Rejuvenation Blueprint for Lakes in Vrishabhavathi Valley (V. Valley)

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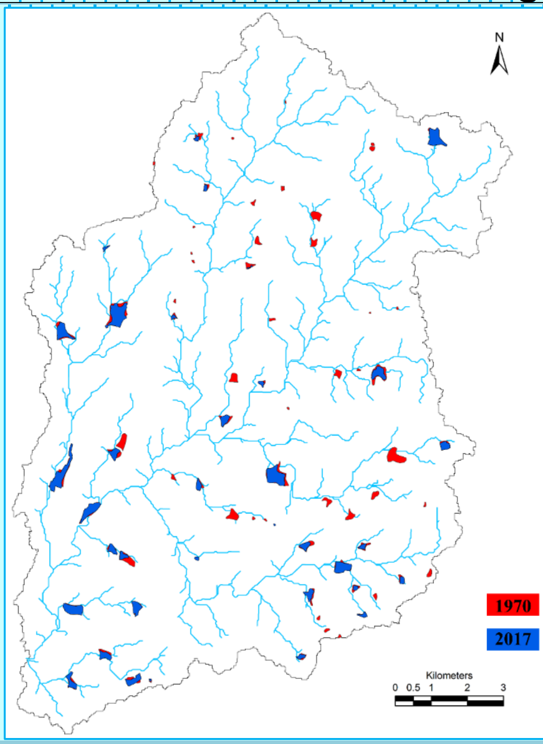
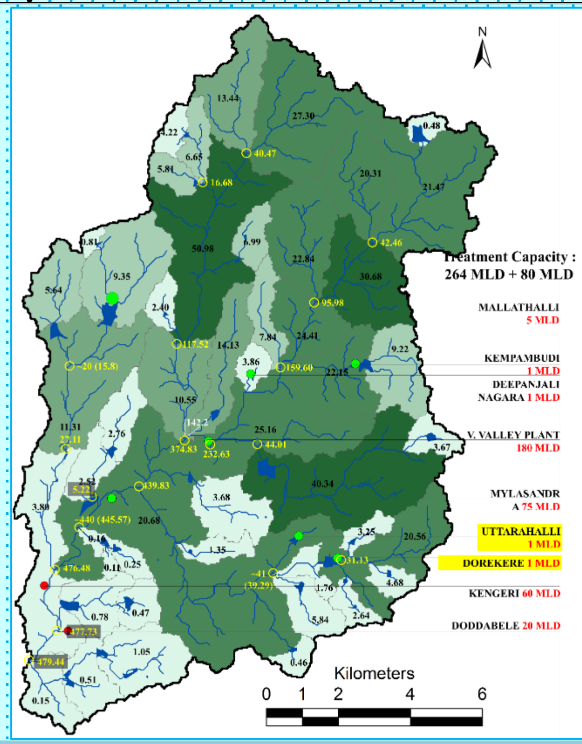
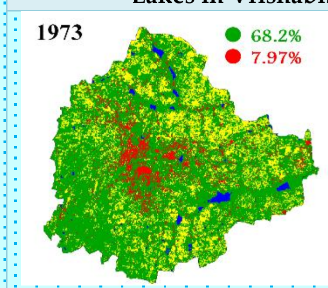


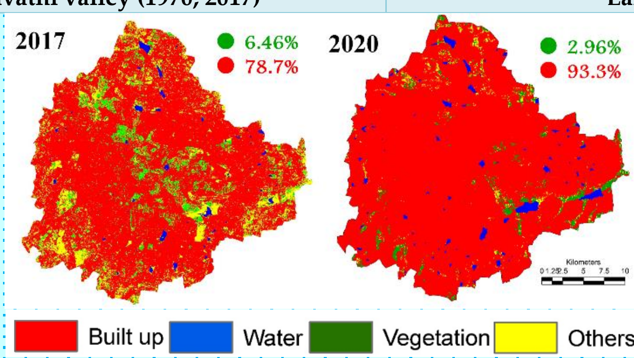
Lakes in Vrishabhavathi valley (1970, 2017)

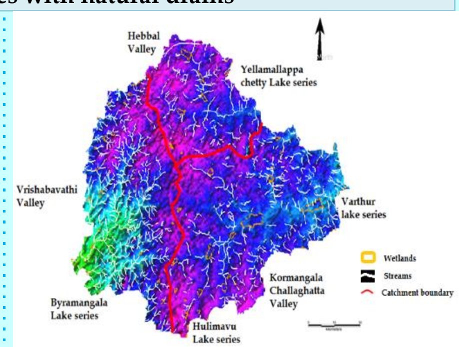


Lakes with natural drains



Bangalore -1970's
Garden City (Green city)





Dead city with concretised landscape - Unplanned, Unrealistic Urbanisation

Drains: Loss of inter connectivity

Adamya Chetana, Basavanagudi, Bangalore
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September 2017

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Rejuvenation Blueprint for Lakes in Vrishabhavathi Valley (V. Valley)

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Rejuvenation Blueprint for Lakes in Vrishabhavathi Valley (V. Valley)

- ❖ Rejuvenate all Lakes in the valley;
- ❖ Re-establish interconnectivity among lakes;
- ❖ Protect streams origin with appropriate catchment treatment (ecological);
- ❖ Stop Pollution – Decentralised treatment options - Sewage treatment through integrated constructed wetlands (similar to Jakkur Model – Secondary Treatment Plant (STP) + Constructed Wetlands + Algae ponds), which will remove nutrients, etc.;
- ❖ No diversion of sewage from upstream to downstream regions and adoption of de-centralized treatment and reuse of treated sewage;
- ❖ Remove all blockades at outlets as well as inlets– so that water will not stagnate, which will enhance aeration in the water body;
- ❖ Remove all encroachments without any considerations or political interventions (lake bed, storm water drains, buffer zone); Encroachments of drains and lake by some influential individuals have made the local citizens vulnerable due to frequent flooding with loss of life and property;
- ❖ Government should refrain from regularising encroachments.
- ❖ Ensure vegetation buffer in the 75 m buffer of the lake, which also helps in treatment of surface run-off;
- ❖ Stop mismanagement of natural drains – narrowing and concretising (against nature's principles – unlined drains help in groundwater recharge as well as remediation apart from mitigating floods)
- ❖ De-siltation to enhance storage capacity and also to remove contaminated sediments; Adopt latest state of the art technology - wet dredging to remove deposited sediments;
- ❖ Implementation of 'polluter pays' principle as per water act 1974;
- ❖ Implementation of 'polluter pays' principle as per the water act 1974; Ensure Zero discharge from industries;
  - Stop dumping of solid waste and construction & Demolition wastes in the lake bed, storm water drain;
  - Remove macrophytes (covered on the water surface) regularly;
  - Regular surveillance through vigilant resident groups and network of education institutions;
  - Regular monitoring of treatment plant and lake water quality (physical, chemical and biological) and the availability of information to the public through internet;
  - Install fountains (with music and LED) to enhance surface aeration and recreation value of the ecosystem;
  - No introduction of exotic species of fauna (fish, etc.);
- ❖ Identify Local NGO for regular maintenance and Management;
- ❖ Public Participation: Decentralised management of lakes through local lake committees involving all stakeholders - Involve local stakeholders in the regular monitoring, maintenance and management;
- ❖ Ban on use of phosphates in the manufacture of detergents; will minimise frothing and eutrophication of water bodies;
- ❖ Digitation of land records (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query based information system to public;

- Planting native species of macrophytes in the buffer zone (riparian vegetation) as well as in select open spaces of lake catchment area;
- Restrictions on the diversion of lake for any other purposes;
- NO construction activities in the valley zones;
- Stop all irrational techniques – sewage diversion, narrowing Rajakaluves, concretising natural drains, removal of wetlands in the buffer zone…
- Good Governance - Single agency with the statutory and financial autonomy to be the custodian of natural resources [ownership, regular maintenance and action against polluters (encroachers as well as those contaminate through untreated sewage and effluents, dumping of solid wastes)]. Effective judicial system for speedy disposal of conflicts related to encroachment.
- Environment education at all levels; Awareness among public about common lands, environment health, etc.
- Efficient Local administration through elimination of Land, water and Waste Mafia.
- **Stop Unplanned Irresponsible Urbanisation – DECONGEST BANGALORE**

Problems, Solutions and Benefits

PROBLEMS	1) Sustained inflow of untreated domestic sewage and industrial effluents; 2) Loss of interconnectivities among lakes - encroachment and shrinkage of Lakes, Rajakaluveys; dumping of solid wastes in the drain and preventing rainwater draining to lakes. 3) Eutrophication of interconnected lakes; 4) Ground water depletion and pollution; 5) Bioaccumulation of trace elements in fish (gets into human food chain); 6) Heavy metal uptake by vegetables grown in the downstream with contaminated water; 7) Mosquito nuisance; water scarcity. 8) Contaminated lakes - den for anti-social activities.
SOLUTION	1) Decentralised sewage treatment through integrated wetlands at identified locations in each lake catchment; 2) Channel bed to be planted with wetland plants to uptake nutrient load; 3) Only treated water to enter the channel and lakes; 4) Removal of Encroachments and all blockades; 5) Restoration of Lakes and Streams; 6) Restricting solid waste dumping in the lake bed and in rajakaluves (natural drains); 7) Monitoring of water quality by network of schools, near the lake/stream. 8) Introduction of native fish species into the lake. 9) Introduction of ducks into the lake to aerate water. 10) Introduction of water fountains to maintain oxygen level which adds up to the aesthetic value of lake.

	11) Providing small weirs (small rectangular bunds) along the valley to improve ground water storage and aeration capability of stream.; 12) Periodic cleaning of lakes and streams; 13) Greening catchment with native terrestrial vegetation along roads, parks, and earmarked areas, which improves both water (reduced overland flow, increased water storage in root zone, percolation) and air quality; 14) Water can be made potable with integrated wetlands system (similar to Jakkur lake) - natural treatments and hence reducing pressure of domestic water demand on Cauvery.
BENIFITS	1) No Sewage water is left untreated; 2) improved ground water (Jakkur as an example) and surface water quality. 3) downstream and upstream users can use the water for a) agriculture and horticulture. b) industrial application (maintenance of greenery, flushing, coolants, washing). c) fisheries; d) afforestation and avenue trees; e) cleaning of roads, f) watering avenue vegetation including Namma Metro and highways g) treated water for flushing -new residential areas with dual lines, 4) Lakes revive to life with treated water resource being perennial, help in creating micro climate, habitat for fishes, bird, etc. help in recharging ground water. 5) Reduced Mosquito breeding with water getting better in quality. 6) Reduced pressure on groundwater resource with time.

Rejuvenation Blueprint for Lakes in Vrishabhavathi Valley (V. Valley)

EXECUTIVE SUMMARY

Lakes and water bodies also referred to as wetlands are one of the most productive ecosystems contributing to ecological sustainability thereby providing necessary linkages between land and water resources. The quality and hydrologic regime of these lakes and wetlands is directly dependent on the integrity of its watershed. In last couple of decades, rapid urbanization coupled with the unplanned anthropogenic activities has altered the wetland ecosystem severely across globe. Changes in land use and land cover (LULC) in the wetland catchments influence the water yield and water quality for the lakes. Apart from LULC changes, the inflow of untreated domestic wastewater, industrial effluents, dumping of solid wastes and rampant encroachments of catchment has threatened the sustenance of urban wetlands. This is evident from the nutrient enrichment and consequent profuse growth of macrophytes, impairing the functional abilities of the wetlands. Reduced treatment capabilities of the wetlands have led to the decline of native biodiversity, prevailing unhygienic conditions with mosquito menace, contamination of groundwater levels, affecting the livelihood of wetland dependent population. Decline in the services and goods of wetland ecosystems have influenced the social, cultural and ecological spaces as well as of water management. This necessitates a systematic lake rejuvenation paradigm and associated monitoring of wetlands to mitigate the impacts through appropriate management strategies. A combination of LULC analysis in the catchment using remote sensing data acquired through the space-borne sensors facilitates identification of valley zones and wetland area. This in turn aids in maintaining records for encroachment and consequent action. Factor like nature of the catchment, wastewater quality and quantity influx, garbage dumping etc. related to water quality are the most important pressure driving the productivity of these rapidly disappearing wetland systems and are reasons for today's dominance of exotic organisms with increasing heterogeneity of biotic components at an intermediate spatial and temporal scale. Nutrient (C, N and P) influx being the most significant reason for the present deterioration of these wetland and water bodies. Suitable catchment management practices with strategic control of untreated industrial and domestic effluents getting into these water bodies will be key for a sustainable city management plan. Recommended de-silting and de-weeding the water bodies, complete treatment of municipal and industrial wastewater, a ban in P use in detergents, removal of encroachments, fencing and green belt around the water bodies, and growth of essential N-rich aquatic vegetation for the livelihood of nearby dependent communities and provision to retain the natural floating islands for in-situ bioremediation. Further strategic planning needs to be adopted at the higher level for increase in consensus for optimal water usage, provisions for rain water harvesting, ground water recharge etc. for fostering sustainable city management.

Vrishabhavathi Valley: Vrishabhavathi Valley is one of the three major valleys in Bengaluru, that flows south, joining Arkavathi, a tributary of river Cauvery. The catchment of V.Valley is nearly 170 sq.km covering about 90 Wards in BBMP. The catchment has about 70 lakes during the early 1970's which has now reduced to ~35 as on 2017. Most of the lakes have been filled and converted into residential/industrial areas, the streams/rajakauveys are narrowed by dumping construction debris, solid wastes there by increasing instances of floods, mortalities in monsoons. Current population in V.Valley (2017) is about 40 lakhs with water demand of 596 MLD (150 lpcd). V.Valley generates about 480 MLD (2017) of domestic sewage which is expected to reach 544 MLD by 2021with the current growth rate before it exits the BBMP limits. The valley has current treatment capability of 265 MLD (working) and 80 MLD (under construction) which is insufficient to treat the domestic waste.

