GHMC and Irrigation & CAD demarcate and fix the FTL boundaries and prepared the lake FTL map.	High in terms of updating and issuing Land Pattas (Records of rights).	Moderate	High. Can help identify encroachments.
	Telangana Housing Board	- Safeguarding valuable properties - Registration of properties. -	No	No	No

		- During the initial phases of Kukatpally Housing board (KPHB) Colony they developed roads, and other utility infrastructures including water supply and sewage pipes. - State government has decided to windup the Housing department and merge it along with the staff and subjects in the Telangana State Road Transport Corporation)			
	Hyderabad Police	- Maintains law and order of the specific geographic region. - Maps the route for Lord Ganesh idol immersion. - On the complaint of HMDA, ICADD and GHMC, police can remove the temporary encroacher like street vendors etc. around lake.	Moderate authority	Moderate interest	High impact
6.	Pollution Control Board	- Gives a report about the existence of water bodies. - Assess the water quality after the celebration of religious festivals – Ganesha festival, Bathukamma festival, Navratri.	High authority as the PCB could issue guidelines on lake water pollution and could also impose penalty on violators	Less interest as PCB's concern is only with respect the water quality parameters and not on the comprehensive	High impact as the strict enforcement of guidelines would help in the improvement of the lake's health.

		- Assess the water quality to find the source of contamination. - Inspects lake on the direction quasi-judicial bodies like NGT. - conducts defoaming spray to curb the foam from overflowing.		plan on the restoration.	
7.	Telangana State Road Transport Corporation	Operates mobile bio-toilets	Less authority as they operate bio-toilets as a welfare measure	Less interest	High impact if the disposal of grey water generated in mobile bio toilets is proper.
8.	Safai Karamcharis	Take public toilet on contract and maintain as per the guidelines of GHMC	Less authority	Less interest	Moderate impact as toilets they had contracted is connected to sewage network operated by HMDA &HMWSSB
9.	Educational Institutions	Imparting education on lake ecosystem and waste management	Less authority	High interest will be shown by students if waste management classes are innovative.	High impact as they are bulk waste generator; knowledge transfer on waste management and benefits of clean IDL lake from students to community
10.	Shopping Complexes	-------	Less authority but could act as a pressure group to influence the project	Less interest as they had to comply with government regulations	High impact as they are Bulk Waste Generator.

				which might require an investment of money and time.	
11.	Poultry Industry	----------	Less authority but could act as a pressure group to influence the project.	Less interest as they had to comply with government regulations which might require huge finance.	High impact as they are Bulk Waste Generator
12.	Hotels and Restaurants	- ------	Less authority but could act as a pressure group to influence the project.	Less interest as they had to comply with government regulations which might require investment of money and time.	High impact as they are Bulk Waste Generator
13.	Street Vendors	------	Less authority but could act as a pressure group to influence the project.	Less interest as they had to comply with government guidelines which might require investment of money and time.	High impact as they are Bulk Waste Generator
14.	Washerman Association	------	Less authority but could act as a	High interest as they are	-High impact as they are Bulk Waste Generator.

			pressure group to influence the project.	dependent on the IDL lake for their livelihood.	- Can participate in lake conservation
15.	Resident Welfare Association	----	Less authority but could act as a pressure group to influence the project.	Their interest level varies from high to low depending upon the facilities available at their apartments.	High impact as they are Bulk Waste Generator. Can participate in lake conservation
16.	Civil Society Groups and Environmental Activists	-----	Less authority but could act as a pressure group to influence the project.	Their interest level varies from high to low depending upon the differences between the proposed project and their interest & ideas.	High impact as they could highly influence the locals to make any changes in the proposed project based on their strategic interest.

The IDL lake is listed as Rangadhamuni Kunta (Lake ID 58) as one of the 119 lakes Identified (under GHMC) for Hyderabad Lake Conservation initiative. The Lake Protection Committee included IDL Lake (Rangadhamini Kunta) in its 7th Phase Notification of FTL and Buffer. Rangadhamini Kunta, Lake ID 4808 (Annexure II). IDL Lake has also been identified as one of the nine lakes to be restored (protection & beautification) in Kukatpally by GHMC under 'Mission Kakatiya'. GHMC has provided an MOU certificate to GOCL to develop the lake under its CSR initiatives. This CSR program is primarily designed for real estate development companies to encourage them to adopt lakes for development. Since the lake is situated in a prime location with high visibility, it has attracted direct investments from the government as well. Thus, though the lake has been listed to be developed by GHMC under its CSR program, the HMDA has already initiated lake beatification work at IDL lake in November 2022.

The Lake Protection Committee:

The Lake Protection Committee was constituted in 2010 (Government of Andhra Pradesh vide G.O.Ms.No. 157, MA&UD(I1) Department, dt. 6-4-2010), in order to cater to the protection of lakes in the Hyderabad Metropolitan Region. It is involved in the administration of the protection and improvement of lakes and their catchments. The Metropolitan Commissioner of HMDA coordinates all the activities of the Committee.

Members of the Lake Protection Committee:

1	The Metropolitan Commissioner, HMDA (Chairman)	10	The Director General, EPTRI (Member)
2	The Commissioner, GHMC (Member)	11	Representative of NGRI (Member)
3	Representative of DG of Police (Member)	12	The Prl. Chief Conservator of Forests (Member)
4	The Managing Director, HMWS&SB (Member)	13	The Collector, Hyderabad District (Member)
5	The Commissioner of Industries (Member)	14	The Collector, R.R.District (Member)
6	The Member Secretary, TSPCB (Member)	15	The Collector, Medak District (Member)
7	The Commissioner of Panchayatraj (Member)	16	The Collector, Nalgonda District (Member)
8	The Chief Engineer, Minor Irrigation (Member)	17	The Collector, Mahabubnagar District (Member)
9	The Director of Town and Country Planning (Member)	18	The Member Environment, HMDA (Member – Convener)

The Lake Protection Committee has listed IDL Lake as Rangadhamuni Kunta (Lake ID 58) among 119 lakes identified for conservation by GHMC.

The list contains following categories:

i) Hyderabad Lake Conservation - Lake Identified (under HMDA): 239 lakes.

ii) Hyderabad Lake Conservation - Lake Identified (under GHMC): 119 lakes (where IDL lake is listed as Rangadhamuni Kunta; Lake ID 58).

iii) Lakes to be taken up for beautification by HMDA: 38 lakes. (Originally IDL lake is not included here)

iv) Lakes to be taken up for beautification by irrigation department: 50.

(https://dyvak8rtbn5om.cloudfront.net/wp-content/uploads/2020/07/Lakes_identified_beautification.pdf)

The following are the functions of the lake protection committee:

1. Listing of all lakes along with their FTL in HMDA area.
2. Wide publicity and awareness campaign for protection of the lakes.
3. To prepare action plan for desilting of the lakes and inflow channels and such other measures required for maintenance or cleaning of the inflow channels into the lakes and issue instructions/ guidelines to the concerned agencies for implementation of action plan.
4. Removal of existing encroachments in the FTL and foreshore areas.

5. To clearly demarcate the lakes up to FTL by raising bunds along FTL and arranging for watch and ward for preventing future encroachments and misuse of the lake environment.
6. To work out and suggest modalities for the regulation and rehabilitation of the existing activities/ structures in the catchment area of the Osmansagar and Himayatsagar lakes.
7. To do such other things as may be incidental or conducive to the efficient administration for the protection and improvement of the lakes and their catchments.
8. The Metropolitan Commissioner, Hyderabad Metropolitan Development Authority shall coordinate all the activities of the Committee on the above and submit periodical reports to the Government.

The Lake Protection Committee included IDL Lake (Rangadhamini Kunta) in its 7th Phase Notification of FTL and Buffer. Rangadhamini Kunta, Lake ID 4808 (Please refer to Annexure II)

IDL Lake Stakeholders' Meeting with HMDA, Irrigation Department and GOCL Corporation Ltd (IDL)

After individual key informer interviews were conducted with all the important stakeholders, a stakeholders meeting was subsequently held at the GOCL Corporation's office at Kukatpally, with the three most important institutional stakeholders:

1. Two representatives of North Tank Division, Irrigation & CAD Department, North Tank Division, GHMC. This department issued the adoption letter to GOCL under their CSR initiative in June 2022 and also approved the IDL Lake Development Plan submitted by GOCL in January 2023.
2. Two representatives from HMDA. HMDA has been given the responsibility of developing IDL Lake directly by the Minister based on recommendations of the Local MLA.
3. Two representatives from GOCL Corporation. GOCL Corporation has adopted IDL Lake under CSR initiative.
   Four members from SaciWATERs' technical team were present in the meeting.

The key findings the of detailed scientific study conducted on the IDL Lake along with the proposed technical solutions towards its restoration, were presented at the stakeholder's meeting.

The important points shared by the participants during the meeting:

- In the 1st phase, HMDA plans to construct a cycling track and waterfront towards the Northern and Eastern side of the lake. The groundwork started in November 2022 with the Minister KT Ramarao (KTR) laying the foundation stone on 2nd December. As per the recommendations from the Kukatpally MLA, HMDA has also submitted a plan for approval comprising Phase 2.
- Phase 2 proposal has two main components viz., (i) Continuation of the construction of the cycling track along the entire FTL boundary & (ii) Diversion of Sewage.
  HMDA officials have assured that any work on GOCL land will be taken up after GOCL's written consent.
- The current FTL area map has been developed based on a survey conducted by a consulting firm and was preliminarily notified by HMDA in the public domain through their website in 2014. Since there

was "no objection" by GOCL at that time, HMDA continues to use the same FTL Maps. The representatives from both the Government Departments informed that though the Preliminary Notification of FTL was issued in 2014, IDL Lake is yet to receive the Final Notification of FTL.

- Regarding the nature-based solutions proposed by SaciWATERs during the Phase-1, both departments' representatives stated that as per their understanding vegetative buffer strip using native aquatic plants species can be allowed. However, GOCL needs to get permission from the senior authorities like GHMC or HMDA Commissioner.
- Regarding developing an overwater elevated walking/ jogging track, they agreed that it will not disturb the hydrology and can be allowed. However, the representatives from the Irrigation department suggested that GOCL should consult and take prior approval from the senior authorities such as GHMC or HMDA Commissioner before starting the work. This is due to existing government guidelines which specify that no development activity is to be allowed inside FTL level.
- While discussing the results of the GIS study, we shared our concerns with the Government representatives that the Lake morphology has become flood prone, and it is near to FTL. This situation is prevalent throughout the year including drought years. The representatives from the Irrigation Department responded and informed us that they had installed a weir at the lake outlet. Whenever there is a forecast for heavy rains, the weir is opened to allow surplus water to flow through the outlet channel to prevent flooding.
- They also informed that the Irrigation & CAD Department (as per guidelines of the Lake Protection Committee) are responsible to maintain FTL of IDL Lake throughout the year in order to prevent any encroachments inside the lakebed. No building / development activity is allowed in the FTL area.

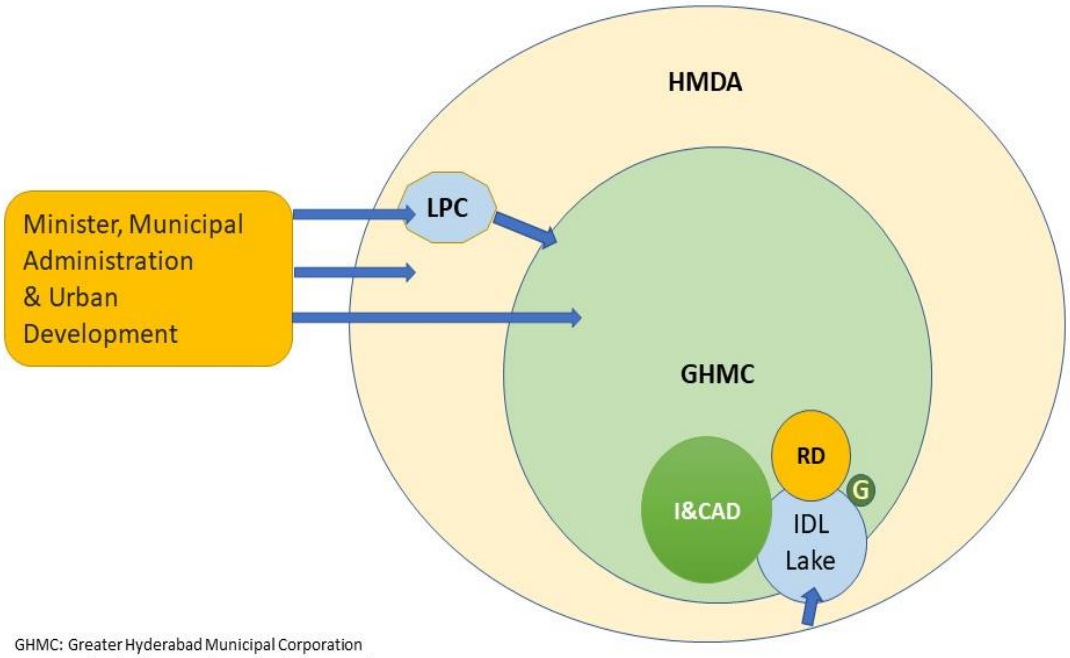
Launch of the Lake Development Programme under CSR Initiative, by the Municipal Administration and Urban Development Minister Mr. K.T. Rama Rao, on 28 March 2023:

50 lakes included to be d. 25 in GHMC limits and 25 in HMDA limits.