Major watersheds of V.Valley are (i) Vrishabhavathi valley, (ii) Katriguppe Valley (joins V.Valley at Rajarajeshwari nagar, before STP), (iii) Nagarabhavi Valley (joins V.Valley at Bangalore University Gate) (iv) Channasandara Valley (joins V.Valley behind RVCE/Global Village techpark, Rajarajeshwari nagar), (v) Sonnenahalli valley (joins V Valley near Vidyapeetha-Kengeri). Details describing watersheds as in Table 1

Highlights:

- Origin - at Bull temple, a small hillock next to Dodda Ganapathi Temple in Basavanagudi, Bangalore South, due to which it is known as Vrishabhavathi river (Vrishabh meaning Bull).
- Number of watersheds: 7 major watersheds in Vrishabhavathi valley;
- Number of lakes: 70 (in 1970's), now 35 (in 2017) ; after swallowing by land mafia (50% disappeared lake)
- Domestic sewage: 480 MLD (2017) and expected to reach 596 MLD (2021)
- Serious threats:
    - Encroachments (rampant in each lake – for example Prakashnagara / Balehannu kere and many such lakes),
    - Sustained inflow of untreated sewage and industrial effluents,
    - nexus of senseless local politicians, bureaucrats, consultants and civil contractors [evident from narrowing and concretizing storm water drains, completely ignoring hydrological functions (groundwater recharge, bioremediation, mitigation of floods) of drains and also violating NGT guidelines on storm water drains and buffer regions].
    - Health issues: Contaminated fodder, fish and vegetable (contamination of food chain) due to polluted water in the lake with untreated industrial effluents (containing heavy metals, etc.). Respiratory and cancer episodes with volatile organic compounds and aerosols in the air environment. Breeding of disease vectors and instances of Chikangunia, Dengu, etc.

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Table 1: Current condition of V.Valley watersheds.

Minor Watershed	Description
1	Originating near Sankey Tank, Sadashivnagar, before it reaches Galianjaneya temple, Sewage about 120 MLD is generated and there are no treatment facilities in this minor watershed
2	Originates at Nandi temple (Basvanagudi) due to which river gets its name Vrishabhavathi. Joins valley originating near Sankey tank at Gali Anjaneya temple. Sewage about 31.5 MLD is generated in this watershed. A small treatment plant ~1 MLD exists downstream of Kempambudi lake that is used for watering Park adjacent to lake. Both Watersheds 1 and 2 combine to form V.Valley contributing about 150 MLD of Sewage.
3	Kartiguppe Valley originating near Yediyur flows through Hosakere halli and Joins Vrishabhavathi Valley at RajaRajeshwari nagar. Sewage of nearly 50 MLD is generated in this watershed and there are no treatment facilities in this watershed. Katriguppe valley and Vrishabhavathi valley both together contribute contributing to 235 MLD of Sewage. A treatment plant about 120 MLD (Secondary)+ 60 MLD (Tertiary) is existing at Rajarajeswarinagar.
4	Nagarabhavi valley originates in Yeshwanthpur, passing thorough industrial areas of Yeswhanthpur, residential areas of Laggere, Nandini layout, Nagarabhavi, and institutions such as Bangalore university and Sports Authority of India, joins V.Valley near Bangalore university Gate. Nagarabhavi Valley generated about 140 MLD of Sewage. Both V.Valley and Nagarabhavi valley together contribute to 374 MLD of Sewage.
5	Channasandra Valley contributed by minor streams of Doraikere, Uttarahalli, Srinivasapura joins V.Valley at Global Village SEZ, Rajarajeswarinagar. The valley contributes to about 61 MLD of Sewage. At this junction, V.Valley generates nearly 440 MLD of sewage. Mylasandra Treatment plant with a capacity of 75 MLD is along the downstream of the junction.
6	Sonnenahalli Valley contributed by stream of Mallathalli, Ullal, Kengeri Satellite town join V.Valley near Vidypeetha (Kengeri) contributes to 30 MLD of sewage. At this junction V.Valley generates 476 MLD of sewage. A treatment facility at Kengeri about 80 MLD is under construction downstream of this junction
7	Other minor stream contribute to nearly 3 MLD of sewage to V.Valley before the valley exits BBMP limits.

Recommendations:

Short term / Immediate Action	
Current Status	Recommendations
1.Poor water quality	1. Regular harvesting of macrophytes – helps in curtailing nutrients accumulation. 2. Improve aeration – (i) installing fountains, removing all blockages, (ii) widening and increasing number of channels / removal of blockades at outlets (refer page 19 – comparative assessment of aerators), 3. Stop dumping of municipal solid waste 4. Evict all waste processing units (in the vicinity of lakes and lake bed) 5. Stop dumping of construction and demolition (C & D) wastes in Rajakaluve, Valley zones and Lake beds 6. Strengthen legal cell (at BBMP, BDA, Forest Department, KLCDA) to address all illegalities and evolve fast track mechanism to speedy disposal and eviction of encroachers and for penalising polluters 7. No diversion of sewage from one locality to another. Decentralised treatment plants to handle sewage in the city (section 5). 8. Ensure that all apartments let only treated water to the lake. Implement mechanisms such as separate electric meters (net metering) and updating of details at respective resident association websites (including a copy at BWSSB web site) 9. Providing water quality details (each apartment discharge) – inflow to the lake at respective resident association websites (including a copy at BWSSB web site) 10. Functional ETP's to ensure zero untreated effluent discharges by industries. KSPCB to ensure zero untreated effluent discharges. 11. Evolving surprise environment audit mechanisms to ensure zero untreated effluent discharges to storm water drains (and lakes). Vetting of inspection report by the respective resident lake association. 12. Installation of surveillance cameras at the outlet of BWSSB STP (inlet of the lakes) and availability of electricity consumption details and surveillance camera streaming details to the public (through cloud sourcing or any other efficient and optimal mechanisms) 13. Formation of local residents association for each lake involving of all stakeholders to aid in regular monitoring and management. 14. Evolve mechanisms to make respective elected members (councillors, MLA and MP) and local ward engineers and bureaucrats accountable for lakes and open area status in their respective jurisdiction.
2. Physical integrity of lakes and storm water drains	1. Surveying and mapping of water body (including flood plains) and buffer zones (30 m as per BDA; 75 m as per NGT) and storm water darins
	2. Surveying and mapping valley zones (eco-sensitive zone as per RMP 2015, and green belt as per CDP 2005). Remove all encroachments without any consideration.

	3. Remove all encroachments (lake bed, Raja kaluves, storm water drains) to prevent calamities related to floods
	4. Identify the common lands, kharab lands, streams, drains, tracks and paths (as per cadastral / revenue maps). This land would be useful to setup waste water treatment plants (STP's) and constructed wetlands.
	5. Identify the areas required for setting up decentralised treatment plants (and if required mechanisms to acquire these lands for public utility)
	6. Stop narrowing and concretising rajakaluve (BBMP's deliberate action to obviate NGT norms (of 50m buffer)
3. Alteration in topography and unplanned concretisation	Refrain from granting any consent for establishment for large scale projects in these catchments with immediate effect (Bangalore is undergoing unplanned, un-realistic urbanisation)
4. Fragmented, un-co-ordinated lake Governance	1. Strengthen KLDCA – single agency / custodian to address all issues related to lakes (including maintenance, monitoring, management and removal of all illegalities) and interconnected drains. This helps in minimising fragmented governance. 2. Scientifically competent committee to address the lake issues.

Short and Long Term Measures

Current Status	Recommendations	Benefits
1. Untreated Sewage	1. No more untreated sewage diversions in the city. 2. Decentralised treatment of sewage (city sewage as well as local sewage in the vicinity of the lake). Model similar to Jakkur Lake – STP with constructed wetlands and algal ponds.	1. Removal of nutrients; 2. Helps in reuse of water; 3. Removal of contaminants; 4. Regulates nutrient enrichment; 5. Recharge of groundwater without any contaminants
2. Untreated Industrial Effluents	Enforcement of 'Polluter pays principle'. Ensure zero discharge through efficient effluent treatment plants.	1. Heavy metal will not get into food chain. Currently vegetables grown with the lake water has higher heavy metals 2. Less kidney failures and instances of cancer in the city
3. Nutrient enriched sediments	De-silting of lake (wet dredging / excavation).	1. Efficient mechanism of rainwater harvesting. Water yield in the catchment is 5.6 TMC and storage capacity of lakes is about 7TMC. 2. Increase the storage capacity 3. Enhances the groundwater recharging potential
4. Encroachment of lakebeds, valley zone and rajakaluves	Evict all encroachments.	1. Common lands would be available for setting up STP, wetlands 2. Removal of encroachments of Rajakaluves and drains would re-establish interconnectivity among lakes so that water would move from one lake to another, enabling treatment of water (through aeration)

5. Regular maintenance of macrophytes	Macrophytes harvesting at regular interval	1. Helps in further treatment of water as macrophytes uptake nutrients and regular harvesting would prevent accumulations 2. Supports livelihood of local people 3. Scope for generating energy (biogas)
6. Frothing	i. Ban Phosphorus use in detergents or regulate detergent with Phosphorous in market ii. Decentralised treatment of sewage (city sewage as well as local sewage in the vicinity of the lake). Model similar to Jakkur Lake – STP with constructed wetlands and algal ponds.	1. Reduces eutrophication of lakes (nutrient enrichment 2. Minimises the instance of frothing 3. Minimises health issues (skin, respiratory, etc.) related to contaminated air; 4. Reduces accident instances

DECONGEST BANGALORE - STOP UNPLANNED & IRRESPONSIBLE URBANISATION

Cities origin can be traced back to the river valley civilizations of Mesopotamia, Egypt, Indus Valley and China. Initially these settlements were largely dependent upon agriculture; however, with the growth of population the city size increased and the economic activity transformed to trading[1]. The process of urbanisation gained impetus with industrial revolution 200 years ago and accelerated in 1990's with globalization and consequent relaxations in market economy.

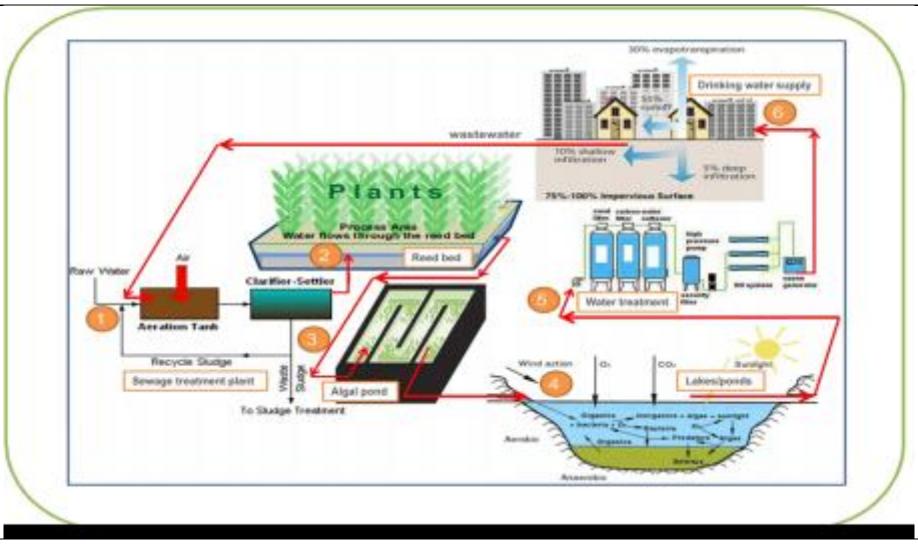
Urbanisation refers to the growth of the towns and cities due to large proportion of the population living in urban areas and its suburbs at the expense of rural areas. In most of the countries the total population living in the urban regions has extensively accelerated since the Second World War. Rapid urbanisation during the 20th century is evident from the dramatic increase in global urban population from 13% (220 million, in 1900), to 29% (732 million, in 1950), to 49% (3.2 billion, in 2005) and is expected to increase to 60% (4.9 billion) by 2030 and 9.6 billion in 2050[2]. Current global population is 7.4 billion and urban population has been increasing three times faster than the rural population, mainly due to migration in most parts of the world. People migrate to urban areas with the hope of a better living, considering relatively better infrastructural facilities (education, recreation, health centres, banking, transport and communication), and higher per capita income. Unplanned urbanisation leads to the large scale land use changes affecting the sustenance of local natural resources. Rapid unplanned urbanisation in most cities in India has led to serious problems in urban areas due to higher pollution[3] (air, water, land, noise), inequitable distribution of natural resources, traffic congestion, spread of slums, unemployment, increased reliance on fossil fuels, and uncontrolled outgrowth or sprawl in the periphery. Urbanisation is one of the demographic issues being investigated in the 21st century, understanding spatial patterns of changes in the land and visualization in advance of growth is imperative for sustainable management of natural resources and to mitigate changes in climate[3]. This would help the city planners in planning to mitigate the problems associated with the increased urban area and population, and ultimately build sustainable cities.