Highlights and the key announcements:

1. The programme focuses on lake adoption by real-estate developers in Hyderabad.
2. Mr. K. T. Rama Rao emphasized that these lake development projects must include beautification of the lake periphery by developing walking tracks, landscaping, open gyms, seating arrangements, toilets, lights for evening walkers, play area for children, gazebos, security arrangements and other facilities. He mentioned that the lake beautification work should be completed by November 2023 (considering the upcoming assembly elections in 2023).
3. Hyderabad would be the first city in India to have 100 per cent sewerage services by July 2023.
4. The Minister handed over the MoU certificates to real estate development companies which have adopted lakes for development. GOCL was also provided with the MOU certificate.
5. **Regarding Private land under FTL:**
   - "The minister mentioned that there are several private plots within FTL limits. He informed that "**No construction is possible on these private parcels as GHMC or any local body would not issue permission**". Hence, the Government has decided to issue **Transferable Development Rights (TDRs) to the owners of the private lands under FTL**. So far, Government had issued **183 TDRs across 13 lakes** and **gained 115 acres**. **These TDRs are issued at 200% and their documents can be sold at TDR Banks to gain value. The** Government is encouraging private landowners to apply for TDR.

   - He also directed GHMC commissioner and special chief secretary of MAUD to ensure that the private players who are developing lakes are careful about the lake FTL and buffer zone, so that this programme is not dragged into any legal trouble.



GHMC: Greater Hyderabad Municipal Corporation
HMDA: Hyderabad Metropolitan Development Authority
I&CAD: Irrigation & CAD Department
RD: Revenue Department
LPC: Lake Protection Committee
G: GOCL

Present Key IDL Lake Stakeholders Engagement

Community Perception

The section on community survey highlights what is important to IDL lake dewellers in the backdrop of its deteriorating condition. The goal of the survey was to gather varied perspectives from individuals with different sources of livelihood in regions. These are the people who witness changes in lake environ, quality and quantity. For this purpose a structured questionnaire survey was drafted for the local people living and working in the surroundings. The respondents of this survey were selected from an area around the IDL lake shores. The tourists are excluded from the survey since they do not qualify as people who have experienced the developments in the lake and its environs over certain period of time. A total of 23 local people responded to the questionnaire survey. We also carried out semi-structured interview for 6 key informants.

The questionnaire survey focused on ecological condition of the lake and the performance of the institutions pertaining to the maintenance of the lake area, its water quantity and quality. To understand the willingness of people to be a part of the lake governance, we also had questions pertaining to the interest, willingness and frequency of the participation in the remedial actions. There were two types of questions:

- Multiple choices selecting one option from the given choices such as Yes, Maybe, Neutral, and No.
- Qualitative- description of a scenario/ situation.

In total, information was gathered from 5 key informants and 24 people from a community survey. These participants are dwellers across the lake. **Figure 1 and 2** outlines the demographic profile of the community interview participants.

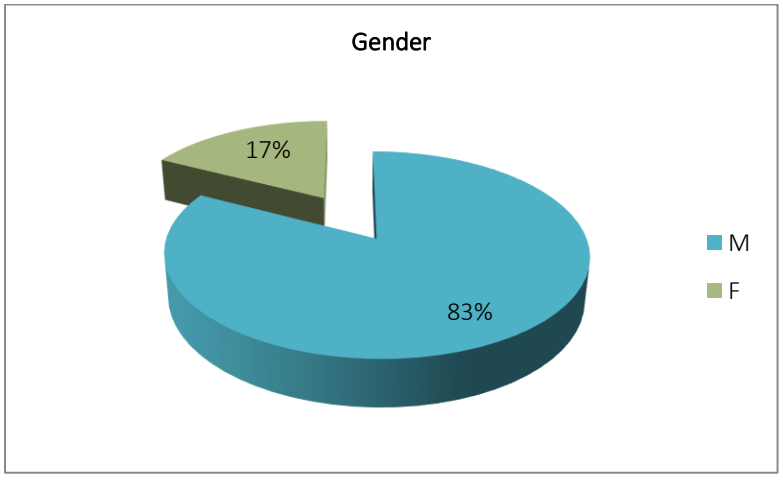


Figure 1

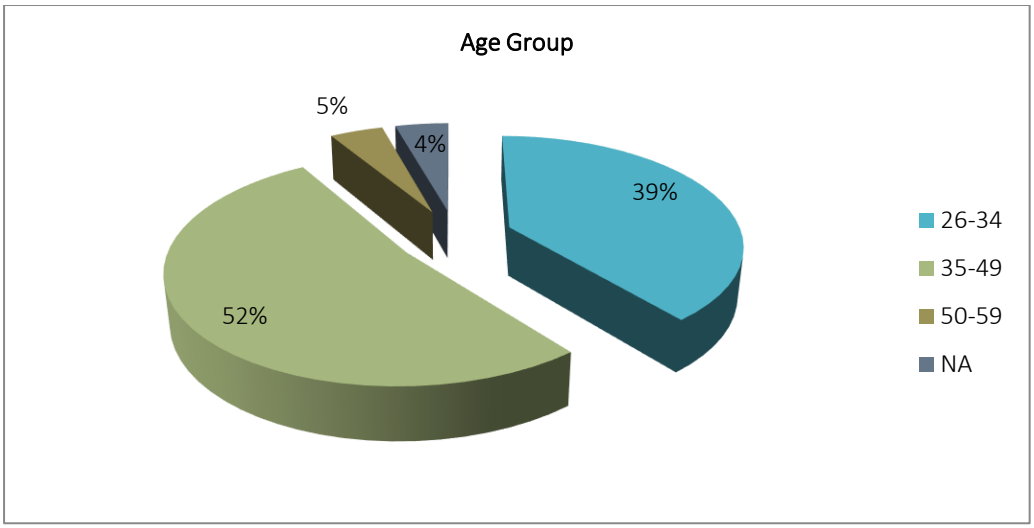


Figure 2

Of the 23 survey respondents, the time spent on lake and its vicinity varied from 2 years to as many as 80 years. These were identified as employees (government and private sector), labors, business operators and house wives. **Figure 3** shows the details year of residence and the occupational background of the respondents.

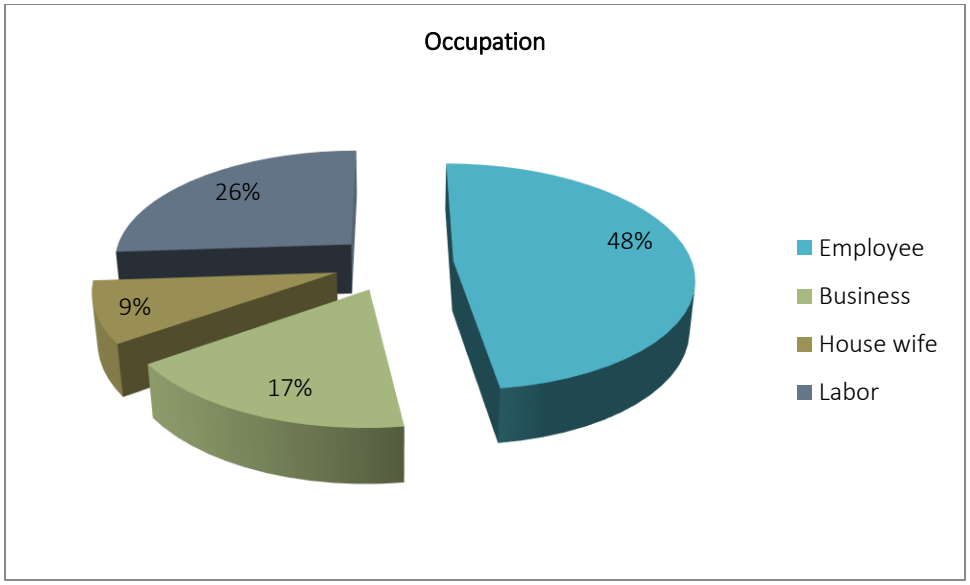


Figure 3

Of the 23 respondents, 22 of them stated that proper sanitation facility at home. Only 1 stated that he used to defecate in the open. With regards to source of water supply the respondents largely depended

on ground water and GHMC. However, depending on the seasonal variations, other sources were also used to meet their daily needs. Depending on the source of water there were changes in water quality and seasonal changes. **Figure 4, 5, 6 and 7** show the sanitation condition , waste disposal facility, water supply condition and changes in water quality.

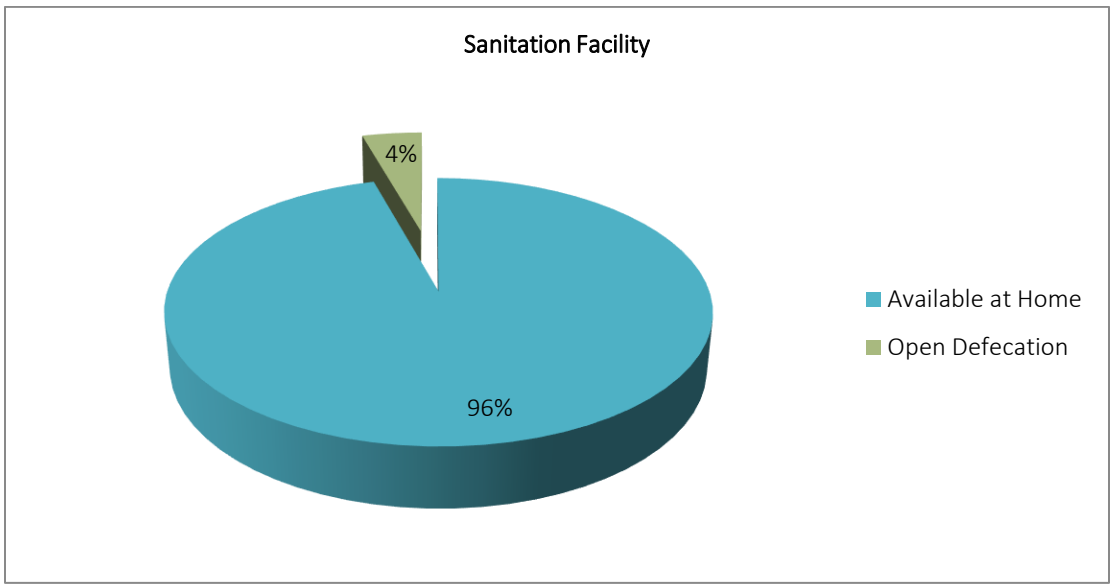


Figure 4

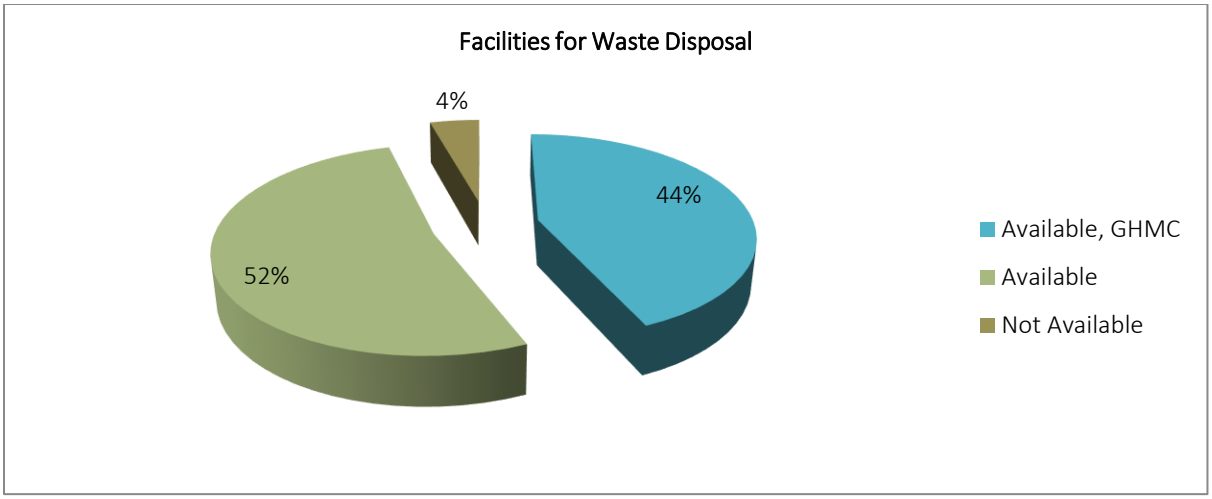


Figure 5

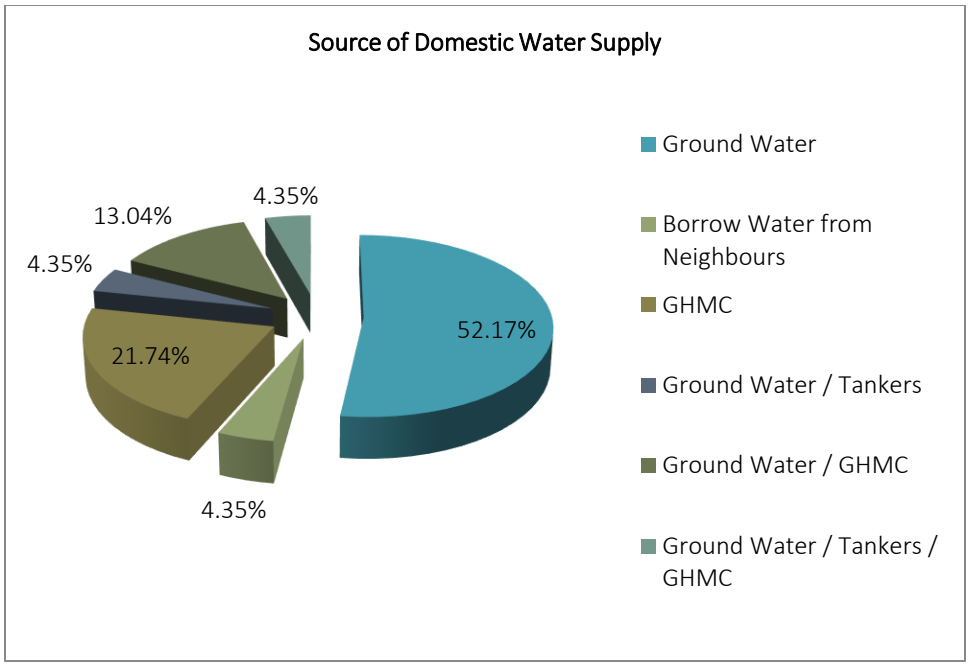


Figure 6

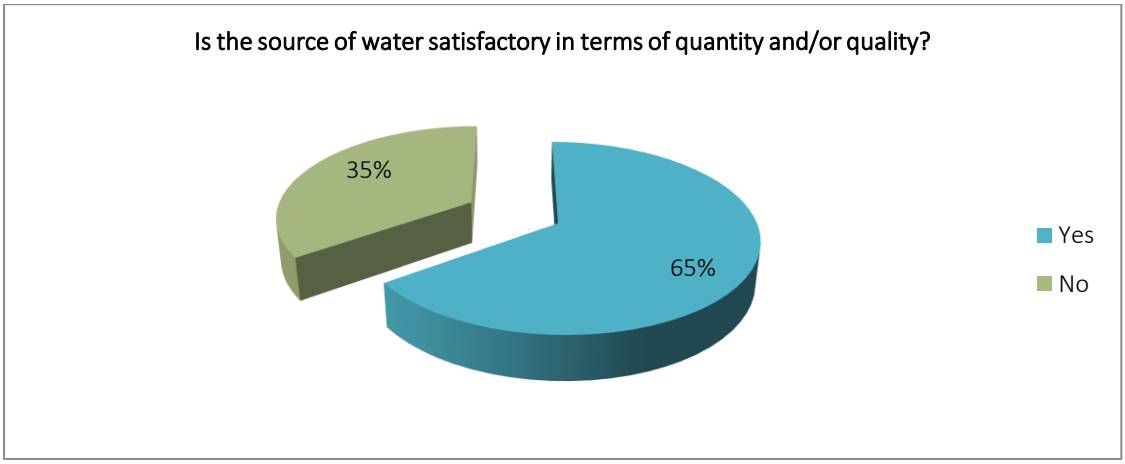


Figure 7

Of the 23 community survey respondents, 22 of them stated that there was proper waste management facility in place. Only one of the respondent stated that he was not aware of such a system in place. However the responses on knowledge about the institution engaged in the water collection was mixed. Figure 8 shows the awareness level among the respondents on this issue. A key informant said "we segregate waste at the household level but GHMC has to ensure that the waste is segregated —wet and

dry, compostable and recyclable. This segregated waste should be collected separately and transported separately for further processing. But unfortunately we are not aware if this is happening."

The most frequently identified issue facing the IDL lake, provided by key informant, was water quality area (in terms of its color and stench emanating from the water) and its consequent impact on the flora and fauna. As a result of which there has been a decrease in the scenic view of the lake. One of the key informants from the apartment association mentioned "the stench from the lake is unbearable and is making it difficult to stay in the locality. Added to this, the mosquito population is also increasing". The top concerns expressed about water quality were algae/aquatic vegetation, bacteria, and chemical contamination and pollution. With reference to the changes in the water quality over the years, there were mixed responses. **Figure 8 and 9** summarize the number of respondents who identified the water quality problems and the changes over the years.

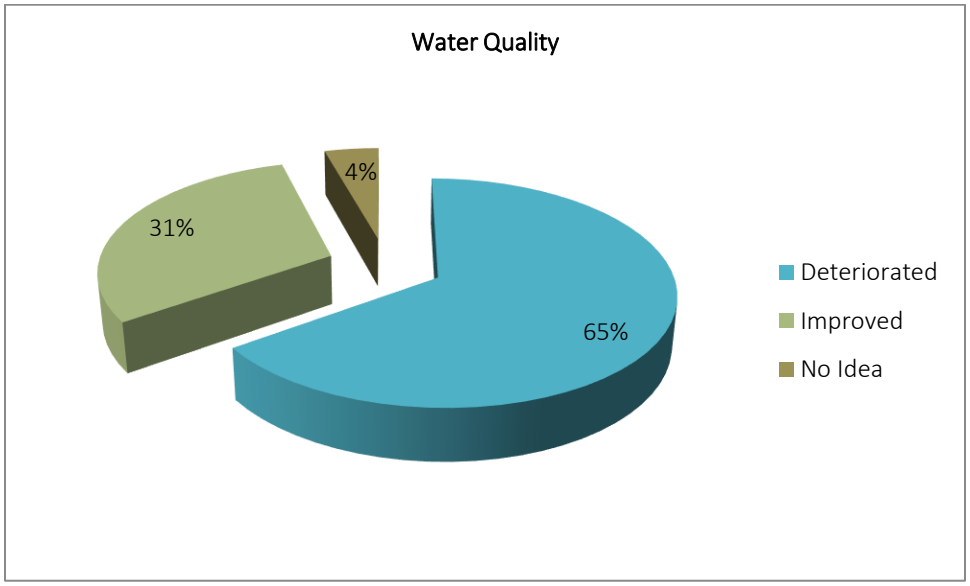


Figure 8

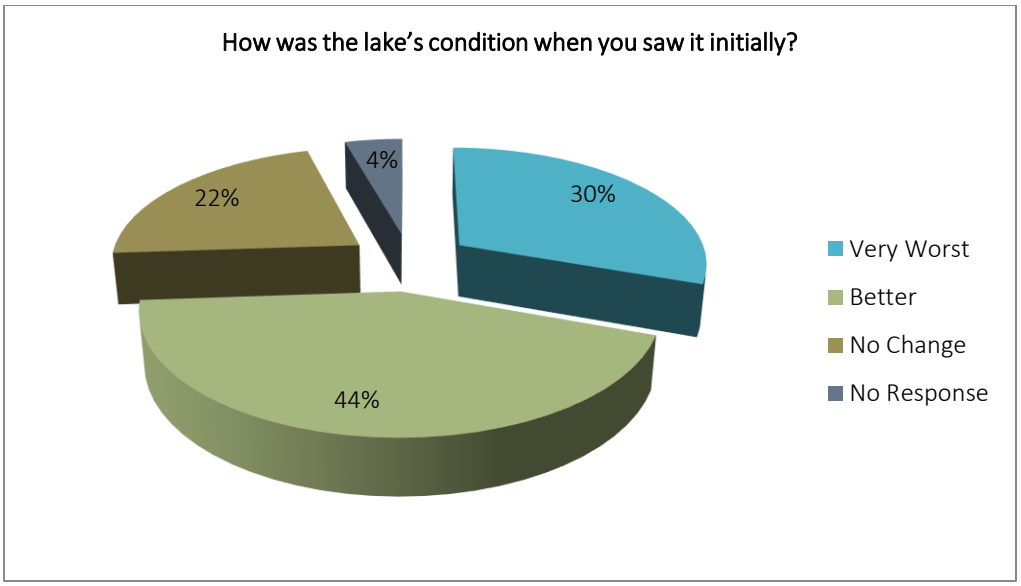


Figure 9

All the interviewed respondents stated that the presence of lake holds significance in the locality. The respondents stated "the lake controls run-off and improves groundwater; provides habitat to flora and fauna; provides recreational space; helps in improving micro climate". **Figure 10** shows the responses given on this aspect.

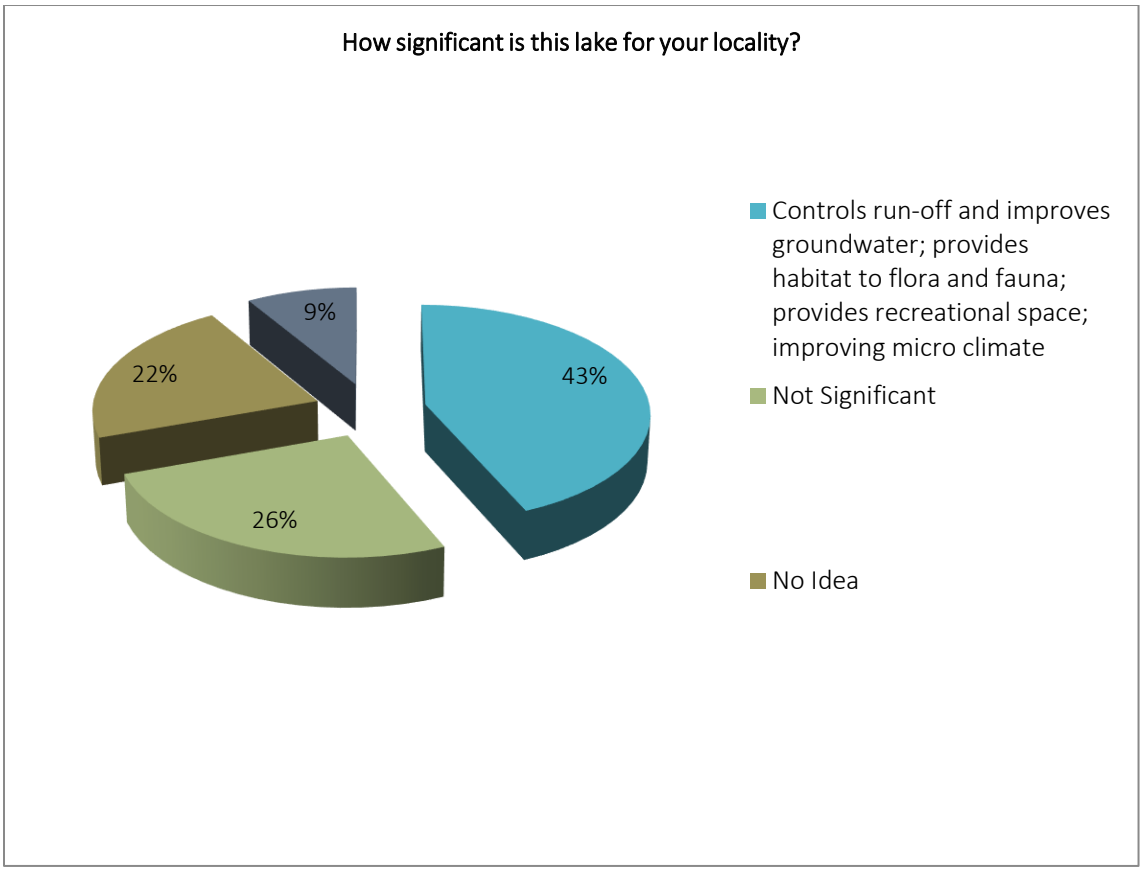


Figure 10

With respect to the benefits derived from the lake the interviewees pointed out: It acts as the wastewater sink and the encroached land is utilized for development (building residential and business complexes). A respondent stated "earlier the lake and its scenic beauty attracted people. The ecological balance within its periphery was maintained through different species of flora and fauna at different levels of water and different times of the year. Thus, people gained recreational and psychological benefits.

The deplorable condition of the lake's quality has not yet severely impacted the property value in the region as per the survey result. The majority of respondents of the survey stated there has been no decrease in the property value. The market value of the real estate is not clear to the residents. **Figure 11** shows the survey results on this aspect.

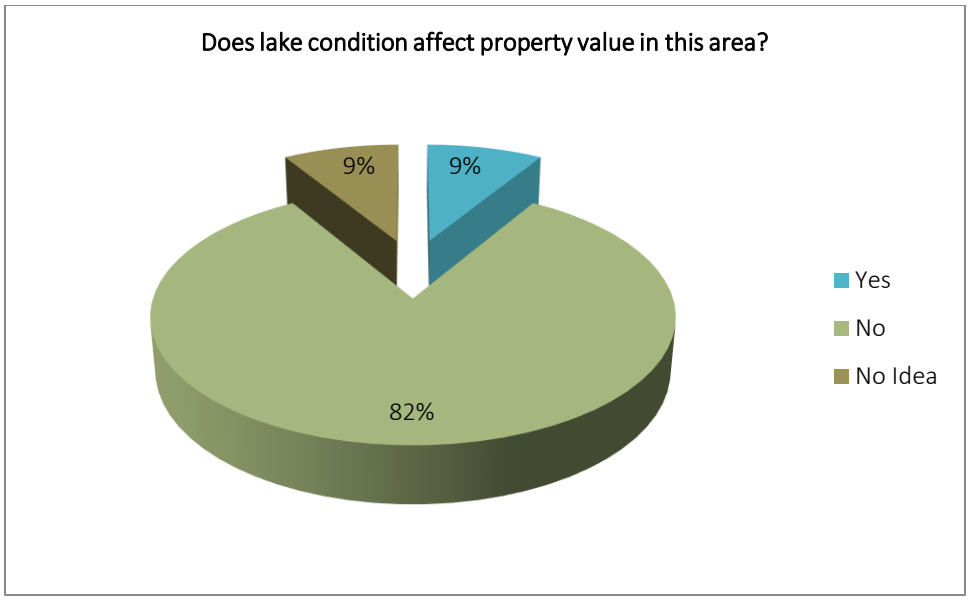


Figure 11

All the respondents (household survey and key informants) stated that the lake's condition is deteriorating at a rapid rate. They said gallons of waste (dry and wet) from the residential complexes are dumped into the lake. A resident stated that "the lake turned into garbage dumping yard. The water is contaminated throughout the year as the drainage water is mixed in the lake. This is happening because there are improper dumping and waste disposal in our area. For instance, late in the nights the local meat shop vendors dispose their waste into the lake." According to interviewees improper dumping and waste disposal are the root cause of water pollution and the stench emanating from the lake. **Figure 12** spells out the responses on causes of water pollution in the lake and probable solution suggested by them.