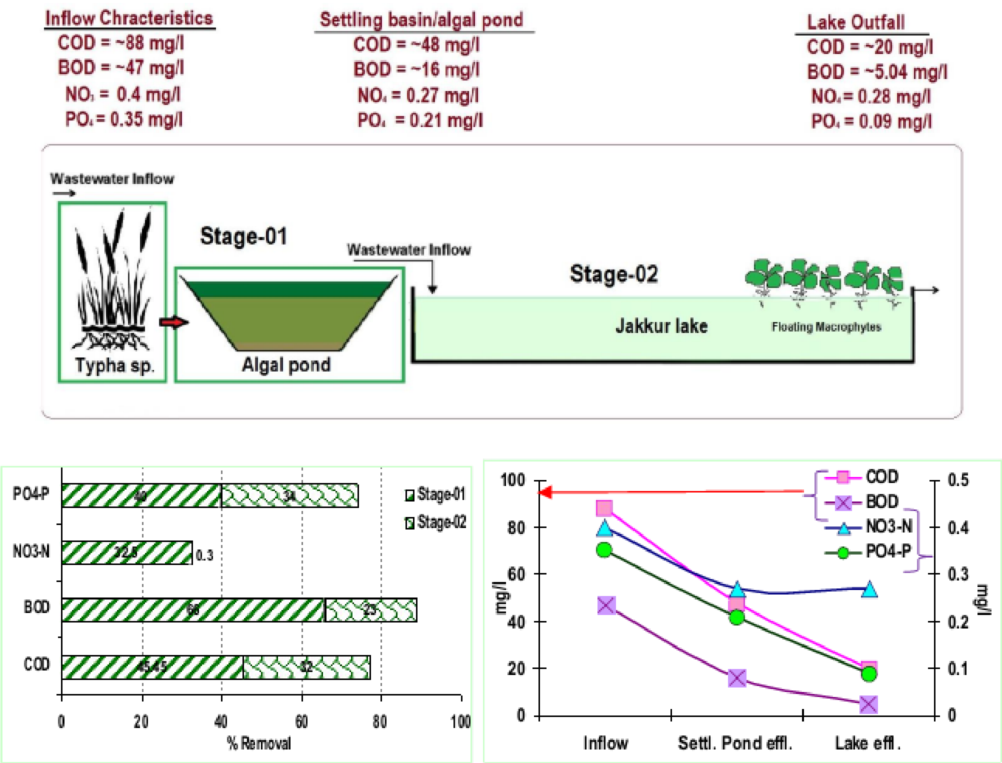
Bangalore is experiencing unprecedented rapid urbanisation and sprawl in recent times due to unrealistic concentrated developmental activities with impetus on industrialisation for the economic development of the region. This has led to large scale land cover changes with serious environmental degradation, posing serious challenges to the decision makers in the city planning and management process involving a plethora of serious challenges such as climate change, enhanced emissions of greenhouse gases (GHG), lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc.

Urbanisation during 1973 to 2017 (1028% concretization or increase of paved surface) has telling influence on the natural resources such as decline in green spaces (88% decline in vegetation), wetlands (79% decline), higher air pollutants and sharp decline in groundwater table. Quantification of number of trees in the region using remote sensing data with field census reveals that there are only 1.5 million trees to support Bangalore's population of 9.5 million, indicating one tree for every seven persons in the city[4]. This is insufficient even to sequester respiratory carbon (ranges from 540-900 g per person per day). Geo-visualisation of likely land uses in 2020 through multi-criteria decision making techniques (Fuzzy-AHP: Analytical Hierarchal Process) reveals calamitous picture of 93% of Bangalore landscape filled with paved surfaces (urban cover) and drastic reduction in open spaces and green cover. This would make the region GHG rich, water scarce, non-resilient and unlivable, depriving the city dwellers of clean air, water and environment**.** Recent BBMP short sighted measures of narrowing and concretisation of drains have led to floods with the loss of life and property.

Decentralised Model for treatment of sewage (similar to Jakkur Lake)

Integrated wetlands system consists of sewage treatment plant, constructed wetlands (with location specific macrophytes), algal pond integrated with a lake. This model is working satisfactorily at Jakkur. The sewage treatment plant removes contaminants ~ 76 % COD (380 mg/l – 88 mg/l); ~78 % BOD (220-47 mg/l); and mineralises organic nutrients (NO_3-N, PO_4^{3-}-P to inorganic constituents. Integration of the conventional treatment system with wetlands [consisting of reed bed (with typha etc.) and algal pond] would help in the complete removal of nutrients in the cost effective way. Four to five days of residence time helps in the removal of pathogen apart from nutrients. However, this requires regular maintenance through harvesting macrophytes and algae (from algal ponds). Harvested algae would have energy value, which could be used for biofuel production. The combined activity of algae and macrophytes helps in the removal of ~45% COD, ~66 % BOD, ~33 % NO_3-N and ~40 % PO_4^{3}-P. Jakkur lake acts as the final level of treatment that removes ~32 % COD, ~23% BOD, ~ 0.3 % NO_3-N and ~34 % PO_4^{3}-P. The lake water with a nominal effort of sunlight exposure and filtration would provide potable water. Replication of this model in Bangalore would help in meeting the water demand and also helps in recharging of groundwater sources without any contamination.





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

There is an urgent need for:

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

A comprehensive approach to water resource management is needed to address the myriad water quality problems that exist today from nonpoint and point sources as well as from catchment degradation. Watershed-based planning and resource management is a strategy for more-effective rejuvenation, protection and restoration of aquatic ecosystems and for protection of human health. In this regard, recommendations to improve the situation of the lakes are:

- **The need for good integrated governance systems in place** with a single agency with statutory and financial autonomy to act as the custodian of lakes for maintenance and action against polluters.
- **Effective judicial systems** for speedy disposal of conflicts related to encroachment
- **Access to information** for the public through digitisation of land records and availability of this geo-referenced data with query based information systems
- **Measures to clean and protect lakes**
  - Removal of encroachments from lakes, lake water beds and storm water drains, regular cleaning of lakes.
  - Proper measures such as fencing to protect lakes and prevent solid waste from going into lakes
  - Install water fountains (music fountains) which enhances the aesthetic value of the lake and also aid as recreation facility to IT professionals (working in IT sector in this locality) and elderly people. This also helps in enhancing oxygen levels through aeration.
  - Introduce ducks (which helps in aeration)
  - Introduces fish (surface, column and benthic dwellers) which helps in maintaining food chain in the aquatic ecosystem. This has to be done in consultation with fish experts.
  - No exotic fish species introduction avoid commercial fish culturing (commercial fishery)
- Decentralised treatment of sewage and solid waste (preferably at ward levels). Sewage generated in a locality /ward is treated locally and letting only treated sewage into the lake (Integrated wetlands ecosystem as in **Jakkur lake**). Integrated wetlands system consists of sewage treatment plant, constructed wetlands (with location specific macrophytes) and algal pond integrated with a lake. Constructed wetland aid in water purification (nutrient, heavy metal and xenobiotics removal) and flood control through physical, chemical, and biological processes. When sewage is released into an environment containing macrophytes and algae a series of actions takes place. Through contact with biofilms, plant roots and rhizomes processes like nitrification, ammonification and plant uptake will decrease the nutrient level (nitrate and phosphates) in wastewater. Algae based lagoons treat wastewater by natural oxidative processes. Various zones

in lagoons function equivalent to cascaded anaerobic lagoon, facultative aerated lagoons followed by maturation ponds. Microbes aid in the removal of nutrients and are influenced by wind, sunlight and other factors (Ramachandra et al., 2014). This model is working satisfactorily at Jakkur. The sewage treatment plant removes contaminants (evident from lower COD and BOD) and mineralises organic nutrients (NO_3-N, PO_4^{3-} P) to inorganic constituents. Integration of the conventional treatment system with wetlands [consisting of reed bed (with typha etc.) and algal pond] would help in the complete removal of nutrients in the cost effective way. Four to five days of residence time in the lake helps in the removal of pathogen apart from nutrients. However, this requires regular maintenance through harvesting macrophytes and algae (from algal ponds). Harvested algae would have energy value, which could be used for biofuel production. The combined activity of algae and macrophytes helps in the removal of ~45% COD, ~66 % BOD, ~33 % NO_3-N and ~40 % PO_4^{3-} P. Jakkur lake acts as the final level of treatment that removes ~32 % COD, ~23% BOD, ~ 0.3 % NO_3-N and ~34 % PO_4^{3-} P. The lake water with a nominal effort of sunlight exposure and filtration would provide potable water. Replication of this model in rapidly urbanizing landscapes (such as Bangalore, Delhi, etc.) would help in meeting the water demand and also mitigating water scarcity through recharging of groundwater sources with remediation.

- **Better regulatory mechanisms** such as
  - To make land grabbing a cognizable, non bailable offence
  - Implementation of the polluter pay principle
  - Ban on construction activities in the valley zones
  - Restriction of diversion of the lakes for any other purposes
  - Decentralised treatment of sewage and solid waste and restriction for entry of untreated sewage into the lakes
- **Encouraging involvement of local communities**: Decentralised management of lakes through involvement of local communities in the formation of local lake committees involving all stakeholders.

Area required for Constructed Wetlands:

Taking advantage of remediation capability of aquatic plants (emergent macrophytes, free floating macrophytes) and algae, constructed wetlands have been designed and implemented successfully for efficient removal of nutrients (N, P, heavy metals, etc.). Different types of constructed wetlands (sub surface 0.6 m depth, surface: 0.4 m, could be either horizontal or vertical) are given in Figure 1. Area required for constructed wetlands depends on the influent sewage quality and expected treatment (BOD removal, etc) is given in equation 1 (Vymazal et.al, 1998). Estimates show that to treat 1 MLD influent, area required is about 1.7 hectares. Figure 2 gives the design of wetlands to treat 1 MLD.

$$A = Q_d(\ln C_o – \ln C_t) / K_{BOD}$$

where A = area; Q_d= ave flow (m^3/day); C_o & C_t = influent & effluent BOD (mg/L); K_{BOD} = 0.10

For example to treat influent (raw sewage: BOD: 60-80) and anticipated effluent (with BOD 10), area required is about 1.7 to 2 hectares. Table 1 lists bioremediation potential of macrophytes.

Figure 1: Variants of constructed wetlands

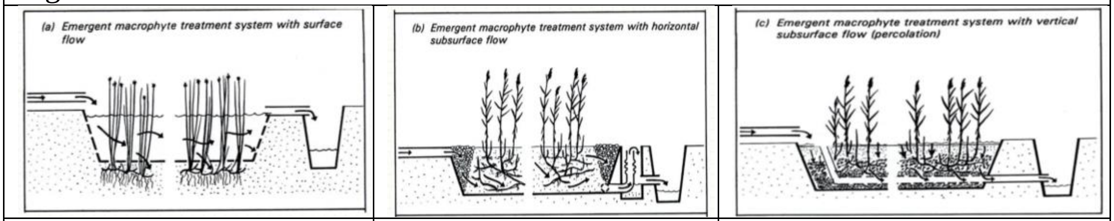


Figure 2: Conceptual design of wetlands

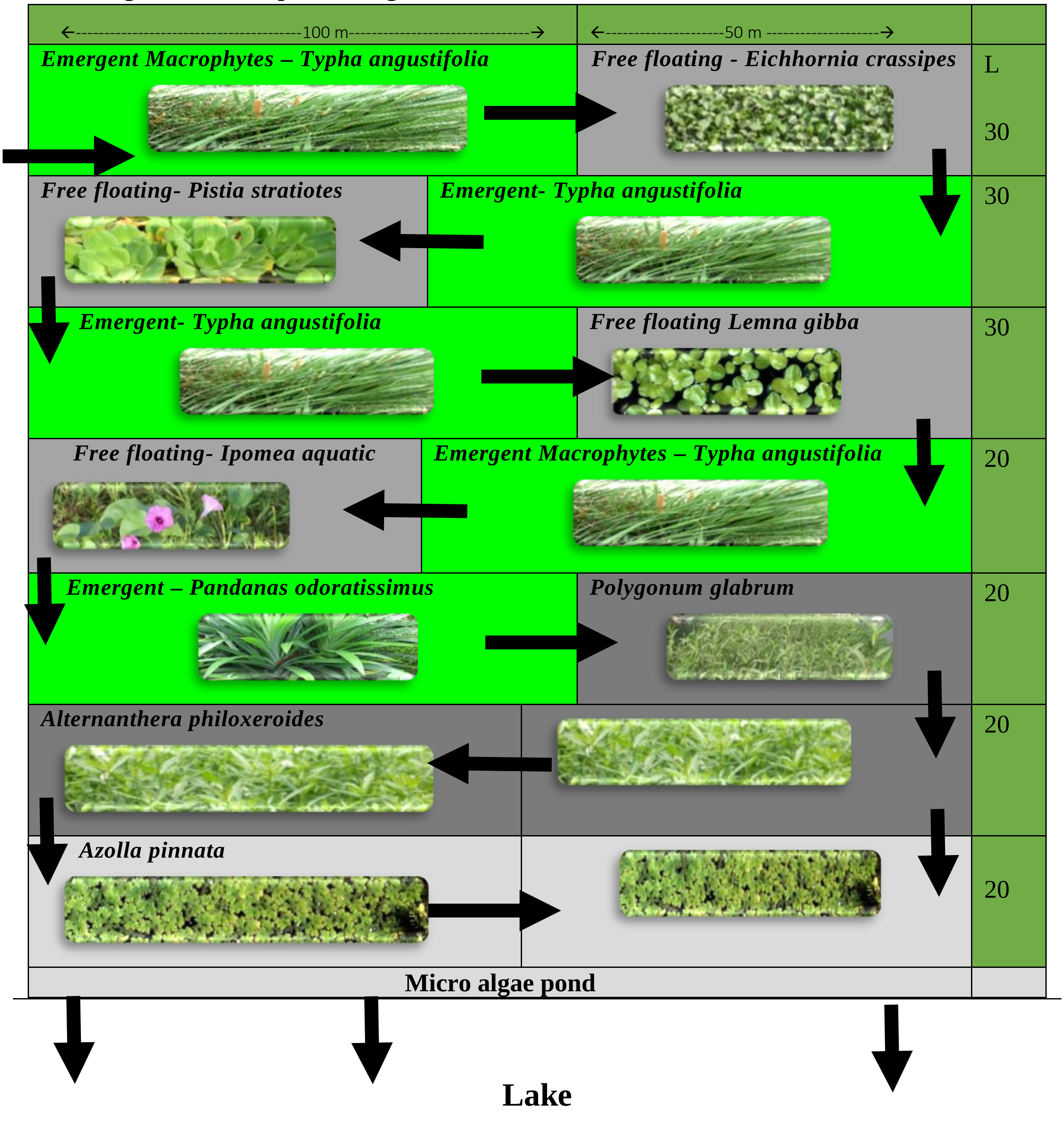


Table 1: Nutrient and heavy metal removal by Macrophytes

Macrophyte	Removal efficiency				Reference	Type of waste water/method
	N	P	COD/ BOD	Heavy metals		
Water hyacinth	65% (nitrate)	65% (phosphate)	75%		Shahabaldin *et al.*, 2013	Domestic wastewater/batch method
	50%(TN)	50%(TP)	50%		Costa *et al.*, 2014	Piggery waste with 20 days HRT
	21.78%-TN	23.02%-TP	64.44%-COD		Jianbo Lu *et al.*, 2008	Duck farm
	72%-N	63%-P			Tripathy *et al.*, 2003	Dairy effluent
				Cr(95%)	Mahmood *et al.*, 2005	Textile wastewater
				Hg-119ng /g Cd-3992µg/g Cu-314 µg/g Cr-2.31mg/g Ni-1.68 mg/g	Molisani et al., 2006 KK Mishra et al., 2007 Hu et al., 2007 Verma et al., 2008	
	2161 mg N/m^2/day or 7887 kg N/ha/yr	**542 mg P/m^2/day or 1978 kg P/ha/yr**			K.R Reddy and J.C.Tucker, 1983	microcosm aquaculture system
	Summer-1278 mg N/m^2/day **Winter-254 mg N/m^2/day**	**Summer-243 mg P/m^2/day** **Winter-49 mg P/m^2/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
Pistia stratiotes	**Summer-985 mg N/m^2/day** **Winter-258 mg N/m^2/day**	**Summer-218 mg P/m^2/day** **Winter-72 mg P/m^2/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
				Hg-0.57mg/g Cr-2.5mg/g Cd-2.13mg/g Ni-1.95mg/g	Mishra et al., 2009 Verma et al., 2008	