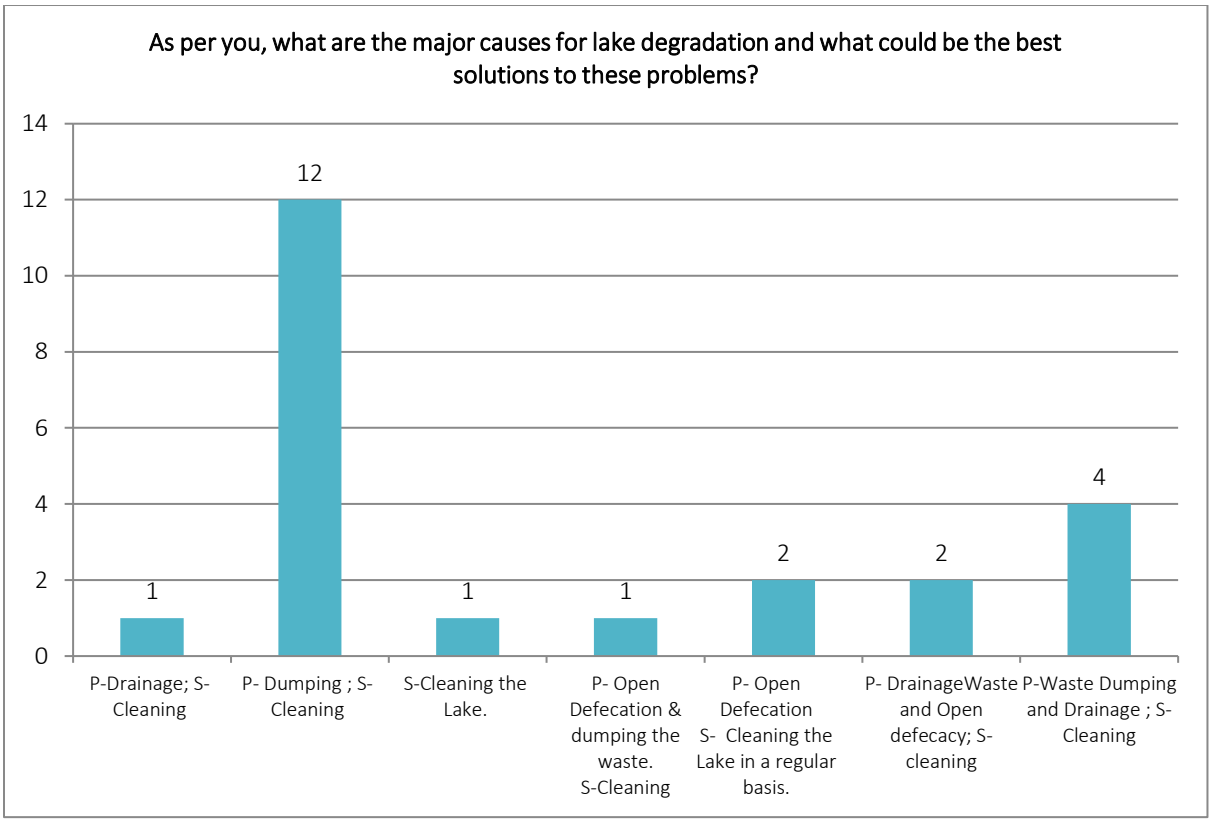


Figure 12

For the question on willingness on lake protection, majority of the interviewees stated that they willing to come forward in protecting the lake. **Figure 13**, shows the variations in the responses given by the respondents. **Figure 14 (a), (b) and (c)** sheds light on:

1. The frequency of time that they can dedicate to lake protection initiatives.
2. The ways through which they can extend their support.
3. An example of the type of monitoring support they want to extend.

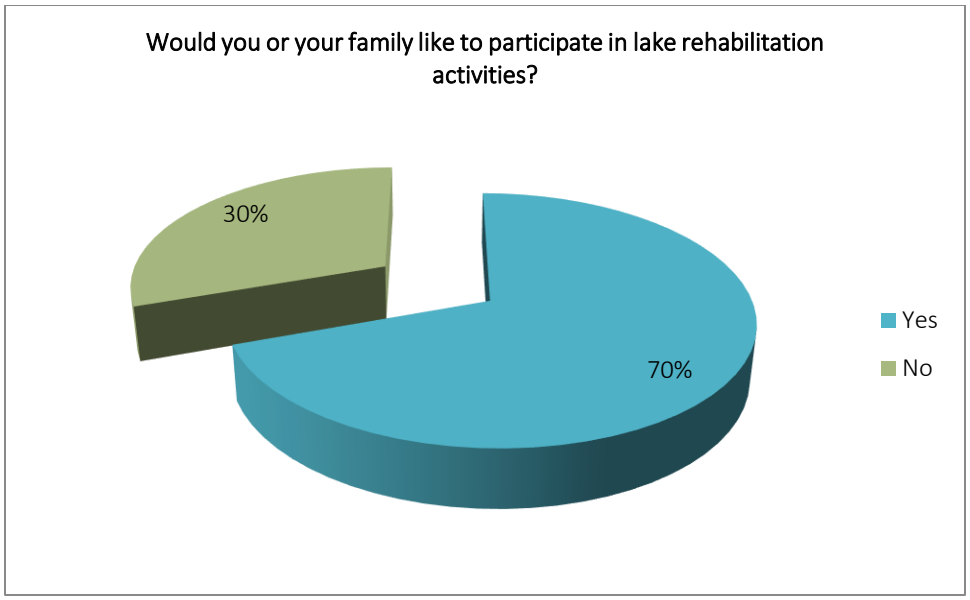


Figure 13

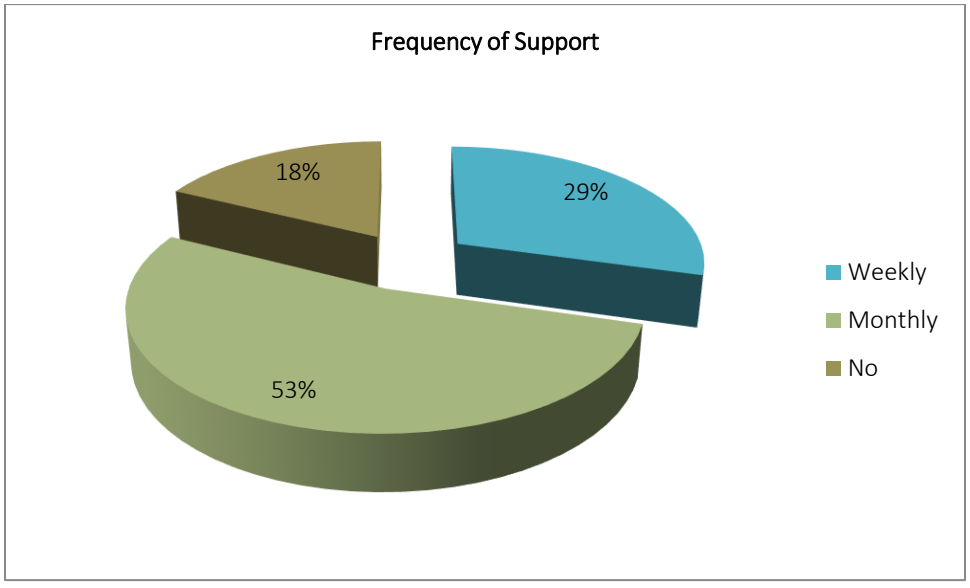


Figure 14 (a)

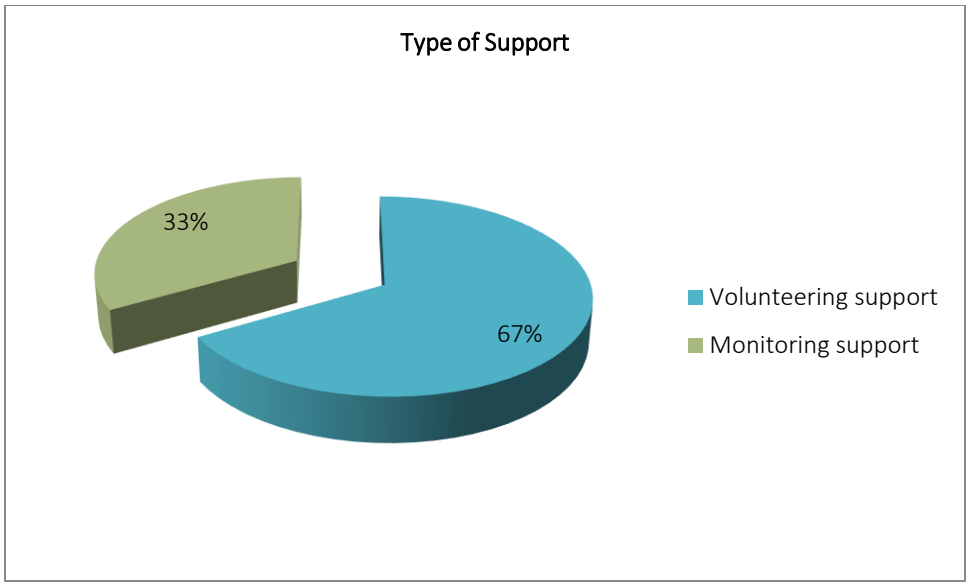


Figure 14 (b)

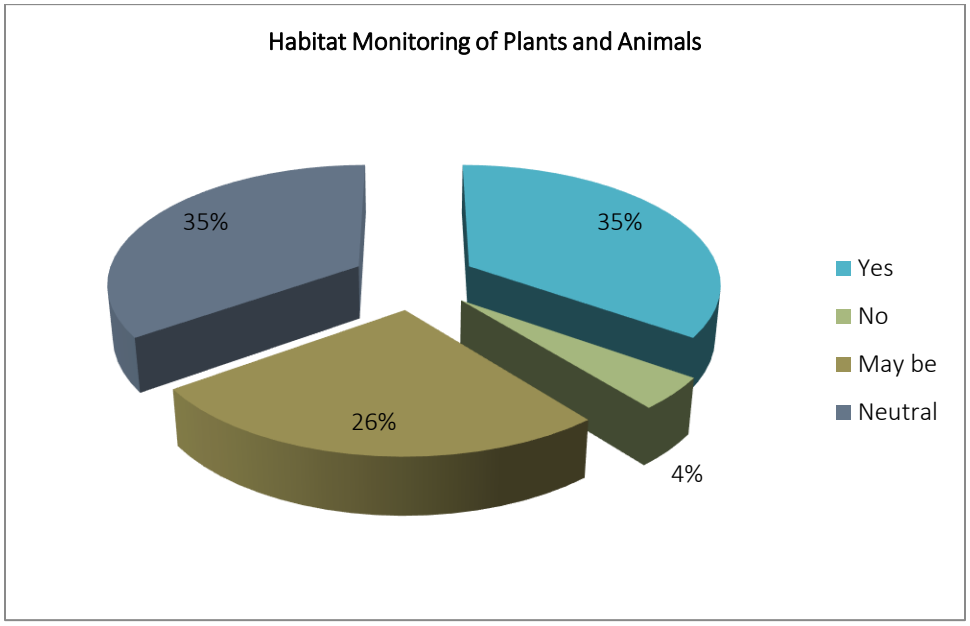


Figure 14 (c)

All the respondents unanimously agreed that the aesthetic value of the lake is important. However, there were differences in the keenness to engage in lake protection activities as per the visit to lake. 47.82% of the people frequented the lake daily while 26.08% visited frequently, 17.39% visited occasionally and 8.69% visited weekly. **Figure 15** shows the frequency of visits to the lake by the respondents.

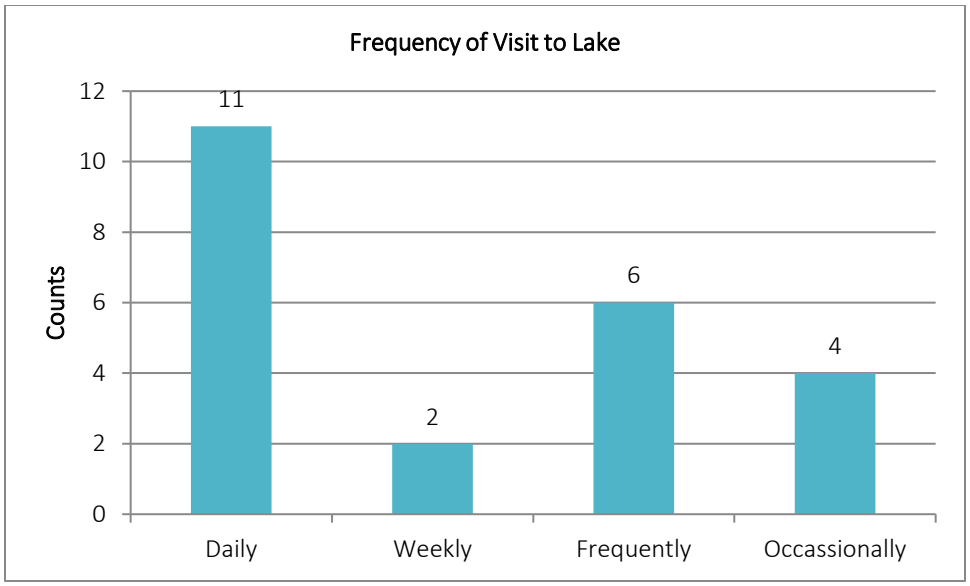


Figure 15

Figure 16 shows the importance given to people's perception about the protection of the lake. 56.52% of people were not sure whether their opinions will be taken into consideration, 26.08% of respondents stated that their views won't be considered and the remaining 17.39% were sure that they views will be considered.

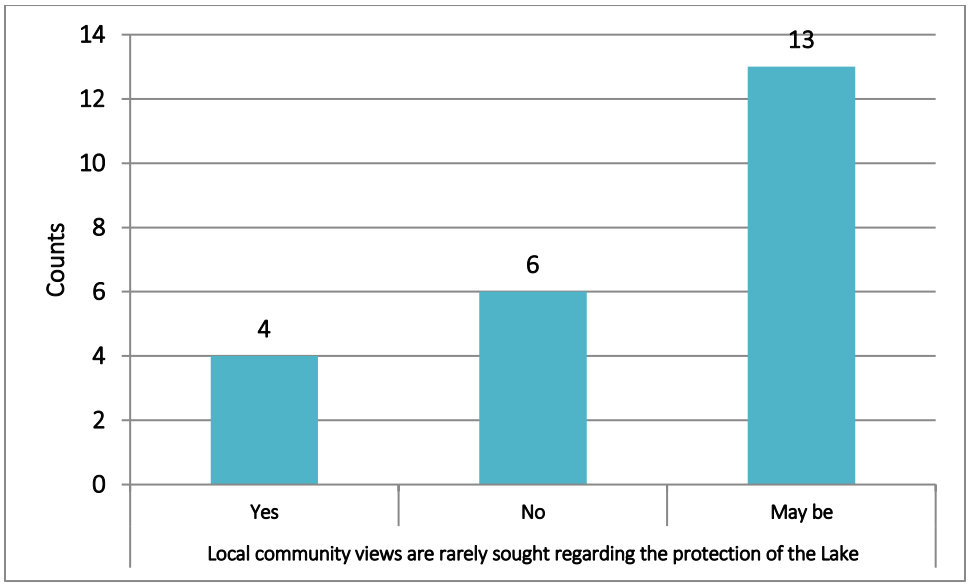


Figure 16

As a remedial action to prevent pollution and control the further deterioration of the lake, curative measure such as: introducing aquatic plants, checking water and soil quality, increasing green cover

outside the lake, plantation & protecting lake bank, removal pest plants and animals, controlled fishing/washing/ religious immersions, stopping littering/ defecation, putting safety measures in place, cleaning of the lake, plantation activities, trimming of over grown plants, adding mulch to the soil were asked to rate from yes, may be, neutral and no. The responses to these suggestions were majorly yes with minimal respondents being neutral.

The top concerns expressed were about water quality, the stench emanating from the lake and the conversion of the lake area into a dumping yard of both solid and liquid waste. Though the interest in finding solutions to arrest lake pollution was prevalent among the respondents, there was ambiguity in their responses with the ways through which they can do the same. The probable reason for this is due to lack of time, lack of information, cost involved in participation of remedial action and the genuine interest (priority) of the community. There is growing awareness about the deteriorating health of the lake. However active community participation can fasten up the process of arresting pollution. Furthermore, involvement of civil society organization can also aid in this process.

Eco-restoration of IDL Lake through PPP Model: Challenges and Opportunities

Challenges:

The case of IDL lake is unique in many ways:

1. Unlike other shrinking urban lakes, the IDL lake has expanded.
2. Unlike drying urban lakes, this seasonal lake has transformed into a perennial water body with water always at FLT.
3. Unlike other neglected urban lakes, the IDL lake is gaining attention from all the stakeholders, putting the Lake on the path of becoming a Poster Child of the Government's urban lake development program.

Prima facie, it appears to be a positive news. However, there is a flip side to the story.

1. Expansion of the lake is unnatural. It has resulted due to the continuous inflow of wastewater and blockage of natural outlets due to road construction and encroachments.
2. The environmental flow is unhealthy. Though the lake has become perennial, the water it receives and holds throughout the year is highly polluted resulting into dead zones across the lake. The pollution load is beyond self-purification and carrying capacity.
3. Though all key government stakeholders are actively involved to speed up the lake development work (given the upcoming assembly elections in December 2023), there seems to be a clear lack of coordination and communication among various stake holders. Furthermore, the proposed project initiatives focus only on the beautification of the periphery regions around the lake, which has become a cesspool. There is no mention of reviving the lake ecosystem and protection of aquatic biodiversity.

Opportunities:

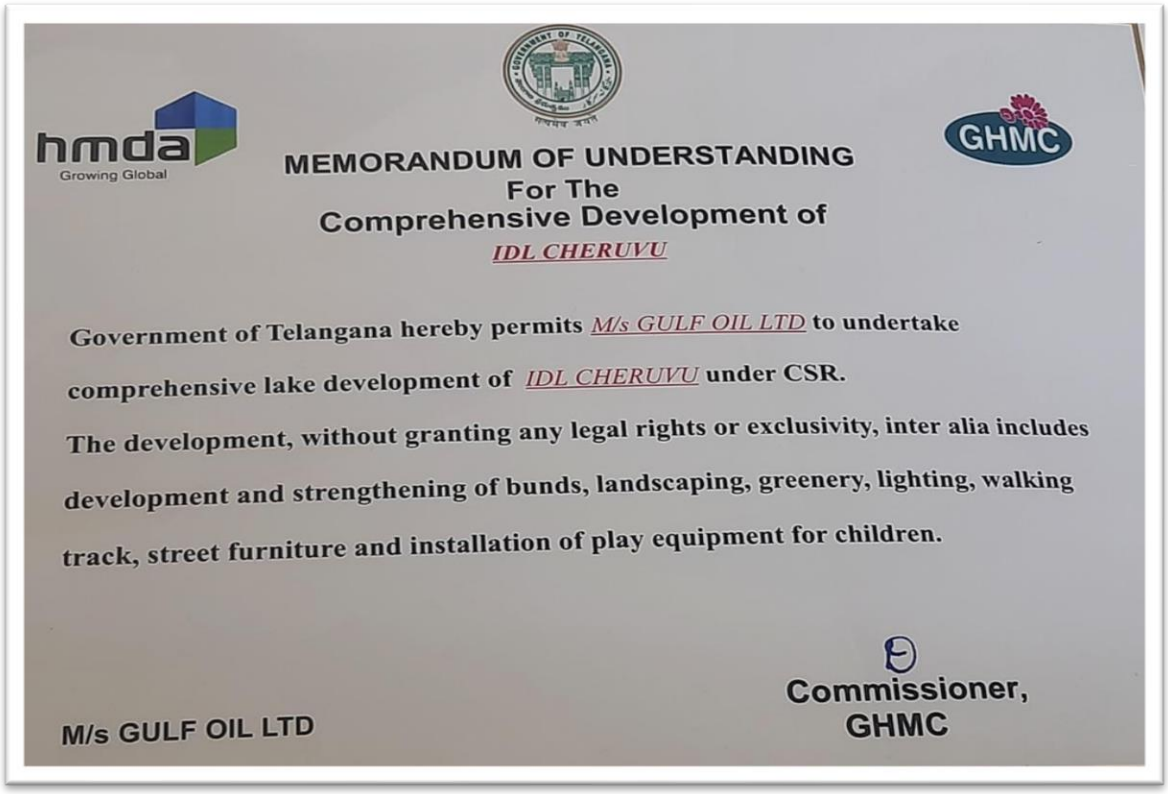
Despite the above-mentioned challenges, the present situation is also offering new opportunities towards lake eco-restoration through multi-stakeholder participation. The policy environment is conducive for a PPP model for lake development. With proper communication and coordination, stakeholders can

complement each other and contribute towards sustainable development of the lake. Fortunately, all necessary action plans and funds have been approved under various schemes.

- HMDA is already working on the beautification and development of public infrastructure around the lake. The process of upgrading capacity of 5 MLD STP to 10 MLD has also started. Diversion of additional wastewater is also proposed under Phase-2 of the restoration program.
- GHMC: Solid waste management: Promoting and supporting Housing associations and local industries/ commercial setups to treat, reuse and recycle their wastewater.
- GOCL can contribute towards ecosystem rejuvenation by applying Nature-based solutions to improve lake water quality and habitat protection for biodiversity.
- Local people have shown willingness to participate and can be engaged in regular lake protection activities such as cleaning of the lake (as volunteers for Swachh Bharat Abhiyan), plantation, eco-tourism, monitoring and evaluation of the project activities and awareness campaigns.

Chapter-6

Timeline of the development around IDL Lake



hmda
Growing Global

GHMC

MEMORANDUM OF UNDERSTANDING
For The
Comprehensive Development of
IDL CHERUVU

Government of Telangana hereby permits *M/s GULF OIL LTD* to undertake comprehensive lake development of *IDL CHERUVU* under CSR.

The development, without granting any legal rights or exclusivity, inter alia includes development and strengthening of bunds, landscaping, greenery, lighting, walking track, street furniture and installation of play equipment for children.

M/s GULF OIL LTD

Commissioner,
GHMC

Timeline of Events / Development around IDL Lake

S. No.	Event/Development	Year
1.	IDL established at Kukatpally	1961
2.	Rangadhamuni (ID) Lake was classified as dry lake (Seasonal Lake, shrinking during summer and swelling during the monsoon)	1975 (As per toposheet of 1975)
3	KPHB Colony started to develop rapidly after Erragadda Flyover was inaugurated by former Chief Minister Dr M Chenna Reddy in 1989	1990s
4	Seasonal lake turns into a perennial lake (change in water spread area wasn't noticed between seasons in any year after 2005-06)	2005-06
5.	Construction of IDL Road (Road led to blocking of irrigation weirs towards eastern side of the lake), pushing water further towards GOCL's private (*Patta*) land	2014
6.	Lake Protection Committee was constituted by the State Government for protection of lakes in the Hyderabad Metropolitan Region	2010
7.	5 MLD Capacity STP was constructed at IDL Lake with support from Japan International Cooperation Agency (JICA)	2012
8.	As per directions of the Lake Protection Committee, the HMDA, GHMC, Irrigation & CAD and Revenue departments demarcated and fixed the FTL boundaries and prepared the lake map. Irrigation & CAD maintains FTL throughout the year to stop encroachments on the lakebed using a weir at the outlet. FTL Map was published on HMDA's website. HMDA issued a preliminary notification regarding fixing the Full Tank Level (FTL) of IDL Lake on HMDA's website for any objections and suggestions by the citizens. (However, GOCL was not consulted and informed during the lake survey, despite the fact that GOCL's private (*Patta*) land were falling under FTL area)	2013
9.	GOCL tried to reclaim its private (*Patta*) land that was unnaturally flooded permanently throughout the year, by filling it. Locals protested the land reclamation and subsequently filed FRI against GOCL. Police visited the site to stop the filling of GOCL's private (*Patta*) land under FTL.	2015/16
10.	Foam spews out of Kukatpally IDL Lake. The foam, which previously was restricted to the boundary line, is now directly touching passers-by, people in buses and other road users on the National Highway. Apart from causing trouble to the road users, the foam was also observed touching the power cables of the Metro Rail Project.	13 July 2018

	GHMC responded that water was polluted with chemicals in IDL Lake and they would coordinate with the Pollution Control Board to conduct defoaming spray to curb the foam from overflowing. (Source: Deccan Chronicle dated 13 July 2018)	
11.	Pro Namo Seva team cleans up IDL Lake: As part of *Swachhata Abhiyan*, the Pro Namo Seva Sangh volunteers launched a massive drive at IDL Lake, Kukatpally, cleaning up the periphery of the lake post-Ganesh Visarjan along with local BJP and GHMC workers. Source: The Hans India https://www.thehansindia.com/news/cities/hyderabad/pro-namo-seva-team-cleans-up-idl-lake-564205	16 September 2019
12.	IDL Lake identified as one of the nine lakes to be restored (protection & beautification) in Kukatpally by GHMC under 'Mission Kakatiya'	06 July 2020
13.	Construction of Immersion Pond	2016-17
	The lake protection committee of HMDA announced that the state government has decided to set up lake protection committees at district-level and submitted a report to the National Green Tribunal (NGT) in connection with cases of Lake encroachments.	13 July 2021
	The State government decided to appoint a special commissioner under Greater Hyderabad Municipal Corporation (GHMC) to look after protection, conservation and development of water bodies in Hyderabad limits, announced by IT Industry and Municipal Administration Minister KT Rama Rao on Monday. The special commissioner will head district level lake protection committees.	13 September 2021 (Not yet appointed)
14.	GHMC accepted the proposals of 25 corporates for adopting and developing lakes in GHMC limits as proposed by the Town Planning section of the corporation. An MoU would be signed after receiving the approval of the GHMC Standing Committee.	25 June 2022
15.	GHMC- Adoption and Development of Tank Rangdhamuni (IDL) Lake letter issued to GOCL Corporation Ltd by the North Tank Division, GHMC.	19 July 2022 Reference: i) GOCL's representation: 9 May 2022 ii) GOCL's proposal examined and accepted by the Commissioner: 3 June 2022 iii) Approved by the Standing Committee, GHMC: 6 July 2022