	Summer-292mg N/m²/day **Winter-70 mg N/m²/day**	**Summer-87mg P/m²/day** **Winter-18 mg P/m²/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
				Ti-221 µg/g Cu-400 µg/g Pb-8.62 mg/g	Babic et al., 2009 Boule et al., 2009 Uysal and Taner 2009	
Lemna minor	**194.9 ± 18.9 g TN/m²/yr**	**10.4 ± 1.7 g TP/m²/yr**	**3869 ± 352g COD/m²/yr**		Umesh et al., 2015	Manure slurry from dairy farm, surface flow wetland
	Summer-292mg N/m²/day **Winter-70mg N/m²/day**	**Summer-87mg P/m²/day** **Winter-18 mg P/m²/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
Lemna gibba				Ur-897 µg/g As-1022 µg/g	Mkandawire et al., 2004	
Spirodela polyrhiza	**Summer-151mg N/m²/day** **Winter-135mg N/m²/day**	**Summer-34mg P/m²/day** **Winter-34 mg P/m²/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
Azolla	**Summer-108mg N/m²/day** **Winter-48mg N/m²/day**	**Summer-33mg P/m²/day** **Winter-10mg P/m²/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
Salvinia	**Summer-406mg N/m²/day** **Winter-96mg N/m²/day**	**Summer-105mg P/m²/day** **Winter-32mg P/m²/day**			K. R. REDDY AND W. F. DE BUSK , 1985	microcosm retention ponds
	48-54 g/m²				Maltais-Landry et al., 2009	Mesocosm with daily total N loading rates 1.16 g/m²

Typha angustifolia				Cr-20210 µg/g Zn-16325 µg/g 7022 µg/g	Firdaus-e-Bareen and Khilji, 2008	
	922 kg N/ha	**114 kgP/ha**			Abdeslam Ennabili et al., 1998	Field study: Coastal wetlands (freshwater or brackish systems) were studied in three river mouth areas in the Tingitan Peninsula
Combination of Water hyacinth, duckweed and blue-green algae	>90%(nitrate)	>90% (phosphate)	BOD-97%	20-100%	Sinha *et al.*, 2000	Sewage water

Quantities of elements that could be removed by continual culture of some aquatic plants (kg/ha/year) (Reference:handbook of utilization of aquatic plants,FAO, http://www.fao.org/docrep/003/x6862e/X6862E11.htm)

Element	***Water hyacinth (Eichhornia crassipes)*** (kg/ha/year)	***Alternanthera philoxeroides*** (kg/ha/year)	***Typha latifolia*** (kg/ha/year)
Nitrogen (N)	1980	1780	2630
Phosphorus (P)	320	200	400
Sulphur (S)	250	180	250
Calcium (Ca)	750	320	1710
Magnesium (Mg)	790	320	310
Potassium (K)	3190	3220	4570
Sodium (Na)	260	230	730
Iron (Fe)	19	45	23
Manganese (Mn)	300	27	79
Zinc (Zn)	4	6	6
Copper (Cu)	1	1	7

RESTRICT PHOSPHATE BASED DETERGENTS IN INDIA

To mitigate Foaming or Algal Bloom in Water bodies of India

Source: Ramachandra T V, Durga Madhab Mahapatra, Asulabha K S, Sincy Varghese, 2017. Foaming or Algal Bloom in Water bodies of India: Remedial Measures - Restrict Phosphate (P) based Detergents, ENVIS Technical Report 108, Environmental Information System, CES, Indian Institute of Science, Bangalore 560012

Algal bloom or foaming is a consequence of nutrient enrichment (N and P) due to untreated sewage (mostly from human and household waste and detergents) and industrial effluents. The phosphorus from several sources reaching water bodies causes pollution leading to algal blooms, frothing, etc. Phosphorus represents both a scarce non-renewable resource and a pollutant for living systems. Primary nutrient, such as carbon, nitrogen, phosphorus, etc. contribute to eutrophication. In fresh water ecosystem, primary producers are able to obtain N from the atmosphere and hence phosphorus is the primary agent of eutrophication. Moreover, elements carbon, nitrogen and phosphorus can generate its weight by 12, 71 and 500 times, and hence phosphorous is the limiting element in primary producers. Nutrients enrichment often leads to profuse growth of invasive species (water hyacinth, etc.), which forms thick mat hindering the sunlight penetration. In absence of sunlight, photosynthetic activities cease affecting the food chain. Absence of sunlight penetration leads to the decline of primary producers (algae) in the region below the macrophyte mat. Most part of nitrogen available in the sewage and industrial effluents is assimilated by producers, while phosphorous gets trapped in the sediment. During pre-monsoon with high intensity winds, churning of lake water happens, leading to the release of phosphorous from sediments forming froth. Foaming is the manifestation of interactions among air bubble, surfactant and hydrophobic particles. The hydrophobic particles congregate at the air-water interface and strengthen the water film between air bubbles. Meanwhile, the particles also serve as collector for surfactant which stabilizes the foam. Surfactants contain slowly biodegradable surfactants and hydrophobic particles are the filamentous bacteria with a long-chain structure and hydrophobic surface. Thus, frothing is due to the presence of slowly biodegradable surfactants (eg. household detergents) from industrial or municipal wastewater, excess production of extracellular polymeric substance (by microorganisms, proliferation of filamentous organisms) and air bubble (wind).

Soaps and detergents belong to the group of chemicals - the surfactants, the group of anionic surfactants. The detergent contains the sequestering and chelating agents such as phos-phates to remove calcium and magnesium ions that are pre-sent in water and can reduce detergent action.

The surfactant nonylphenol ethoxylate (**NPE)**, an endocrine disruptor and estrogen mimic; phosphates, which help remove minerals and food bits but cause harmful algal blooms in waterway.

Phosphates are low cost option to increase the efficacy of the detergent. However, phosphates act as nutrients to the environment and are largely responsible for problems to the environment. Problems are:

- excessive growth of algae, which cause eutrophication of water bodies.
- responsible for the formation of white foam which act as a barrier to entry of oxygen and light in the water, affect aquatic flora and fauna.
- Similar is the case of phosphate fertilizer used in farming, which also gets into water bodies.

Surface Aeration for Lakes to increase the dissolved oxygen levels in the water body.

SUGGESTIONS:

a. Remove macrophytes – regularly (till the nutrient inflow into the lake is checked / or treated sewage is let into the lake)
b. remove all blockades at outlets – so that water will move leading to natural aeration
c. install surface fountains in the regions of stagnant water
d. installation of fountains (surface aeration) enhances not only the aeration but also recreation value of the lake. Music fountains would aid in de-stressing as well as recreation

S No.	**Description**	**Fountain (Surface Aeration)**	Bubble Aerator (Bottom Up Aeration)
1	Oxygen transfer rate/efficiency	Oxygen transfer upto 6 to 12".	10 times higher
2	Cost	Operating cost is high.	relatively higher initial and regular maintenance cost
3	Power Consumption	Power requirement is higher	less power when compared to surface aeration.
4	Safety	Requires insulation of cables	Airline pipe can run to the air compressor which can be kept at some place isolated from water.
5	Frothing	No frothing	Frothing is inherent.
6	Clogging problem	No problem of clogging.	Clogging problem is inherent. System has a lifetime of 1-2 years. Biofilm may develop (clogging the filter). When this problem encounters, it starts consuming more energy.
8	Suitability	For shallow lakes	For deeper lakes (Suitable to install at deeper points in our case).
7	Miscellaneous	a. Evaporation rates may increase. b. prevents froth.	Frequent cleaning is required.

Waste-Water Treatment Unit Operations and Processes

The wastewater treatment bioprocesses transform minute solids and dissolved organic matter present in wastewaters into organic and inorganic solids that can be settled by application of flocculants.

Process analysis:

1. Microbes as bacteria – transforms particulate carbonaceous colloidal matter and dissolved organics present in wastewater into bulkier cellular lumps/tissues and into gases as a metabolic by product.
2. The gases escape into the environment
3. The cellular masses are removed with the help of sedimentation tanks or clarifiers.
4. The main objectives of Bio-treatments are to reduce organic matter in wastewaters mainly measured in the form of BOD, COD and TOC.
5. Bio-treatments also remove nutrients (N and P) from wastewaters.
6. These bioprocesses are used in tandem with other physico-chemical processes for attaining optimal effluent quality.
7. Bio-processes technologies used in wastewater treatment can be broadly divided into three categories – Aerobic, Anaerobic and Anoxic
8. These processes can be run either as suspended growth system or attached growth system or as a combination of both.

Working of Conventional Wastewater Treatment Systems: The conventional treatment set up for wastewaters comprise of primary, secondary and tertiary treatments (Table 3) that involves various steps

Screening is essentially to remove larger floating solids that take a very long tome for breakdown and decomposition. The screen comprises of an ordered array of flat metal plates that are welded to the horizontal bars at ~ 4 cm – 2 cm spacing. During the course of the water flow, the screens are juxtaposed perpendicular to the flow direction. The large amount of floating materials, sand debris, polymers etc stuck to the screen is removed manually or through other mechanical means. These floatable materials are then carried out as solid waste for proper disposal.

The grit removal process mainly intends to remove heavy and inert inorganic matter. Grit, dense coarse materials, sand, shells, gravel and other heavy inorganic matter tend to settle by sedimentation in the settling basin within a minute. The materials are then send to proper disposal sites.

The primary clarification happens in a settling basin that is intended for settling of heavier inorganic matter. These clarifiers have detention period of ~ 120 minutes and are mostly circular in shape. The settled materials on various parts of the clarifiers are scraped and pushed towards the centre with the help of rakers and the settled material mostly known as primary sludge are then transported to the through the primary sludge pump to the sludge digesters. Importantly in this exercise ~40 % of BOD and ~70 % of suspended solids are removed.

Secondary treatment involving suspended aerobic processes in carried out with the help of aerobic microbes. At this stage, the wastewater are mostly devoid of particulate inorganic and organic matter and comprise of decomposed or semi-decomposed organic matter i.e. carbohydrates, proteins, lipids, fibres etc., in the presence of oxygen and aerobic bacteria these compounds are broken down into simpler forms as carbon dioxide, ammonia, water etc. The microbial activity transforms these dissolved forms into flocculating biomass and the finer organic matter into settleable mass. The oxygen is provisioned through the help of surface aerators that helps in the growth of aerobic bacteria that are required for the decomposition of organic matter. The powerful surface aerators droves the wastewater through a mechanical churning process from the bottom of the aeration tank units and splatters it over the surface thus ensuring oxygenation mobilisation.

Secondary treatment involving attached growth processes involves of wastewater over a combination of media that acts as substrates for attachment and growth of microbes over the surfaces. In this biological process the surface grown biological microbial assembly absorbs the organic matter the wastewaters and starts multiplying of the surface of the substrates. When the weight of the surface biomass becomes critical is swept away by the trickling waters that captured in the subsequent settling units and are often recycled back. Various types of media can be used for development of the attached microbial communities as gravel, pebbles; granite of ~10-15 cm is often used in trickling filters.

The final round of settling the solids is performed by the secondary clarifiers where the microbial flocks comprising of cellular biomass and organic aggregates are made to settle. Usually these settling clarifiers are circular in shape and with a retention time of ~90-120 min. The same rakers are used to draw the settled sludge to the centre which is then carried for recirculation to the aerobic tanks or the trickling filters. The excess amount of the solid/sludge is transferred to the sludge thickeners that separate the excess water content in the sludge. This biological process ensures ~90% of BOD removal and ~90% of SS removal of the influent wastewater.

Table 3: Various wastewater treatment and process parameters

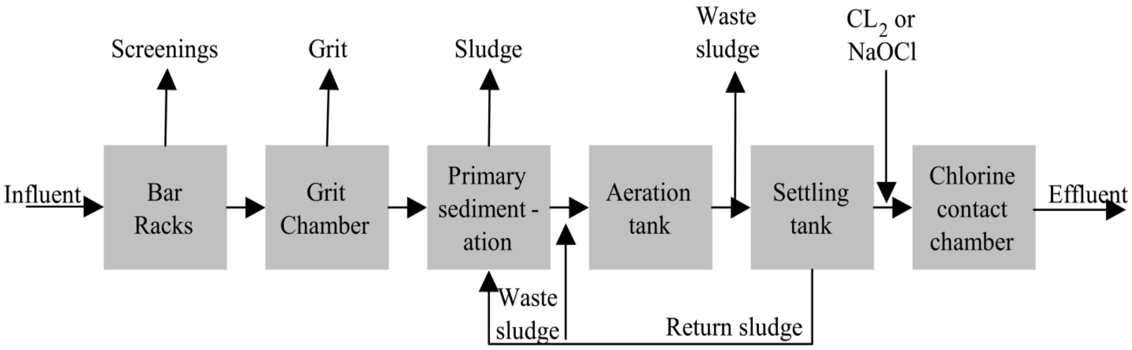
Physical	Chemical	Biological
• **Screening** • **Comminute** • **Flow equalization** • **Sedimentation** • **Flotation** • **Granular-medium filtration**	• Chemical precipitation • Adsorption • Disinfection • Dechlorination • Other chemical applications	• Activated sludge process • Aerated lagoon • Trickling filters • Rotating biological contactors • Pond stabilization • Anaerobic digestion • Biological nutrient removal

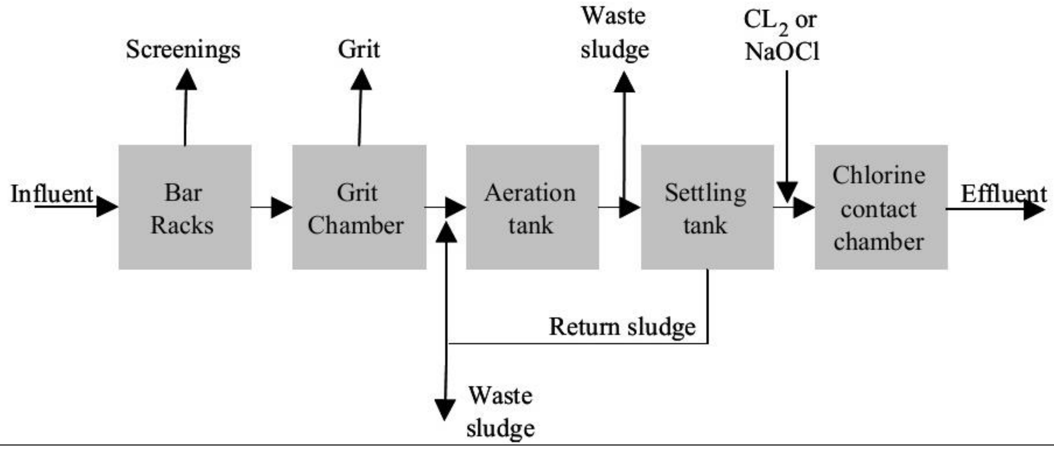
WWT Technologies working at Bangalore are

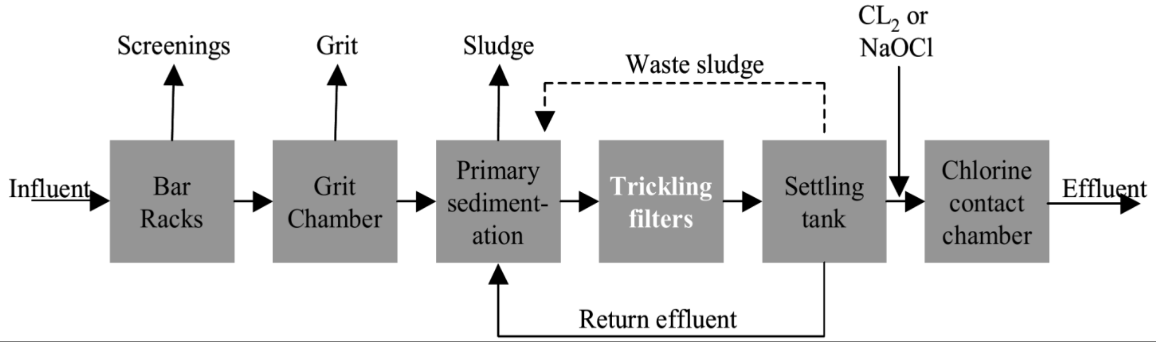
1. ASP (Activated Sludge Process)
2. EA (Extended Aeration)
3. TF (Trickling Filters)
4. UASB (Up-flow Anaerobic Sludge Blanket Reactor)
5. SBR (Sequential Batch Reactor)
6. MBR (Membrane Bio-Reactor)
7. MBBR (Moving Bed Biofilm Reactor)
8. CAB (Cascading Algal Bioreactor)

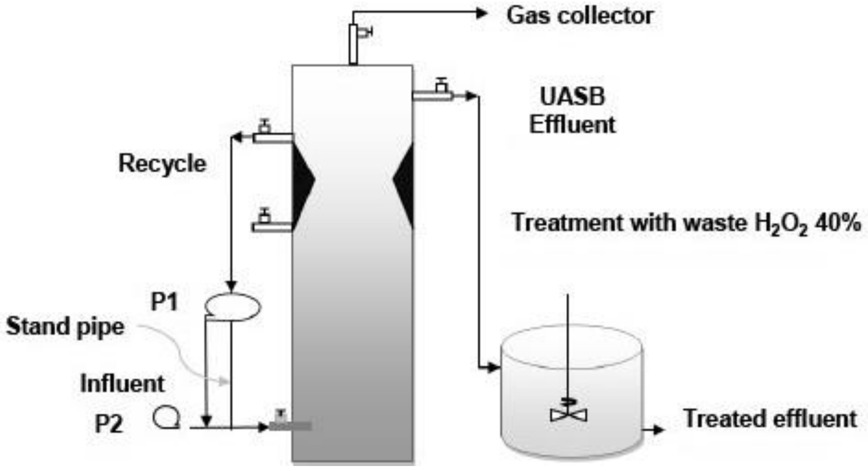
   Comparative assessment of wastewater treatment process are given in Table 4.

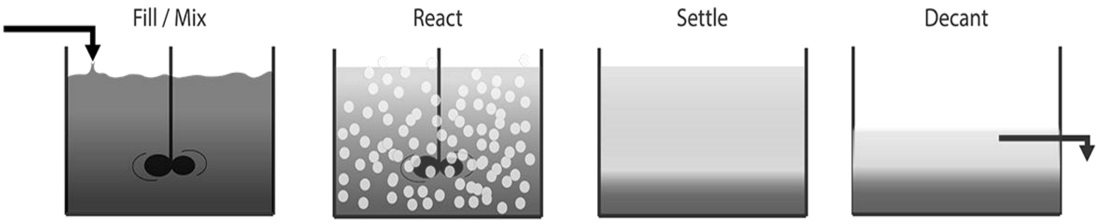
Table: 4: Comparative assessment of wastewater treatment process

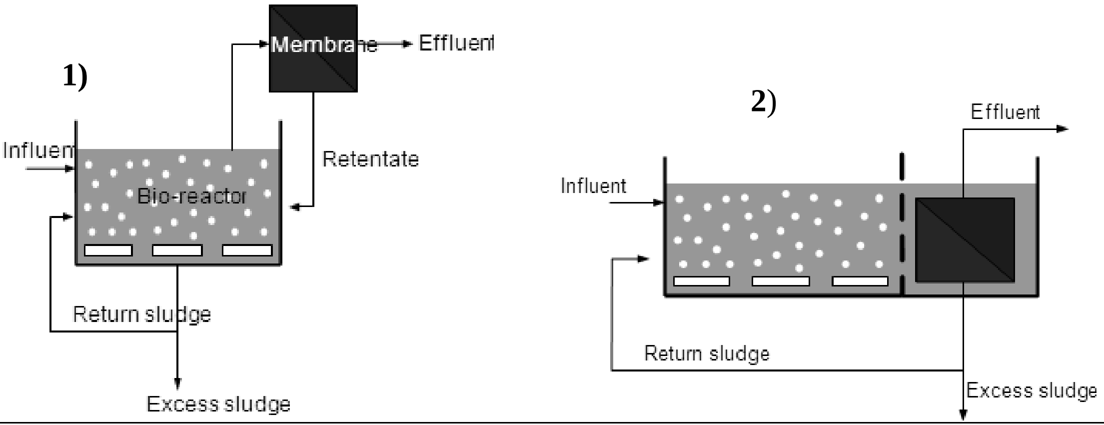
I	**Treatment Process: Activated-sludge process (ASP/EA)**
2	**Sketch** 
3	**Technical details and Operation** ASP is microbial assisted wastewater stabilisation technique that runs continuously in an aerobic environment with the help of activated i.e. force suspended bacterial mass. In this process the clarified wastewater after preliminary treatment including primary settling in let into an aeration basin in which activated biomass mostly comprising of bacteria and protozoans aerobically degrade the wastewater organics into CO_2, sludge mass (new cells) and other end products. The microbes that forms the activated biomass in ASP mainly comprise of gram negative bacteria, C and N oxidisers, floc/non-floc forming members, aerobic and facultative anaerobic bacteria. The other group of organisms are the protozoans that are flagellates, ciliates and amoeba. To maintain the aerobic environment for the growth and development of the above mentioned microbial communities aerobic conditions are maintained either with the help of mechanical or diffused aeration in the treatment basin. This also serves to maintain a completely mixed system essential to keep the contents in the reactor usually known as the mixed liquor distributed in the basin. With in a short retention time the organics are converted essentially into larger sludge masses and CO_2, and then the mixed liquor is transferred to the secondary clarifier where the sludge/biomass is allowed to settle and the clarified effluent is all set for disposal and reuse. During this operation, a substantial part of the sludge from the secondary clarifier is recycled back to the aeration unit to maintain the activated biomass concentrations. **Land Area requirement:** 0.09 Ha/MLD (0.1 Ha/MLD-Tertiary Treatment included) **Power requirement:** 186 kWh/d/MLD
4	**Feasibility** This is the most widely used option for treatment of domestic wastewater for medium to large towns where land is scarce. ASP is only appropriate for a centralized treatment facility with the construction of long distance sewage channels, a well-trained staff, constant electricity, technical equipment (monitoring appliances), appropriate funding and a highly developed management system that ensures that the facility is correctly operated and maintained. Because of economies of scale and less fluctuating influent characteristics, this technology is more effective for the treatment of large volumes of flows of municipal wastewater from medium to large towns of 10000 - 1 million population equivalent. ASP works in almost every climate for the removal of both settable (physical primary treatment) and dissolved, colloidal and particulate organic matter and nutrients (biological removal in the activated sludge). The treatment capacity is low in colder environments.
5	**Economics:** Infrastructure/Capital Cost: Rs. 68 lakhs/MLD OM Cost: Rs. 12 lakhs/MLD/Y Running cost: 0.32 paisa/litre
6	Suitability in the present context: Unsuitable

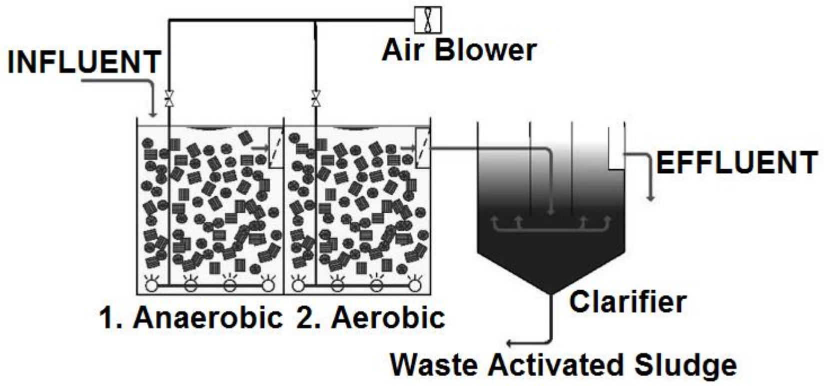
II	**Extended aeration (EA)**
1	**Treatment Process: Extended aeration (EA)**
2	**Sketch** 
3	**Technical details and Operation** This aerobic bioprocess can be considered as a small modification to the ASP where the untreated raw wastewater is directed straight away to the aeration basin without any primary clarification for treatment. Such simplifications tend to provide longer aeration time (thus called extended aeration) with retention and thus reduce the need for additional mechanisation. A high BOD removal through extended aeration makes it highly desirable that needs a tertiary treatment for a high effluent quality. It is mostly preferred over ASP where the waste loads are relatively low and provides lesser needs for mechanisation. In case of ASP both clarifiers generate voluminous sludge that requires sludge treatment and processing before disposal. However EA agitates all wastewater and the sludge in a single clarifier. This results in high concentration of inert solids than in secondary sludge. Therefore a longer HRT with adequate mixing time is required for the digestion of primary solids in addition to organic matter in the dissolved form that produces an aged sludge. This requires greater energy per unit volume of the waste oxidised. Unlike conventional ASP aged sludge is produced in extended aeration process. **Land Area requirement:** 0.08 Ha/MLD (0.1 Ha/MLD-Tertiary Treatment included) **Power requirement:** 186 kWh/d/MLD
4	**Feasibility** Extended aeration is typically used to minimize design costs for waste disposal from small communities, commercial facilities and establishments, or schools. Compared to conventional ASP, a longer mixing time with aged sludge offers a stable biological ecosystem better adapted for effectively treating waste load fluctuations. In some instances C sources as sugar is added to sustain essential micro biota for treatment when the feed has no carbonaceous matter. Sludge has to periodically removed, as sludge volume approaches the storage capacity.
5	**Economics:** Infrastructure/Capital Cost: Rs. 68 lakhs/MLD OM Cost: Rs. 11.75 lakhs/MLD/Y Running cost: 0.32 paisa/litre
6	Suitability in the present context: **Unsuitable**