17.	In a press release, HMDA proposed lakefront development at IDL Lake. Bund beautification, development of walkways, landscaping and seating arrangements to be taken up. (Other works to be taken up under the supervision of GHMC include cleaning of water hyacinth and waste material, biological wetland treatment, floating wetland and plantation, diversion of sewerage, bund strengthening and placing dustbins). (Source: Telangana Today, https://telanganatoday.com/hmda-plans-to-develop-idl-lake)	19 July 2022
18.	Tender floated by HMDA to upgrade three STPs within the Hussain Sagar catchment area with capacities of 5 MLD, 20 MLD and 30 MLD to 10 MLD, 40 MLD and 60 MLD respectively at an estimated project cost of ₹127 Crores, as per tender documents placed on the HMDA website. Officials from the HMDA informed that existing capacities of the STPs are not sufficient to treat the entire inflows into the lake from upstream. The STPs are located at IDL Lake, Kukatpally (5 MLD), near Indira Gandhi Rotary (20 MLD) and near KIMS hospital, Patigadda (30 MLD). (Source: The Hindu, 1 November 2022)	1 November 2022
19.	Lake bund strengthening work commenced at IDL Lake by HMDA without securing NOC from the Irrigation & CAD Dept. HMDA removes food stalls from the lake periphery. Locals objected that at least 10 feet of the lake was filled up with mud that is pushing lake FTL inside. However, HMDA said that they are merely beautifying the lake bund and no NOC is required for the beautification of the lake bund. (Source: The Times of India, 18 November 2022, https://timesofindia.indiatimes.com/city/hyderabad/locals-raise-hackles-over-idl-lake-works-hyderabad-metropolitan-development-authority-denies-filling-it-up/articleshow/95590386.cms)	17 November 2022
20.	KT Rama Rao, Minister for Municipal Development and Urban Development (MA & UD) laid the foundation stone for development of IDL Lake (Rangadhamuni Cheruvu) in Kukatpally with an estimated cost of ₹9.8 crore.	2 December 2022

	(Source: The Hindu, 3 December 2022)	
21.	**Lake Developers' meeting organised by GHMC**: The meeting was presided over by the Chief City Planner (CCP), Mr. Devender Reddy. Along with the other lake developers, GOCL Corporation was asked to submit a Conceptual Plan by 31st December 2022, specifically for a Lake Development Project launched by Mr. K.T. Rama Rao on 4th January 2023. GOCL representatives shared their concerns regarding HMDA taking up Lake development activities assigned to GOCL, despite the fact that GOCL has received all the permission to adopt IDL Lake. The Chief City Planner advised that there is no reason to worry as HMDA is only working on lake bund strengthening across the city. All the lake developers were asked to present their comprehensive plans. The CCP assured during the meeting that any conflicts or confusions can be taken care at later stages when the implementation will start.	28 December 2022
22.	SaciWATERs on behalf of GOCL prepared a conceptual plan for Eco-restoration of IDL Lake. GOCL submitted the conceptual plan to GHMC (Annexure III).	31 December 2022
23.	GOCL received a letter from the Irrigation & CAD Department, Govt. of Telangana informing in principle acceptance of conceptual plan submitted instructing GOCL to start the proposed work along the FTL boundary and buffer zone immediately. Agency is instructed to start the activities along the GOCL land.	25 January 2023
24	GOCL submitted the revised DPR to the Irrigation & CAD Department, Govt. of Telangana informing.	20 March 2023
25	Launch of the Lake Development Programme under CSR Initiative, by the Municipal Administration and Urban Development Minister Mr. K.T. Rama Rao. - Display of Lake eco-restoration plan by GOCL & SaciWATERs in the exhibition area - GOCL received an MOU certificate from GHMC. - The minister shared the scheme of Transferable Development Rights (TDRs) to the owners of the private lands under FTL. These TDRs are issued at 200% and their documents can be sold at TDR Banks to gain value. The minister encouraged private landowners to apply for TDR. - The minister advised lake developers to be careful about lake boundaries (FTL & buffer zones) to avoid any legal complications.	28 March 2023

Visual Timeline of Development around IDL Lake

May 2003 – First available image- water spread area was very less during summer months.

December 2003 –Post monsoon water spread area.

Feb 2005 –bund broadening started.

October 2006 – Band width increase for longer patch along the road.

March 2008 – Out drain can be seen till 2008 on the right side of the road.

February 2010 – construction of STP and pump house

January 2012 – Road construction work started.

February 2014 – Wide Road

April 2014 – Newly constructed wide metalled road

November 2016 – Immersion Pond construction started

November 2017 – Immersion Pond construction completed

October 2022 – latest image available

Chapter-7

Technical solutions for Eco-restoration of IDL Lake

VII: Technical solutions for Eco-restoration of IDL Lake

Approach

To ensure holistic rejuvenation of the water body, a three-fold approach is being proposed in Two Phases.

- Improving the quality of water in the lake
- Reviving the natural ecosystem
- Urban placemaking
- Sustainability of the initiative: (Institution Building- PPP Model for lake protection, management & monitoring); Information, Education & Communication (IEC); and Capacity building of local youth

Each of the above concepts are described in detail in the following sections.

Figure: Visualization of all the potential interventions at the IDL lake

Phase-I: Lake restoration activities along GOCL Land boundary

Reviving the natural ecosystem

1.1 Vegetative Buffer Strip as a Nature based Solution:

A vegetative buffer strip is proposed as one of the Nature-based solutions in the shoreline area along the GOCL Land i.e. around 700 m stretch with 20- 50 m thickness based on the available space (conceptually shown in the Image below).

The Vegetative Buffer Strip or Conservation buffers are permanent strips of natural vegetation placed in the landscape to influence ecological processes and provide a variety of goods and ecosystem services to human society. The proposed vegetative strip aims to prevent nonpoint pollution source and to provide undisturbed vegetative habitat along the shoreline.

Multifunctional role of vegetative buffer strip

Vegetated strips play a multi-functional role that covers a range of processes:

- Protection of water quality in surface waters
- Habitat improvement for aquatic biodiversity (provides excellent breeding and nesting ground for breeding and feeding for birds and other aquatic species)
- Shading
- carbon sequestration
- flow capture,
- biomass production,
- landscape diversity and ecofriendly beatification

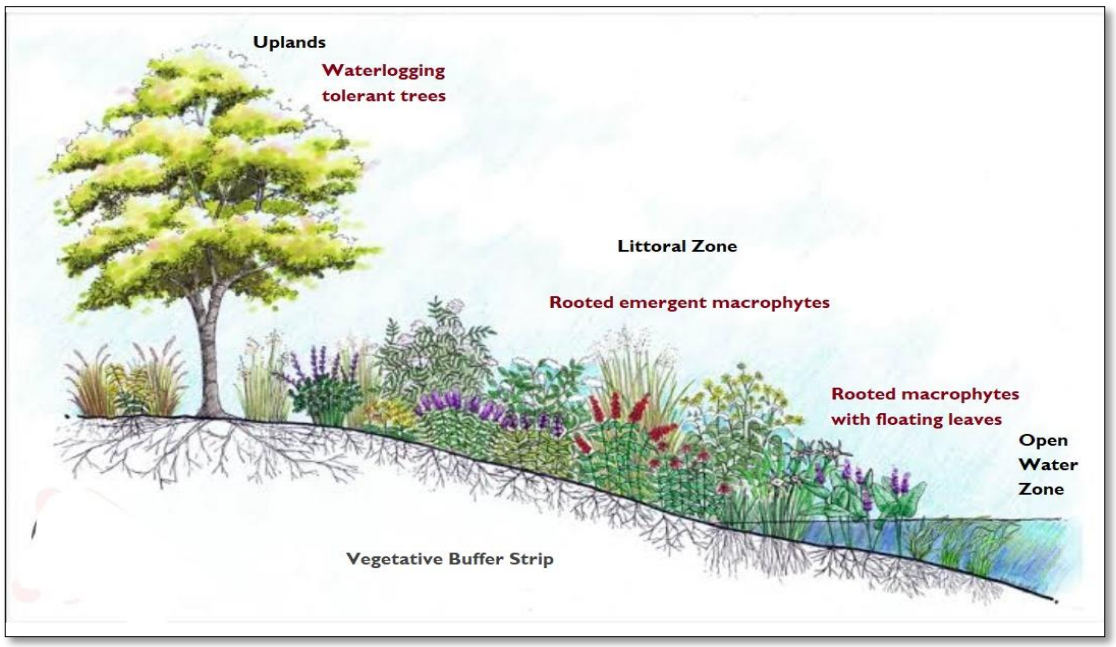


Figure: Cross sectional visualization of vegetation interventions along the IDL lake – Schematic 1

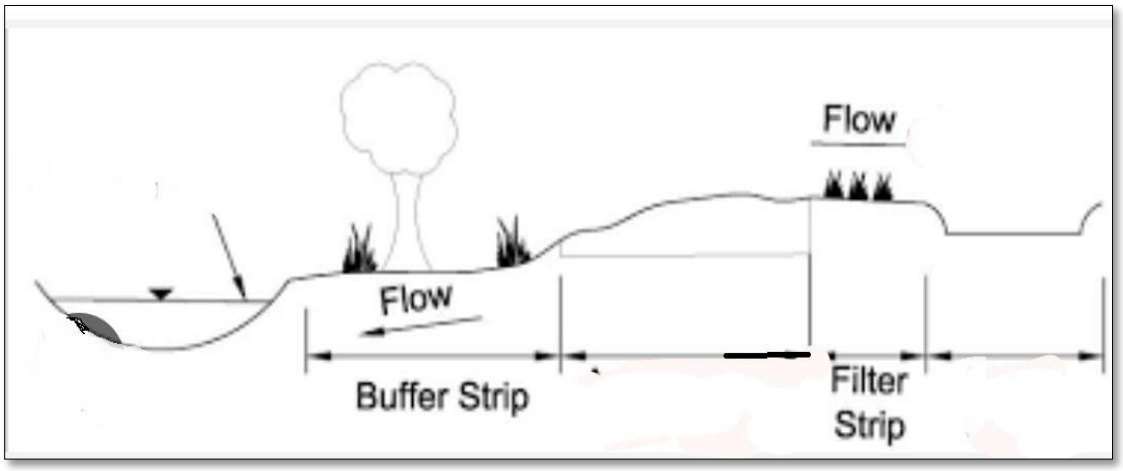


Figure: Cross sectional visualization of vegetation interventions along the IDL lake – Schematic 2

Species recommended for Vegetative Buffer Strip

a. Waterlogging tolerant tree species	
1	*Acacia Nilotica*
2	*Arjuna Terminalia*
3	*Pongamia pinnata*
4	*Syzygies cumini*
5	*Dendrocalamus strictus*.
6	*Salix tetrasperma*
7	*Barringtonia racemosa*
b. Emergent Macrophytes for banks	
1	*Scirpus articulatus*
2	*Typha aungustata*
3	*Phragmites sp.* (common reed)
4	*Ipomoea aquatica*
5	*Ipomoea carnea*
6	*Cyperous sp*
7	*Vallisneria spiralis*
c. Aquatic Macrophytes with Floating Leaves	
1	*Lotus Nelumbo nucifera*
2	*Nymphaea pubescens*
3	*Nymphaea nouchali*
4	*Nymphaea alba*
5	*Ludwigia adscendens*

Approx. 5000 plants can be planted. These plants will be largely the shore plants from three categories; Trees (500) shrubs (2250), herbs creepers including aquatic plants (2250). These will be a mix of wild and ornamental. Pathways need to be planted with flowery hedges.
A mechanism will be required for the proper management of natural vegetative strip and regular control of the growth of aquatic plants.

Urban placemaking

One of the key important components proposed is to develop walking/jogging infrastructure at the lake to increase usability and become a vibrant public space. This came up as a requirement from the residents around the lake during our field visits. Therefore, an overwater wooden elevated walking/jogging track is being proposed around the lake. The length of the proposed walking/logging track is 0.8 km. This track will close the loop between the existing waterfront developments like existing bund and walking track over it and the existing ghat on the northern side of the lake.

The proposed overwater wooden elevated track is ecofriendly and will not disturb the hydrology of the lake. The 0.8 Km track is proposed along the GOCL land boundary, considering the 'buffer zone guidelines for the industries.'

This urban placemaking will also provide an incentive for the local community to protect and conserve the lake.

Figure: Overwater Elevated Walking/Jogging Track (Reference Image)

Other aspects like landscaping, plantation, street furniture, and amenities like lighting, open gyms, toilets etc. can be included in the proposal. The cost of these components needs to be estimated based on the final requirements.