III	**Trickling Filters (TF)**
1	**Treatment Process: Trickling Filters (TF)**
2	**Sketch** 
3	**Technical details and Operation** Trickling filters are aerobic attached growth systems and are the most common biological treatment process in this category that efficiently removes wastewater organics. The TF comprises a bed made up of a highly permeable medium. This acts as a substratum to which several organisms are attached forming a bio-film, through which the wastewater percolates and falls off. The filter media are rocks or dense plastic matter used as packing material. The bio-film or the slimy layer absorbs the essential organic matter present in the wastewater and are also adsorbed on to the slimy layer. The outermost portion of the slimy layer comprise of aerobes that degrade the organic matter aerobically. With more exposure of the slimy layer with the nutrients in wastewater, the thickness of the bio-film grows and thus at deeper layers relative concentration of O_2 is low, thereby promoting the growth of anaerobic microflora just near the filter medium. As the bio-film thickness increases in this attached growth process, the organic matter is completely degraded before it reaches the microbes near the surface of the filter media. This results in deprivation of nutrients which consequently leads to death of the surface micro-biota and are thus removed on their own by the velocity of the flowing liquor that is known as “sloughing”. The liquid after filtration is collected with the help of an underdrain system, in addition to bio solids, that gets detached from the surface of the medium. The collected treated water is then clarified with the help of a settling tank, where the solids are separated from the treated wastewater. **Land Area requirement:** 0.25-0.5 Ha/MLD **Power requirement:** 180 kWh/d/MLD
4	**Feasibility** This technology can only be used following primary clarification since high solids loading will cause the filter to clog. Since trickling filter only receive liquid waste, they are not suitable where water is scarce or unreliable. Moreover, trickling filters require some specific material (i.e. pumps and replacement parts) and skilled design and maintenance. A low-energy (gravity) trickling system can be designed, but in general, a continuous supply of power and wastewater is required. However, energy requirement for operating a trickling filter is less than for an activated sludge process or aerated lagoons (extended aeration). Compared to other technologies (e.g., WSP), trickling filters are compact, but are still best suited for peri-urban or large, rural settlements. Trickling filters can treat domestic blackwater or brownwater, greywater or any other biodegradable effluent. They are typically applied as post-treatment for upflow anaerobic sludge blanket reactors or for further treatment after activated sludge treatment. Trickling filters can be built in almost all environments, but special adaptations for cold climates are required. Proper insulation, reduced effluent recirculation, and improved distribution techniques can lessen the impact of cold temperatures.
5	**Economics:** Infrastructure/Capital Cost: Rs. 4-5 million/MLD OM Cost: Rs.5 lakhs/MLD/Y Running cost: 0.141 paisa/litre
6	Suitability in the present context: **Unsuitable**

IV	Up-flow Anaerobic Sludge Blanket Reactor (UASB)
1	**Treatment Process: Up-flow Anaerobic Sludge Blanket Reactor (UASB)**
2	**Sketch** 
3	**Technical details and Operation** Up-flow anaerobic sludge blanket (UASB) technology is an anaerobic wastewater treatment technique. The treatment process involves formation of a blanket of granular sludge that remains in suspension in the reactor. The wastewater is pumped upwards, through the blanket of sludge and in the mean time the organic matter present in the wastewater in degraded by the anaerobic microflora present in the sludge. The upward flow due to pumping in conjugation with the settling action of the sludge granules due to gravity helps in the suspension of the sludge blanket with the help of wastewater derived flocculants. The sludge forming process is slow, which initiates with the formation of small minute aggregates over which bacteria grows and eventually these aggregates form into dense and compact bio-films called granules. Anaerobic environment in conducing for the production of biogas in UASB that has high % of CH_4. This gaseous by product can be captured and generate energy that reduces the running power cost. The UASB reactors are suitable for diluted wastewaters (<5 % TSS with particle size ~1 mm). **Land Area requirement:** 0.1 Ha/MLD (0.11 Ha/MLD-Tertiary Treatment included) **Power requirement:** 126 kWh/d/MLD
4	**Feasibility** A UASB is not appropriate for small or rural communities without a constant water supply or electricity and skilled labour. It is particularly adapted for densely populated urban areas as it has low land requirements. The technology is relatively simple to design and build, but developing the granulated sludge may take several months. The UASB reactor has the potential to produce higher quality effluent than Septic Tanks, and can do so in a smaller reactor volume. Although it is a well-established process for large-scale industrial wastewater treatment and high organic loading rates up to 10 kg BOD/m^3/d, its application to domestic sewage is still relatively new. It is often used for brewery, distillery, food processing and pulp and paper waste since the process typically removes 80-90% of COD. Where the influent is low-strength or where it contains too many solids, proteins or fats, the reactor may not work properly. Temperature is also a key factor affecting the performance. UASB reach high treatment levels regarding organics and the produced biogas can be used for energy conversion. Pathogens, however, as well as nutrients are not removed. Due to the low nutrient removal, the effluent is adapted for reuse in agriculture after further treatment or considering some special health protection measures. UASB are not adapted for colder climates.
5	**Economics:** Infrastructure/Capital Cost: Rs. 6.8 million /MLD OM Cost: Rs.11.53 lakhs/MLD/Y Running cost: 0.28 paisa/litre
6	Suitability in the present context: **Suitable but requires further treatment**

V	Sequential Batch Reactor (SBR)
1	**Treatment Process: Sequential Batch Reactor (SBR)**
2	**Sketch** 
3	**Technical details and Operation** A sequencing batch reactor (SBR) is a treatment process that consists of a sequence of steps that are carried out in the same containment structure, usually a tank reactor. They are also referred to as "fill-and-draw" systems. Although SBR systems exist that do not use aeration (anaerobic SBRs), a typical SBR system is designed to include aeration in the treatment step. A typical sequence for a SBR system is: 1. FILL, when the tank is filled with fresh wastewater, 2. REACT, when aeration and mixing are used to promote microbial removal of waste constituents, 3. SETTLE, when aeration and mixing devices are turned off to allow settling of suspended solids, and 4. DRAW, when clear effluent is drawn from the top of the reactor. Waste solids can be removed from the reactor after the DRAW stage from the bottom of the tank, or during the REACT stage while the wastewater is completely mixed. The SBR treatment process requires a liquid waste input, so it is more suitable for flush systems than for scrape or pit-storage systems. **Land Area requirement:** 0.045 Ha/MLD (0.05 Ha/MLD-Tertiary Treatment included) **Power requirement:** 154 kWh/d/MLD
4	**Feasibility** SBRs are typically used at flow rates of 5 MGD or less. The more sophisticated operation required at larger SBR plants tends to discourage the use of these plants for large flow rates. As these systems have a relatively small footprint, they are useful for areas where the available land is limited. In addition, cycles within the system can be easily modified for nutrient removal in the future, if it becomes necessary. This makes SBRs extremely flexible to adapt to regulatory changes for effluent parameters such as nutrient removal. SBRs are also very cost effective if treatment beyond biological treatment is required, such as filtration.
5	**Economics:** Infrastructure/Capital Cost: Rs. 7.5 million /MLD OM Cost: Rs.8.51 lakhs/MLD/Y Running cost: 0.29 paisa/litre
6	Suitability in the present context: **Suitable but requires further treatment for nutrient removal**

VI	Membrane Bio Reactor (MBR)
1	**Treatment Process: Membrane Bio Reactor (MBR)**
2	**Sketch** 
3	**Technical details and Operation** A membrane bioreactor functions with a coupled activity of membrane filtration with a biological active sludge system. Such systems help in replacement of the sedimentation basin as observed in classical biological purification and aids in separation of sludge from the effluent. This helps to ensure that all floating matter is retained, whereby sedimentation is no longer a restrictive factor for sludge concentration. A membrane reactor is thus able to process significantly higher sludge concentrations (10-20 g/l) with a lower reactor volume, compared to conventional systems. The membrane can either be placed next to the biological basin (1. External or separate system), or in the basin (2. Internal or submerged). External systems involve continuous cross-flow circulation along the membranes. Both tubular and flat plate membranes are used to realise this. An internal system involves the effluent being extracted from the active sludge using under-pressure. This normally involves the use of hollow fibres or flat plate membranes. Micro and ultra filtration membranes are used for both types of MBR. **Land Area requirement:** 0.45 Ha/MLD (No Tertiary Treatment required) **Power requirement:** 302 kWh/d/MLD
4	**Feasibility** Membrane reactors are have been used throughout the world, for industrial as well as municipal wastewaters now. Membrane bioreactors can be used for biologically degradable wastewater flows as municipality wastewaters. The quality of the MBR permeate is greatly determined by the quality of the influent. Disruptive substances (e.g. long fibres or sharp particles) that can block or damage the membrane must be removed before wastewater is added to the MBR. Undissolved matter can normally be sufficiently removed using a simple sieve (gauze width 0.5 - 2 mm). Dissolved substances, primarily high calcium contents and aluminium salts, can also cause damage to the membranes. Specific toxic partial flows from, the chemical industry are not suitable unless sufficiently diluted with other process effluents. Excess sludge is produced as a by-product and necessitates from the system on a regular basis. The cleaning fluids also need to be disposed of. AOX could form if cleaning is carried out using NaOCl. Pure oxygen (O_2) can be used to introduce sufficient oxygen into the MBR. This will result in fewer problems with foam and odour-forming.The MBR combines a biological wastewater purification system with a physical process, which increases the complexity. Both steps require specific attention to process execution and optimisation of control parameters. Full-scale MBR systems are normally thoroughly automated. Close follow-up is needed to allow the process to run correctly.
5	**Economics:** Infrastructure/Capital Cost: Rs. 30 million/MLD OM Cost: Rs. 1.2 lakhs/MLD/Y Running cost: >2 paise/litre
6	Suitability in the present context: **Suitable but can only used at decentralised levels**

VII	Moving Bed Biofilm Reactor (MBR)
1	**Treatment Process: Moving Bed Biofilm Reactor (MBR)**
2	**Sketch** 
3	**Technical details and Operation** A Moving Bed Biofilm Recator (MBBR) reactor consists of a tank with submerged but floating plastic (usually HDPE, polyethylene or polypropylene) media having specific gravity less than 1. The large surface area of the plastics provide abundant surface for bacterial growth. Biomass grows on the surface as a thin film whose thickness usually varies between 50-300 μm. Medium or coarse bubble diffusers uniformly placed at the bottom of the reactor maintains a dissolved oxygen (DO) concentration of > 2.5-3 mg/L for BOD removal. Higher DO concentrations are maintained for nitrification. To retain the media flowing out of the tank, screens are placed on the downstream walls. A clarifier or a DAF is placed downstream of the MBBR tank to separate the biomass and the solids from the wastewater. No sludge recycle is required for this process. Wastewater enters the Moving Bed Biofilm Reactor MBBR where the biomass attached to the surface of the media degrades organic matter resulting in BOD removal and/or nitrification depending on the type and characteristic of the wastewater. Organic carbon is converted to carbon dioxide and leaves the system while the ammonia and nitrogen in the organics are converted to nitrates through nitrification process. Oxygen required for the process is provided through the diffusers installed at the bottom of the reactor. The treated wastewater then flows through the screens to the downstream clarifier/DAF where the biomass and solids are separated from the wastewater. **Land Area requirement:** 0.045 Ha/MLD (0.55 Ha/MLD-Tertiary Treatment included) **Power requirement:** 224 kWh/d/MLD
4	**Feasibility** It is stable under load variations, insensitive to temporary limitation and provides consistent treatment results Normally it generates low solids and requires no or minimum polymer for solid/liquid separation MBBR requires a small footprint that is typically 1/3 rd the space required for ASP. Involves a low capital cost and is comparable to cost of ASP and is much is cheaper than the MBR process. This has provisons for up-gradation i.e. existing plants can be upgraded easily with MBBR. MBR is easy to operate, has automatic sludge wasting, has no sludge Return and no MLSS, and there no issue of media clogging.
5	**Economics:** Infrastructure/Capital Cost: Rs. 7.5 M/MLD OM Cost: Rs.0.06-0.12 M/MLD/Y Running cost: Rs.0.35/m^3
6	Suitability in the present context: **Suitable but can only used at decentralised levels**

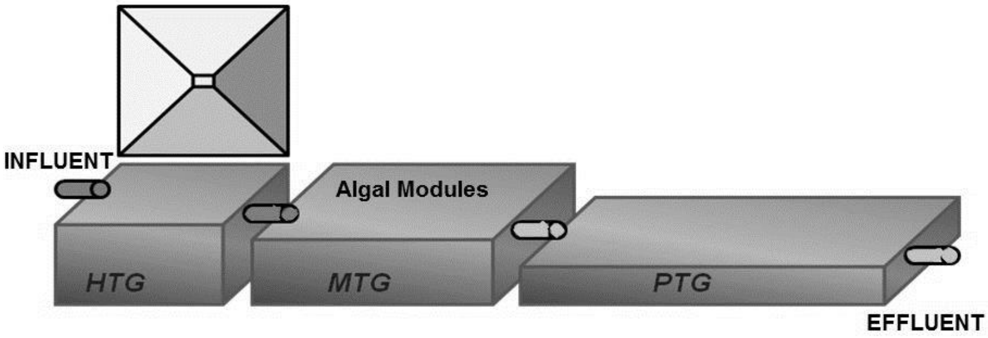
VIII	Cascading Algal Bioreactor (CAB)
1	**Treatment Process: Cascading Algal Bioreactor (CAB)**
2	**Sketch** 
3	**Technical details and Operation** A cascading Algal bioreactor consists of a series of reactors mainly comprisisng of an initial anaerobic reactor, followed by micro aerophilic reactor and an aerobic reactor. This reactor is entirely gravity driven and works on spilling over after retention of 3-4 days. This basically works with an array of microbes working differently in various reactors as a function of nutrient concentration and redox. The open surface areas in the reactors 2 and 3 allows for aeration and sunlight penetration that helps in growth of select algal species. This bioprocess uses a combination of both attached and suspended algal consortia for wastewater treatment and solids removal. The water at the effluents requires a minimum detention for clarification. High DO levels upto 200 % saturation, is achievable with high nutrient removal ability. 99.99 % bacteria removal also takes place due to a higher retention and high light penetration together with photosynthesis aided pH increase mechanism. The initial reactor with a high C load becomes anaerobic and largely works with algal bacterial symbiosis. A baffled clarifier is used to separate the biomass from the effluent. This algal biomass that is often found to be valorisable can be further used as a feedstock for biofuel. No sludge recycle is required for this process and bulk of the biomass used is algae. However a small algal population can be recycled for efficient algal retention in the system. **Land Area requirement:** 0.3 Ha/MLD (0.31 Ha/MLD-Tertiary Treatment included) **Power requirement:** 6 kWh/d/MLD
4	**Feasibility** These bioreactors require a slightly higher area and open spaces for their operation. CAB can also be used to treat other categories of waste water as dairy, tannery, agricultural, poultry, aquaculture waste water etc. at a higher efficiency with a minimal cost. Such type of systems can be more adaptable due to its provisions for revenue generation by selling algal biomass as bio-diesel feed-stocks, single cell proteins, commercially important metabolites and pigments. These systems have chances of washouts and thus proper flow regulations are required. There are chances of bio-fouling and growth of undesired anoxic bacteria in the aerobic zones due to overloading. Seasonal grazer attacks are also possible due to favourable physico-chemical environment.
5	**Economics:** Infrastructure/Capital Cost: Rs. 2 lakhs/MLD OM Cost: Rs.4.46 lakhs/MLD/Y Running cost: 0.11 paisa/litre
6	Suitability in the present context: **Suitable at decentralised levels**

Figure 3 provides comparative account of performance of various wastewater treatment options. Table 5 lists the treatment efficiency and area requirement for WWTP, while Table 6 lists the relative advantages of various treatment technologies and Table 7 gives the comparative assessment of capital and OM Cost. Proposed wastewater treatment set-up for sewage influx is given in Figures 4 and 5 respectively.

Table 5: Treatment efficiency and area requirement for WWTP

Parameter	Treatment Technologies					
	ASP/EA	UASB+EA	SBR	MBR	MBBR	CAB
Treatment efficiency						
BOD, mg/l	<20	<20	<10	<5	<30	<30
COD, mg/l	<250	<250	<100	<100	<250	<100
TSS, mg/l	<100	<100	<10	<5	<100	<100
Bacterial removal (log orders)	~2-3	~2-3	~3-4	~5-6	~2-3	~4-5
TN rem. Efficiency (%)	10-20	10-20	70-80	70-80	10-20	70-
TP rem. Efficiency (%)	-	-	80-90	-	-	60-
Area Requirements						
Area Requirement (Ha/MLD)	0.09	0.1	0.045	0.045	0.045	0.3
Sec + Tertiary Treatment	0.1	0.11	0.05	0.045	0.055	0.31

Table 6: Relative advantages of various treatment technologies

Criteria	ASP/EA	UASB+EA	SBR	MBR	MBBR	AP	Comments
Quality of Treated effluent	++	++	+++	++++	++	++	++++ → very high
Nutrient Removal potential	+	+	+++	++	+	+++	+++ → high
Low Land Requirement	++	+ ++	+++	+++	+++	+	++→ medium
Low Capital Cost potential	+++	+++	++	+	++	+++	+→ low
Low Power Requirement	++	++++	+++	+	++	++++	++++ → very high
Electricity generation potential	+	++	+	+	+	+ +	+++ → high
Low O & M Skills potential	+++	+++	++	+	+++	++++	

Table 7: Capital and OM Cost

Cost estimation	Treatment Technologies					
	ASP/EA	UASB+EA	SBR	MBR	MBBR	CAB
Capital Cost						
Capital Cost in Rs.	68	68	75	300	68	2
OM Cost						
Power (kWh/d/MLD)	186	126	154	302	224	6
Power cost [@ Rs. 6 per kWh]	46	31	38	76	56	6
Annual Power Cost	4.07	2.75	3.37	6.65	4.9	0.5
Annual Repair Costs	2.38	2.48	1.84	--	1.94	1.76
Annual Chemical Costs	5.3	6.3	3.3	--	5.3	7.2
Total Annual OM Costs	11.75	11.53	8.51	--	12.14	4.46
*Annual Man Power Cost	14.04	14.04	8.64	--	10.32	10.68
Treatment Cost, paisa/litre	0.32	0.28	0.29	--	0.33	0.11

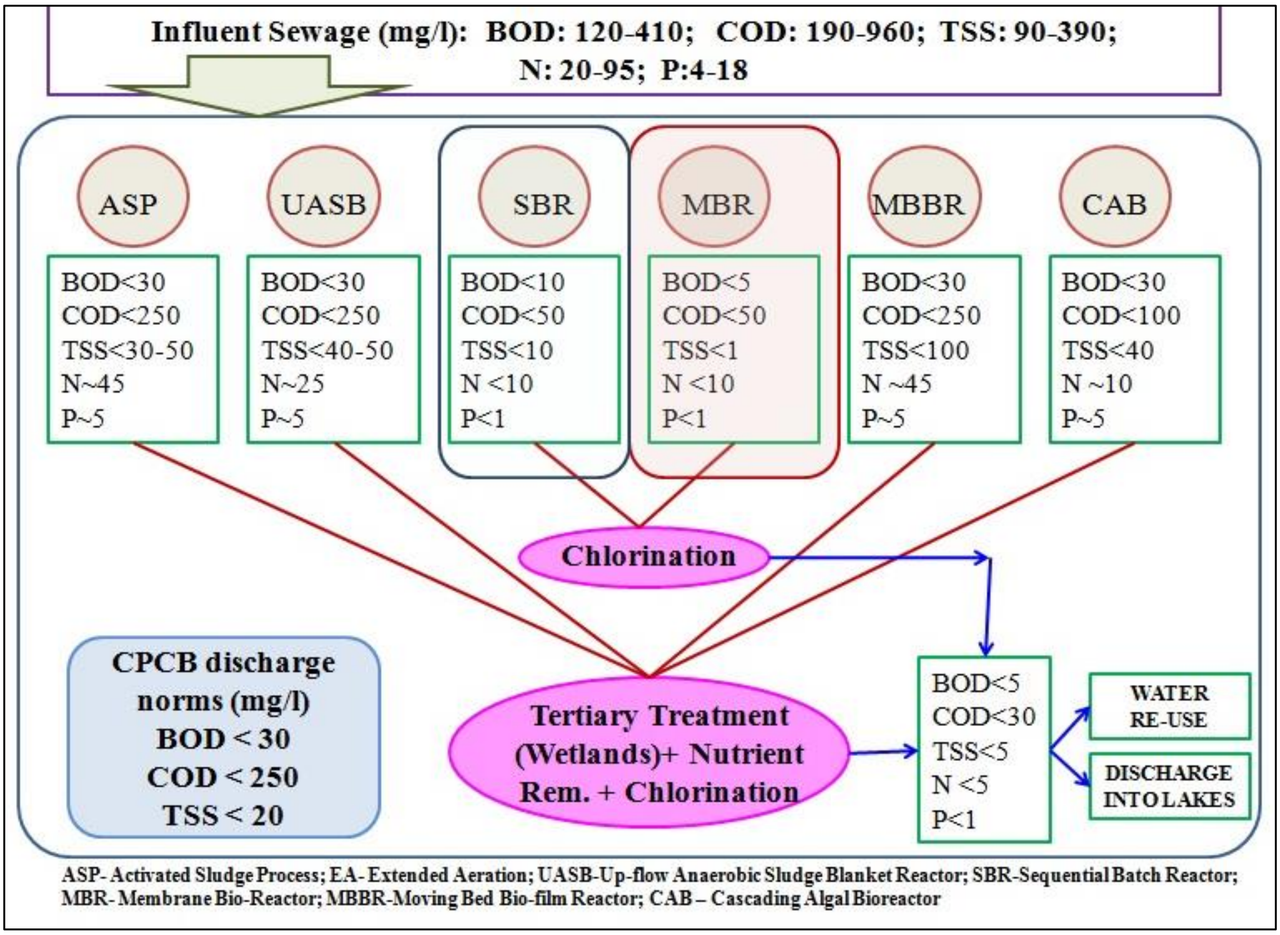


Figure 3: A comparative account of treatment performance of the WWT technologies

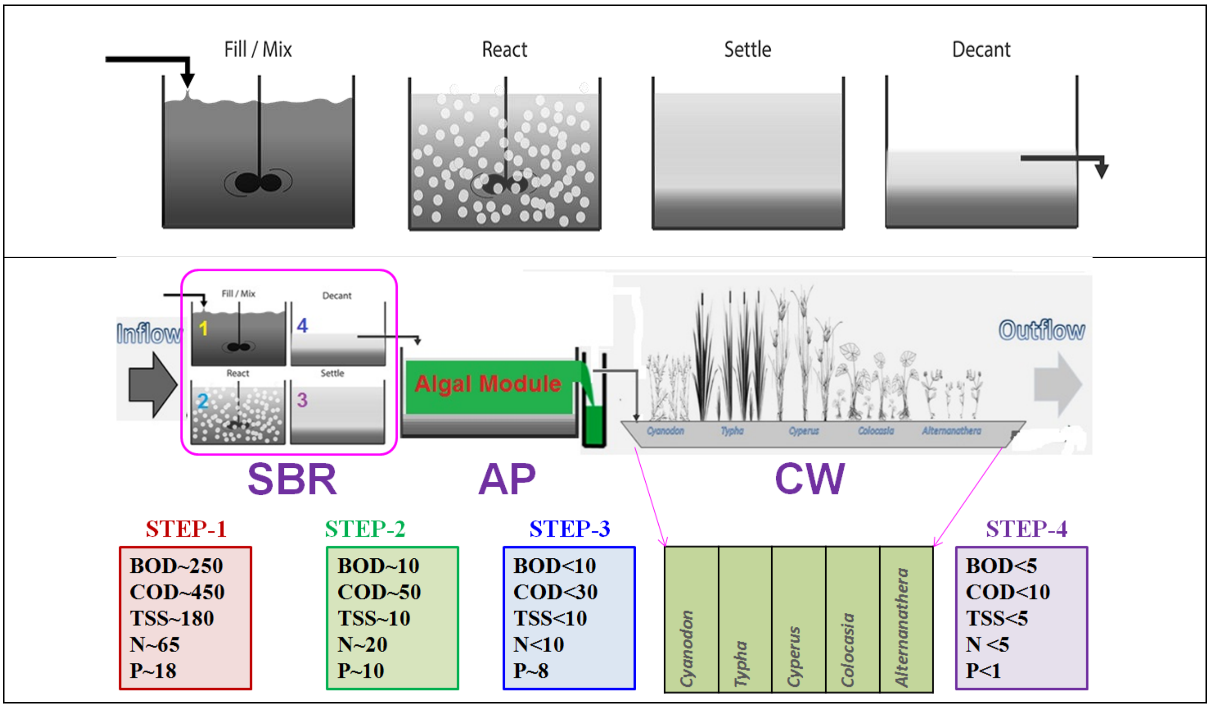


Figure 4: Proposed wastewater treatment set-up for lakes in V. Valley

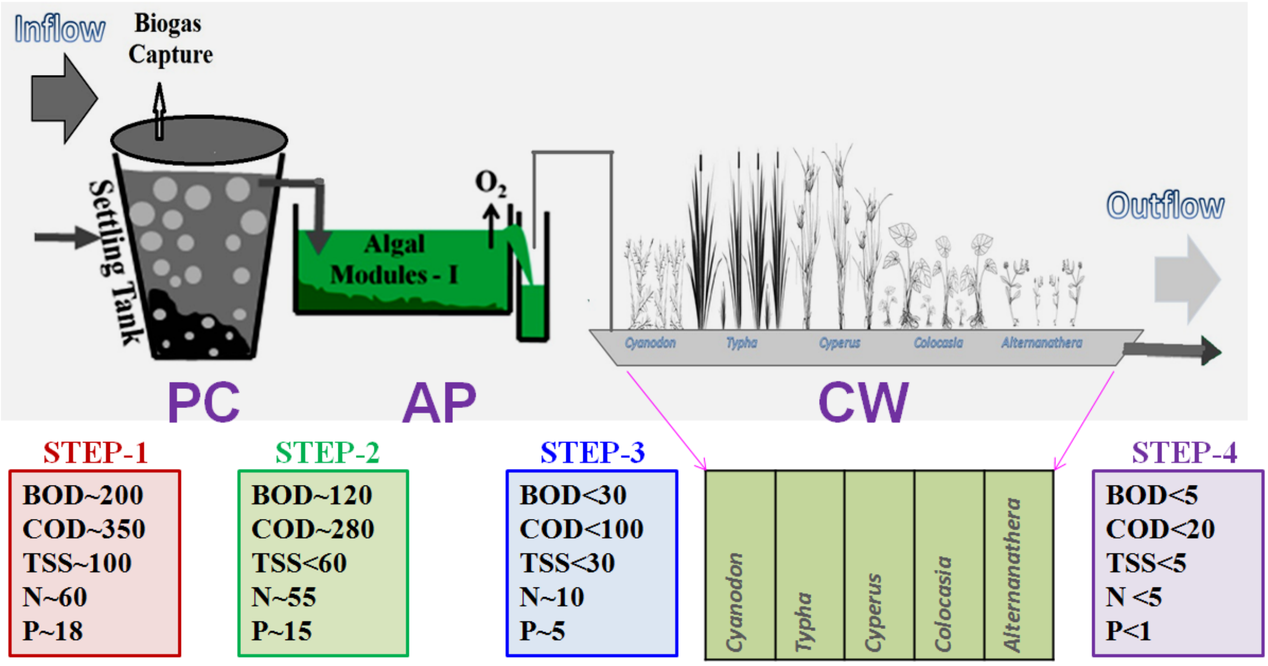


Figure 5: Proposed wastewater treatment set-up for downstream lakes receiving partially treated sewage

INTRODUCTION

UNPLANNED URBANISATION IN BANGALORE: NON-RESILIENT AND UNLIVABLE WITH UNABATED SENSELESS CONCRETISATION

Rapid urbanisation coupled with industrialisation in urban areas has greatly stressed the available water resources qualitatively and quantitatively in India. This has also resulted in the generation of enormous sewage and wastewater after independence. Unplanned urbanisation and ad-hoc approaches in planning are evident everywhere, from settlements to sanitary systems and networks. Urban areas in India lack adequate infrastructure for sanitation, leading to inappropriate management of the wastewater and sewage generated in the locality. Most of the sewage and wastewater generated is discharged directly into storm water drains that ultimately link to water bodies. Bangalore is located on a ridge with natural water courses along the three directions of the Vrishabhavaty, Koramangala–Challaghatta (KC) and Hebbal–Nagavara valley systems along the foothills of the terrian, and these water courses are today being misused for the transport and disposal of the city's untreated sewage. The shortfall or lack of sewage treatment facilities has contaminated the majority of surface and ground waters. These aquatic resources are now unfit for current as well as future use and consequently pose critical health problems.