Estimated Budget

Phase 1 (Lake restoration activities along GOCL Land)

1. Vegetative Buffer Strip as a Nature Based Solution (Aquatic Macrophytes along the walkway and waterlogging tolerant trees on GOCL land)	Estimated Cost (in INR)
Estimated amount for 5000 Plants	5,00,000
Total 100 human days (Labor Charges)/Rs 1500/ Day for plantation	1,50,000
Ground preparation 100 human days (Labor Charges)/Rs 1500/Day	1,50,000
Transport	40,000.00
Sub-Total (INR)	8,40,000
2. Urban place making Interventions along GOCL Land	
Wooden walking/logging track (0.8 m long) @ 10000-15000/running meter Sub-Total	1,20,00,000
Phase I- Grand Total	**1,28,40,000**

Phase – II (After the Sewage diversion system is installed by HMDA and HMWSSB)

Improving the quality of water in the lake

To ensure ease of implementation and low maintenance systems, Nature Based Solutions (NBS) are being proposed for improving the quality of water in lake and consistently teat the wastewater entering the lake on a regular basis.

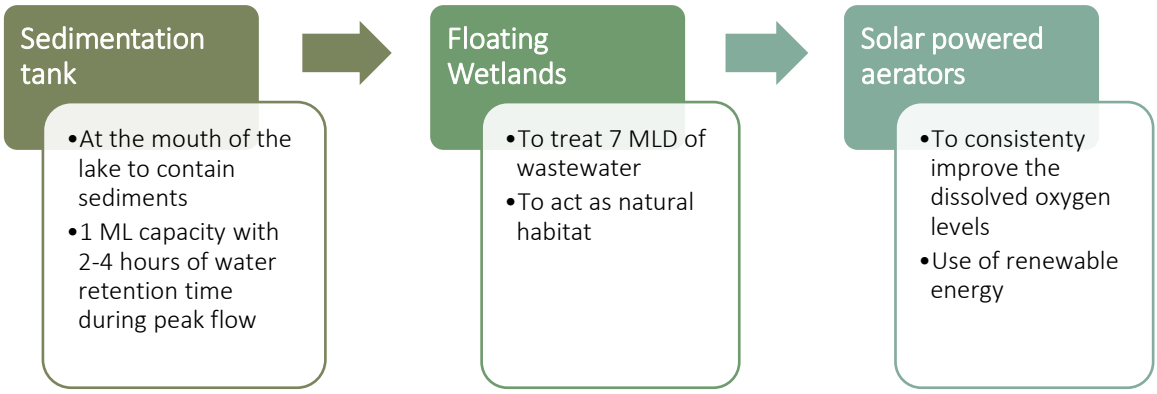
However, as a precursor to installing these systems it is essential to desilt/desludge the lake to:

- *address the issue of anerobic conditions prevalent in the lake and removal of toxic and contaminated sediments.*
- *increase the water holding capacity of the lake.*

The existing water management structures like the surplus weirs, sluice gates and screen channels may need a few improvements to ensure water balance in the lake.

Dredging and desilting of lake (reference image)

The proposed NBS system is a combination of Floating Wetlands and Solar powered Aerators that help in improving the condition of water in the lake and also treat the wastewater entering the lake. The wastewater flows (quantity) and its characteristics (quality) described in the previous sections have been considered for sizing and design of the NBS system. Below is a schematic diagram of the proposed NBS system.



Sedimentation Tank at the mouth of the Lake *(reference image)*

Floating wetlands (Reference image)

Solar Aerator (Reference image)

The technical details and related cost estimation for the compulsory preparatory activities and NBS for treating the wastewater is presented in the table below.

Estimated Budget

Sl. No.	Component	Tech. Specs.	No. of Units	Unit Cost (INR)	Total Cost (INR)
A. Preparatory activities					
i.	Dredging and Desilting of the lake	Average depth of 2m	3.69 lakh Cum	190 per Cum	7,02,00,000
ii.	Refurbishment of hydraulic structures	Sluice gates	---	Lumpsum	25,00,000
				Sub-Total	7,27,00,000
B. Installation of NBS to treat 7 MLD wastewater					
i.	Construction of Sedimentation Tank at the mouth of the Lake	Capacity: 1 ML Retention time: 2-4 hrs.	1 MLD	48,00,000	48,00,000
ii.	Installation of Floating Wetlands	2 sqm per cum of wastewater	14,000 sqm	3,000 per sqm	4,20,00,000
iii.	Introducing solar aerators	Aerate 26 acres of area	30 units	1,00,000 per unit	30,00,000
				Sub-Total	4,98,00,000
				Total Cost	12,25,00,000

3. Sustainability of the initiative

- Institution Building- PPP Model for lake protection, management & monitoring);
- Information, Education & Communication (IEC); and
- Capacity building of local youth towards protection of lake

Institution Building (PPP Model):

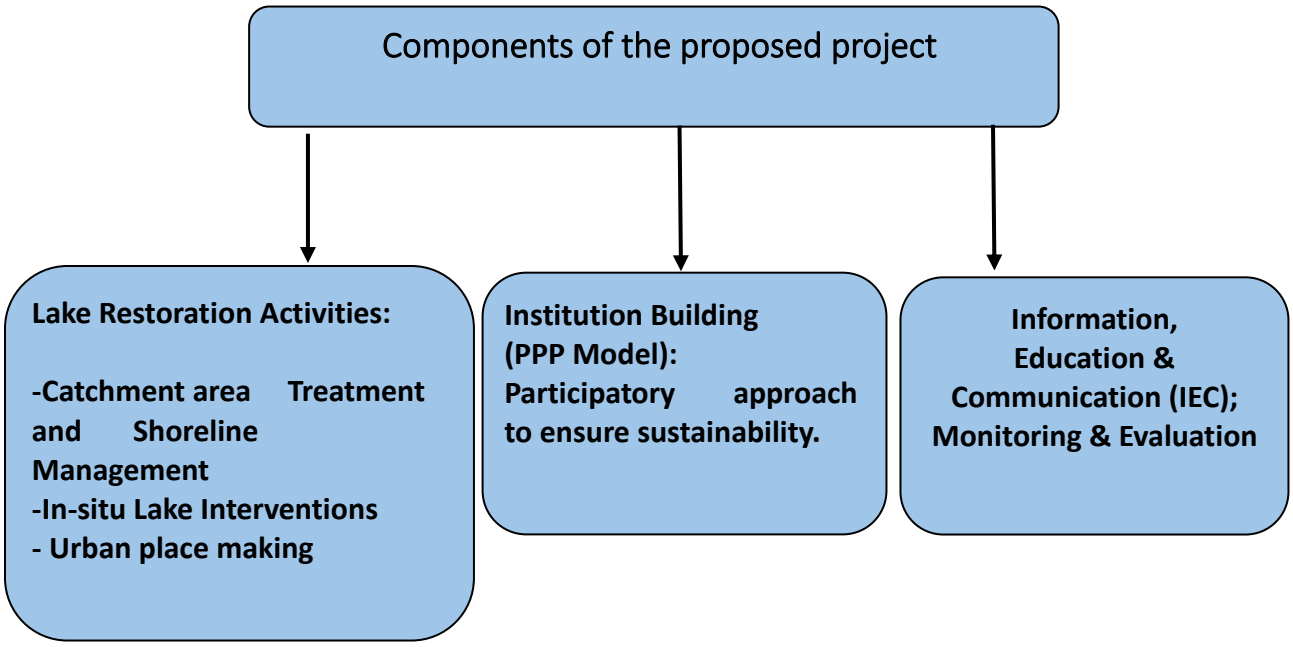
3.1 Lake conservation and management committee (A multistakeholder platform)
Sustainability of conservation measures require active participation from all the stakeholders i.e. local communities, civil societies, regulatory and administrative bodies, corporates, research institutes etc.

3.2 Ecotourism development through PPP involving local youth.

3.3 Information, Education & Communication (IEC):

- Awareness campaigns,
- Lake interpretation centre,
- Educational Field trips for youth,
- Research

Estimated Budget:
Program Coordinator: INR 6,00,000/- (@ INR 50,000/ month for One Year)



Expected Outcomes:

1. Improved water quality
2. Enhanced water storage capacity of the lake leading to flood resilience
3. Healthy natural aquatic biodiversity and improved ecosystem services for local community
4. Urban placemaking
5. Sustainable Management of IDL Lake

Opportunities

- **Developing a pilot project on water reclamation:**

With huge amount of sewage inflows being diverted into IDL site and lake, it begs for necessary holistic intervention which may require a multi stakeholder approach to help water reclamation i.e., divert the flows, treat wastewater, and put water to necessary use.

Urban areas in India lack proper reuse policies of treat wastewater or similar examples, this site can possibly present a case for 'water reclamation pilot' within the city where water can be diverted, treated, and reused for various urban purposes. For any such proposal diversion of sewage inflows is necessary.

- **Development of waterfront as a true eco-tourism site with careful planning:**

The new IDL access road is the recent past has been developed as a dual space to accommodate traffic flow and providing space for food trucks in the evening. This dual space is a tactical measure which can be future developed into a place making initiative. In many places across world dualism in space utilization has been accepted as a success story and equitable urban planning/ design example. IDL Lake offers already existing crowd created space. With proper planning and design interventions, the IDL access road can astatically uplift the lake and can crate space for public interaction. This can be an incentive for local populations to preserve the lake ecosystem.

Recommendations regarding flooding of GOCL's land:

- During present times when the news of reduced water levels and shrinkage of water bodies is widely acknowledged, the IDL Lake stands as a distinct contrast. This seasonal lake has turned perennial with an increase in its overall area. However, the factors responsible for this are not something to be appreciated. With heavy inflow of untreated sewage and natural rainwater, the IDL Lake floods the site throughout the year. The increased lake area is in dangerously proximity towards few of the company's workshops, causing serious safety concerns. Considering the present situation and also that the final notification of FTL and Buffer zone for IDL Lake is yet to be issued, it is recommended that GOCL should approach the Lake Protection Committee (LPC) and concerned higher authorities with a request to reconsider the FTL demarcation. GOCL can share the present scientific study that clearly illustrates that the water spread area has increased by about 14 acres from the original area (i.e. its natural state). At full tank level, the present perimeter is 2690 m vis-à-vis 1790 m earlier. The higher water spread area was recorded during the 2013 FTL Survey due to unnatural flooding which resulted due to continuous heavy sewage inflow into the lake. If concerned authorities are convinced, the lake area can easily be brought back to its original or natural state through a weir. The weir has been installed near the outlet by the Irrigation Department to control the lake's water level. As mentioned earlier, as per the LPC's guidelines, FTL is maintained throughout the year to prevent any encroachments.
- Urban wastewater is becoming a serious challenge for city administrative bodies and calls for holistic and sustainable approaches. To keep installing more and more STPs to treat the ever-growing volume of sewage doesn't seem to be the permanent solution in the long run. Rather, governmental policies should focus on addressing the root cause, which can be achieved through public participation. Housing associations and local industries/ commercial entities should be encouraged to treat, reuse, and recycle their wastewater at the source point. This will reduce the burden on both constructed and natural infrastructure and will bring both economic and ecological benefits to the city.

  this site can possibly present a case for 'reuse pilot' within the city where water can be diverted, treated, and reused for various urban purposes. For any such proposal diversion of sewage inflows is necessary.

Annex-1: Flow measurement details

Sample Point- 1 Channel from Balaji Nagar opposite to HDFC Bank

Sub Point-1:

Table 3: Flow Measurements at Sub Point-1 of Sample Point- 1 Channel from Balaji Nagar opposite to HDFC Bank

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
12:15 PM	5.7	0.14	0.15	0.1197	430.92
3:00 PM	5.7	0.1	0.2	0.114	410.4
9:30 PM	4.2	0.07	0.15	0.0441	158.76
11:30 PM	4.2	0.05	0.16	0.0336	120.96
5:30 PM	5	0.09	0.15	0.0675	243
7:30 PM	5	0.1	0.18	0.09	324
2:00 AM	4	0.04	0.22	0.0352	126.72
4:00 AM	3.5	0.05	0.25	0.04375	157.5
6:00 AM	3.5	0.04	0.22	0.0308	110.88
8:00 AM	4.8	0.12	0.14	0.08064	290.304
10:00 AM	5.2	0.17	0.16	0.14144	509.184
				Average flow in cum/day	262.0571
				No of hours	20
				Total flow for the number of hours	5241.142
				MLD	5.241142

Sub Point-2:

Table 4: Flow Measurements at Sub Point-2 of Sample Point- 1 Channel from Balaji Nagar opposite to HDFC Bank

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
12:15 PM	5.7	0.13	0.3	0.2223	800.28
3:00 PM	5.7	0.1	0.19	0.1083	389.88
9:30 PM	4.2	0.06	0.19	0.04788	172.368
11:30 PM	4.2	0.04	0.17	0.02856	102.816
5:30 PM	5	0.1	0.13	0.065	234
7:30 PM	5	0.08	0.2	0.08	288
2:00 AM	4	0.06	0.25	0.06	216
4:00 AM	3.5	0.06	0.24	0.0504	181.44
6:00 AM	3.5	0.06	0.24	0.0504	181.44
8:00 AM	4.8	0.11	0.32	0.16896	608.256
10:00 AM	5.2	0.14	0.38	0.27664	995.904
				Average flow in cum/day	379.1258
				No of hours	20
				Total flow for the number of hours	7582.516
			MLD		7.582516

Sub point 3:

Table 5: Flow Measurements at Sub Point-3 of Sample Point- 1 Channel from Balaji Nagar opposite to HDFC Bank

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
12:15 PM	5.7	0.14	0.33	0.26334	948.024
3:00 PM	5.7	0.12	0.22	0.15048	541.728
9:30 PM	4.2	0.09	0.22	0.08316	299.376
11:30 PM	4.2	0.04	0.15	0.0252	90.72
5:30 PM	5	0.1	0.14	0.07	252
7:30 PM	5	0.08	0.25	0.1	360
2:00 AM	4	0.05	0.2	0.04	144
4:00 AM	3.5	0.05	0.2	0.035	126
6:00 AM	3.5	0.05	0.21	0.03675	132.3
8:00 AM	4.8	0.11	0.31	0.16368	589.248
10:00 AM	5.2	0.14	0.36	0.26208	943.488
				Average flow in cum/day	402.444
				No of hours	20
				Total flow for the number of hours	8048.88
				MLD	8.04888

Sub Point-4:

Table 6: Flow Measurements at Sub Point-4 of Sample Point- 1 Channel from Balaji Nagar opposite to HDFC Bank

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
12:15 PM	5.7	0.12	0.32	0.21888	787.968
3:00 PM	5.7	0.1	0.28	0.1596	574.56
9:30 PM	4.2	0.09	0.2	0.0756	272.16
11:30 PM	4.2	0.04	0.19	0.03192	114.912
5:30 PM	5	0.09	0.2	0.09	324
7:30 PM	5	0.08	0.26	0.104	374.4
8:00 AM	4.8	0.12	0.38	0.21888	787.968
10:00 AM	5.2	0.16	0.4	0.3328	1198.08
				Average flow in cum/day	554.256
				No of hours	20
				Total flow for the number of hours	11085.12
				MLD	11.08512

Total Flow:

Table 7: Total Flow measurements of all sub points of Sample Point- 1

Sub Point-1, MLD	Sub Point-2, MLD	Sub Point-3, MLD	Sub Point-4, MLD	Average flow, MLD
5.24	**7.58**	**8.04**	**11.08**	**7.989**

Sample 2 : Inlet- 2 (Inlet channel of STP)

Inlet-2 Sub Point-1:

Table 8: Flow Measurement at Inlet 2- Sub point-1:

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr.
11:00 AM	10.20	0.08	0.18	0.14688	528.768
12:00 PM	10.20	0.04	0.06	0.02448	88.128
4:00 PM	10.20	0.05	0.05	0.0255	91.8
6:00 PM	10.20	0.5	0.04	0.204	734.4
8:00 PM	10.20	0.05	0.07	0.0357	128.52
10:00 PM	10.20	0.05	0.04	0.0204	73.44
12:00 AM	10.20	0.4	0.04	0.1632	587.52
2:00 AM	10.20	0	0	0	
4:00 AM	10.20	0	0	0	
6:00 AM	10.20	0	0	0	
8:00 AM	10.20	0.04	0.06	0.02448	88.128
10:00 AM	10.20	0.06	0.12	0.07344	264.384
				Average flow in cum/day	287.232
				No of hours	20
				Total flow for the number of hours	5744.64
				MLD	5.74464

Inlet-2 Sub point-2:

Table 9: Flow Measurement at Inlet 2- Sub point-2:

Time	Wastewater Width/dia (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.08	0.14	0.11424	411.264
12:00 PM	10.20	0.04	0.05	0.0204	73.44
4:00 PM	10.20	0.05	0.01	0.0051	18.36
6:00 PM	10.20	0.3	0.02	0.0612	220.32
8:00 PM	10.20	0.04	0.03	0.01224	44.064
10:00 PM	10.20	0.04	0.04	0.01632	58.752
12:00 AM	10.20	0.4	0.03	0.1224	440.64
2:00 AM					
4:00 AM					
6:00 AM		No flow			
8:00 AM	10.20	0.04	0.05	0.0204	73.44
10:00 AM	10.20	0.06	0.09	0.05508	198.288
				Average flow in cum/day	170.952
				No of hours	20
				Total flow for the number of hours	3419.04
				MLD	3.41904

Inlet 2- Sub Point-3:

Table 10: Flow Measurement at Inlet 2- Sub point-3

Time	Wastewater Width/dia (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.07	0.15	0.1071	385.56
12:00 PM	10.20	0.05	0.05	0.0255	91.8
4:00 PM	10.20	0.04	0.01	0.00408	14.688
6:00 PM	10.20	0.4	0.01	0.0408	146.88
8:00 PM	10.20	0.04	0.03	0.01224	44.064
10:00 PM	10.20	0.04	0.05	0.0204	73.44
12:00 AM	10.20	0.3	0.02	0.0612	220.32
2:00 AM					
4:00 AM					
6:00 AM	No flow				
8:00 AM	10.20	0.04	0.06	0.02448	88.128
10:00 AM	10.20	0.06	0.09	0.05508	198.288
				Average flow in cum/day	140.352
				No of hours	20
				Total flow for the number of hours	2807.04
				MLD	2.80704

Inlet 2- Sub point-4 **Table 11: Flow Measurement at Inlet 2- Sub point-4**

Time	Wastewater Width/dia (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.08	0.14	0.11424	411.264
12:00 PM	10.20	0.05	0.07	0.0357	128.52
4:00 PM	10.20	0.04	0.02	0.00816	29.376
6:00 PM	10.20	0.4	0.02	0.0816	293.76
8:00 PM	10.20	0.04	0.04	0.01632	58.752
10:00 PM	10.20	0.04	0.04	0.01632	58.752
12:00 AM	10.20	0.3	0.01	0.0306	110.16
2:00 AM					
4:00 AM					
6:00 AM		No flow			
8:00 AM	10.20	0.04	0.06	0.02448	88.128
10:00 AM	10.20	0.07	0.14	0.09996	359.856
				Average flow in cum/day	170.952
				No of hours	20
				Total flow for the number of hours	3419.04
				MLD	3.41904

Inlet-2, Sub point-5:

Table 12: Flow Measurement at Inlet-2, Sub point-5:

Time	Wastewater Width/dia (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.09	0.15	0.1377	495.72
12:00 PM	10.20	0.06	0.08	0.04896	176.256
4:00 PM	10.20	0.04	0.03	0.01224	44.064
6:00 PM	10.20	0.4	0.02	0.0816	293.76
8:00 PM	10.20	0.04	0.03	0.01224	44.064
10:00 PM	10.20	0.05	0.04	0.0204	73.44
12:00 AM	10.20	0.4	0.02	0.0816	293.76
2:00 AM	No flow				
4:00 AM					
6:00 AM					
8:00 AM	10.20	0.05	0.08	0.0408	146.88
10:00 AM	10.20	0.09	0.14	0.12852	462.672
				Average flow in cum/day	225.624
				No of hours	20
				Total flow for the number of hours	4512.48
				MLD	4.51248

Inlet 2, Sub point-6:

Table 13: Flow Measurement at Inlet 2, Sub point-6:

Time	Wastewater Width/dia (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.09	0.18	0.16524	594.864
12:00 PM	10.20	0.06	0.1	0.0612	220.32
4:00 PM	10.20	0.04	0.04	0.01632	58.752
6:00 PM	10.20	0.5	0.04	0.204	734.4
8:00 PM	10.20	0.05	0.05	0.0255	91.8
10:00 PM	10.20	0.05	0.06	0.0306	110.16
12:00 AM	10.20	0.5	0.04	0.204	734.4
2:00 AM	No flow				
4:00 AM					
6:00 AM					
8:00 AM	10.20	0.05	0.08	0.0408	146.88
10:00 AM	10.20	0.09	0.16	0.14688	528.768
				Average flow in cum/day	357.816
				No of hours	20
				Total flow for the number of hours	7156.32
				MLD	7.15632

Inlet-2 Sub point-7:

Table 14: Flow Measurement at Inlet 2, sub point -8:

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.1	0.21	0.2142	771.12
12:00 PM	10.20	0.06	0.13	0.07956	286.416
4:00 PM	10.20	0.04	0.04	0.01632	58.752
6:00 PM	10.20	0.4	0.05	0.204	734.4
8:00 PM	10.20	0.06	0.06	0.03672	132.192
10:00 PM	10.20	0.05	0.08	0.0408	146.88
12:00 AM	10.20	0.5	0.03	0.153	550.8
2:00 AM	No Flow				
4:00 AM					
6:00 AM					
8:00 AM	10.20	0.07	0.1	0.0714	257.04
10:00 AM	10.20	0.1	0.18	0.1836	660.96
				Average flow in cum/day	399.84
				No of hours	20
				Total flow for the number of hours	7996.8
				MLD	7.9968

Inlet 2, sub point -8:

Table 15: Flow Measurement at Inlet 2, sub point -8:

Time	Wastewater Width(m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
11:00 AM	10.20	0.1	0.21	0.2142	771.12
12:00 PM	10.20	0.06	0.13	0.07956	286.416
4:00 PM	10.20	0.04	0.04	0.01632	58.752
6:00 PM	10.20	0.5	0.05	0.255	918
8:00 PM	10.20	0.06	0.07	0.04284	154.224
10:00 PM	10.20	0.06	0.11	0.06732	242.352
12:00 AM	10.20	0.6	0.05	0.306	1101.6
2:00 AM					
4:00 AM					
6:00 AM					
8:00 AM	10.20	0.07	0.1	0.0714	257.04
10:00 AM	10.20	0.09	0.2	0.1836	660.96
				Average flow in cum/day	494.496
				No of hours	20
				Total flow for the number of hours	9889.92
				MLD	9.88992

Total Flow:

Table 16: Total Flow Measurement at Inlet 2

Sub Pt-1	Sub Pt-2	Sub Pt-3	Sub Pt-4	Sub Pt-5	Sub Pt-6	Sub Pt-7	Sub Pt-8	Total
5.744	3.41	2.80	3.42	4.51	7.156	7.99	9.89	5.615

Sample Point-3 Inlet 3: STP inlet channel (STP Inlet Diversion)

Table 17: Flow Measurement at Inlet 3: STP inlet channel (STP Inlet Diversion)

Time	Drain Dimensions		Velocity (m/s)	Flow Measurements	
	Wastewater Width (m)	Wastewater Depth (m)		Discharge in cum/sec	Discharge in cum/hr
12:00 PM	2	0.08	0.16	0.0256	92.16
	2	0.08	0.14	0.0224	80.64
4:00 PM	2	0.75	0.15	0.225	810
	2	0.75	0.12	0.18	648
6:00 PM	2	0.75	0.09	0.135	486
	2	0.75	0.1	0.15	540
8:00 PM	2	0.76	0.09	0.1368	492.48
	2	0.76	0.09	0.1368	492.48
10:00 PM	2	0.78	0.1	0.156	561.6
	2	0.78	0.09	0.1404	505.44
12:00 AM	2	0.75	0.09	0.135	486
	2	0.75	0.08	0.12	432
2:00 AM	2	0.67	0.09	0.1206	434.16
	2	0.67	0.08	0.1072	385.92
4:00 AM	2	0.65	0.09	0.117	421.2
	2	0.65	0.07	0.091	327.6
6:00 AM	2	0.67	0.11	0.1474	530.64
	2	0.67	0.12	0.1608	578.88
8:00 AM	2	0.68	0.12	0.1632	587.52
	2	0.68	0.12	0.1632	587.52
10:00 AM	2	0.8	0.13	0.208	748.8
	2	0.8	0.11	0.176	633.6
				Average flow in cum/day	493.7563636
				No of hours	24
				Total flow for the number of hours	11850.15
MLD					11.850

Sample Point 4: STP Outlet

Table 18: Flow Measurement at STP Outlet

Time	Actual width (m)	Wastewater Width(m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
2:30 PM	0.85	0.40	0.14	0.42	0.02352	84.672
5:15 PM	0.85	0.40	0.14	0.43	0.02408	86.688
7:00 PM	0.85	0.40	0.14	0.42	0.02352	84.672
9:00 PM	0.85	No Flow				
11:00 PM	0.85					
1:00 AM	0.85					
8:00 AM	0.85	0.40	0.14	0.42	0.02352	84.672
10:00 AM	0.85	0.40	0.14	0.42	0.02352	84.672
					Average flow in cum/day	85.0752
					No of hours	24
					Total flow for the number of hours	2041.805
					MLD	2.041805

Sample Point 5: Lake Outlet

Table 19: Flow Measurement at Lake Outlet

Time	Wastewater Width (m)	Wastewater Depth (m)	Velocity (m/s)	Discharge in cum/sec	Discharge in cum/hr
1:30 PM	0.6	0.04	0.56	0.01344	48.384
4:30 PM	0.6	0.37	0.58	0.12876	463.536
6:30 PM	0.6	0.36	0.46	0.09936	357.696
8:15 PM	0.6	0.35	0.46	0.0966	347.76
10:20 PM	0.6	0.35	0.4	0.084	302.4
12:00 AM	0.6	0.35	0.59	0.1239	446.04
2:00 AM	0.6	0.35	0.58	0.1218	438.48
4:00 AM	0.6	0.36	0.56	0.12096	435.456
6:00 AM	0.6	0.32	0.45	0.0864	311.04
8:00 AM	0.6	0.35	0.48	0.1008	362.88
10:00 AM	0.6	0.35	0.52	0.1092	393.12
				Average flow in cum/day		355.1629
				No of hours		20
				Total flow for the number of hours		7103.258
				MLD		7.103258