Bangalore is the principal administrative, cultural, commercial, industrial and knowledge capital of the state of Karnataka. Greater Bangalore, an area of 741 km^2 including the city, neighbouring municipal councils and outgrowths. Bangalore is one of the fastest growing cities in India, and is also known as the 'Silicon Valley of India' for heralding and spearheading the growth of Information Technology (IT) based industries in the country. With the advent and growth of the IT industry, as well as numerous industries in other sectors and the onset of economic liberalisation since the early 1990s, Bangalore has taken the lead in service- based industries, which have fuelled the growth of the city both economically and spatially. Bangalore has become a cosmopolitan city attracting people and business alike, within and across nations (Sudhira et al., 2007; Ramachandra and Kumar, 2008).

The undulating terrain in the region facilitated the creation of a large number of tanks in the past, providing for the traditional uses of irrigation, drinking, fishing and washing. This led to Bangalore having hundreds of such water bodies through the centuries. There were 1452 water bodies in 1800 in the current spatial extent of Bangalore (741 sq.km). A large number of water bodies (locally called lakes or tanks) in the city had ameliorated the local climate, and maintained a good water balance in the neighbourhood. A current temporal analysis of wetlands, however, indicates a decline of 79% in Greater Bangalore during 1970- 2017, which can be attributed to unplanned intense urbanisation processes. The undulating topography, featured by a series of valleys radiating from a ridge, forms three major watersheds, namely the Hebbal Valley, Vrishabhavathi Valley and the Koramangala and Challaghatta Valleys. These form important drainage courses for the interconnected lake system which carries storm water beyond the city limits. Bangalore, being a part of peninsular India, had the tradition of storing this water in these man-made water bodies which were used in dry periods. Today, untreated sewage is also let into these storm water streams which progressively converge into these waterbodies and results in a) algal bloom b) proliferation of exotic aquatic weeds and macrophytes c) large scale fish kill due to asphyxia (zero dissolved oxygen levels) and d) frothing due to P enrichment.

Large-scale developmental activities in recent times due to unplanned urbanisation in the lake catchment has resulted in reduced catchment yield and higher evaporation losses. Inefficient primary feeder channels feeding the lake have also contributed to water shortage and reduced catchment flow. However, this shortage has been supplemented by an increased quantum of sewage inflow. Due to the sustained influx of fresh sewage over several decades, nutrients in the lake are now well over safe limits. Thus, any solution to this problem can go a long way in restoring thousands of such water bodies in India.

Carbon and nutrient (N and P) recycling are very important for sustainable development and there has been significant accumulation of these nutrients into urban water bodies, lakes and tanks, thus causing phenomenal alteration to the aquatic integrity of the system resulting in deterioration of these systems at the same time resulting in degradation of water quality and higher GHG emissions. This has not only rendered these systems useless but also has impacted the microclimate of the regions and the ground water resources and is certainly a potential threat to existence.

Bangalore has been witnessing a manifold increase in its population, due to IT and BT boom in the city for the last 3 decades. This has resulted in a serious change in both the land cover consequent to the land use and alteration to existing use of water resources and the local hydro-geology of the region. Due to a large population in the city there has been a unprecedented demand for resources and basic amenities but incidentally the city has been witnessing a huge deterioration of the vital landscape elements as vegetation (6.46 %) and water bodies (1.03 %), air (RSPM: 190-347 $\mu g/m^3$; 39-83 $\mu g/m^3$ NO_x; 8-20 $\mu g/m^3$ SO_2; KSPCB under NAAQM at Graphite) and water resources (90 % surface water (Ramachandra et al., 2015) and 60 % ground water (CG), noise (>100 db; permissible 60-70 db, KSPCB). Rampant urbanisation without any fundamental understanding of the assimilative capacity of the city region and the hydro-geological and climatic variability's, have lead to an unsustainable city profile. This has not only resulted in a disturbance in the water balance of the region but also has affected the micro-climate of the region immensely.

Historically the lakes, tanks and water bodies were created basically for maintaining a hydro-geologic regime in water flows for checking floods, recharging, and maintaining the ground water table. They also act as sediment traps, prevent clogging up of natural valleys and reduce erosion by regulating run off. Lakes and Tanks belong to wetland ecosystem and have a larger biological and ecological role that acts as natural filters to myriads of pollutants and maintains a balance between the biota and the aquatic environment. Due to unplanned urbanization most of the tanks/lakes/water bodies in the districts have been transformed to built-up area wrecking the drainage patterns and the hydrologic regime in the city. Therefore, measures for rejuvenation of tanks and lakes in the city will definitely build up ground water resources and safeguard our future water availability for domestic use. In requires an integrated effort by State authorities (BBMP, BDA, etc.) to conserve and rejuvenate major tanks in Bangalore city in consultation with various stakeholders.

2.0 **STUDY AREA**: Bangalore

Bangalore city and Greater Bangalore: Bangalore is located in the Deccan plateau, toward the south east of Karnataka state extending from 12^{o}49'5"N to 13^{o}8'32"N in latitude and 77^{o}27'29" E to 77^{o}47'2"E in longitude (Figure 1). Spatially Bangalore urban area has spatially increased from 69 sq.km (1901), 161 sq.km (1981), 221 sq.km (2001) to 741 sq.km (2006, Greater Bangalore). The decadal (2001 to 2011) population increase in urban India is 31.8% and in Karnataka is 31.5%. However, Bangalore witnessed dramatic decadal increase of 44%. The population has increased from 4.3 Million (Bangalore city in 2001) to 8.4 Million (in 2011, Greater Bangalore) and the population density has increased from 7880 persons per square kilometre to over 11330 persons per square kilometre. Bangalore receives an annual average rainfall of 750-850 mm. Bangalore located on the ridge with the topography undulating from 700 m to about 962 m AMSL. Taking the advantage of undulating terrain, earlier administrators of the region constructed interconnected water bodies (lakes/tanks) to meet the domestic and irrigation demand in the region. This is evident from historical records, Ganga rulers (870 AD) had constructed Agara, Bellandur and Varthur lake systems to facilitate irrigation, agriculture and other needs (District Gazetteer of Bangalore, *Chapter 4, 214-215,http://gazetteer.kar.nic.in/gazetteer/distGazetteer*). Similarly earlier sensible rulers had constructed and managed many lakes [Mayisandra (1245 AD), Ramasandra (1340), Allalasandra (1544 AD), Tippasandra (Anekal taluk- 1614 AD), Tirumalapura (1766), Mattikere (1834)] to sustain irrigation, domestic and other anthropogenic needs. Integrated lake management through regular desilting activities were also reported at Ramasandra Lake (1515 AD). The interconnected lake system in Bangalore also aided in transporting storm water from the city centre to outskirts. Bangalore City (spatial extent in 1980's is 161 sq.km) had about 274 lakes and was aptly known as city of lakes, which helped in recharging groundwater resources, moderating micro climate, supported local livelihood (fish, fodder, etc.), irrigation and domestic water demand apart from recreation facilities.

Bangalore landscape with undulating terrain forms three major watersheds (Figure 1) namely Koramangala and Challaghatta valley (K C Valley), Hebbal Valley and the Vrishabhavati Valley (V Valley). K&C valley is the largest catchment (255 sq. km.) in Bruhat Bengaluru (with spatial extent of 741 sq.km), followed by Hebbal valley (207 sq. km.) and Vrishabhavati valley (165 sq. km.). Interconnected lakes in KC and Hebbal valleys' join at Nagondanahalli village (BBMP Ward 94 – Hagadur) and finally joins Dakshina Pinakin River. Interconnected lake systems in Vrishabhavathi valley joins Arkavathi River which is a tributary of the river Cauvery.

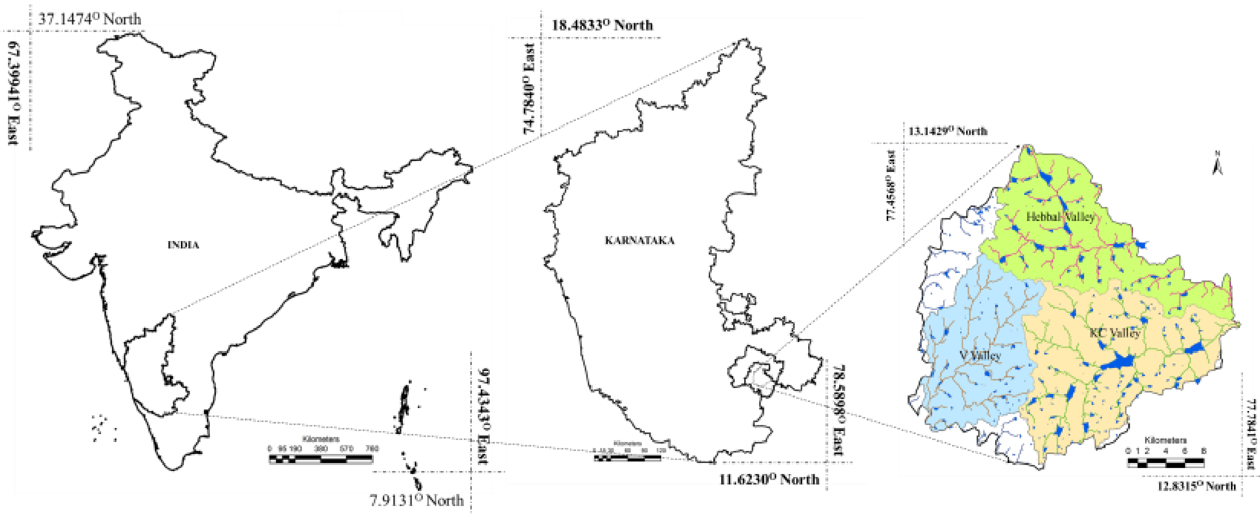


Figure 1: Location of KC-Valley (source: http://ces.iisc.ernet.in/energy)

Bangalore is experiencing unprecedented rapid urbanisation and sprawl in recent times due to unplanned unrealistic concentrated developmental activities. This **has led to large scale land cover changes with the serious environmental degradation,** posing serious challenges to the decision makers in the city planning and management process involving a plethora of serious challenges such as loss of green cover and water bodies, climate change, enhanced greenhouse gases (GHG) emissions, lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc.

Urbanisation and loss of natural resources (wetlands and green spaces): Urbanisation during 1973 to 2017 (1028% concretization or increase of paved surface) has telling influence on the natural resources such as decline in green spaces (88% decline in vegetation), wetlands (79% decline), higher air pollutants and sharp decline in groundwater table. Figure 1 depicts the unrealistic urban growth during the last two decades. Quantification of number of trees in the region using remote sensing data with field census reveals that there are only 1.5 million trees to support Bangalore's population of 9.5 million, indicating one tree for every seven persons in the city. This is insufficient even to sequester respiratory carbon (ranges from 540-900 g per person per day). Geo-visualisation of likely land uses in 2020 through multi-criteria decision making techniques (Fuzzy-AHP: Analytical Hierarchal Process) reveals calamitous picture of 93% (Table 1) of Bangalore landscape filled with paved surfaces (urban cover) and drastic reduction in open spaces and green cover. This would make the region GHG rich, water scarce, non-resilient and unlivable, depriving the city dwellers of clean air, water and environment

(Source: Ramachandra T V and Bharath H. Aithal, 2016. Bangalore's Reality: Towards unlivable status with unplanned urbanisation trajectory, Current Science (Guest Editorial)), 110 (12): 2207-2208, 25 June 2016)

UNPLANNED URBANISATION IN BANGALORE: NON-RESILIENT AND UNLIVABLE WITH UNABATED SENSELESS CONCRETISATION

1028% INCREASE IN PAVED SURFACE DURING 1973 TO 2017

Solution: Enough is Enough, **DECONGEST BANGALORE**.

- SHIFT MAJOR INSTALLATIONS TO OTHER CITIES IN KARNATAKA,
- STOP FURTHER INDUSTRIAISATION AND COMMERCIAL ESTABLISHMENTS IN BANGALORE.
- PROTECT OPEN SPACES – LAKES, PARKS, ETC.
- STOP FURTHER GROWTH OF DYING CITY – WITH WATER AND OXYGEN SCARCITY
- BWSSB SHOULD STOP ISSUING NOC (No Objection certificate) TO MAJOR BUILDING PROJECTS AS THERE IS NOT SUFFICIENT WATER (either Cauvery water or Groundwater) IN THE CITY.

Bangalore is experiencing unprecedented rapid urbanisation and sprawl in recent times due to unrealistic concentrated developmental activities. This **has led to the large scale land cover changes with serious environmental degradation,** posing serious challenges to the decision makers in the city planning and management process involving a plethora of serious challenges such as climate change, enhanced emissions of greenhouse gases (GHG), lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc.

BENGALURU LAND USE, LAND COVER DYNAMICS

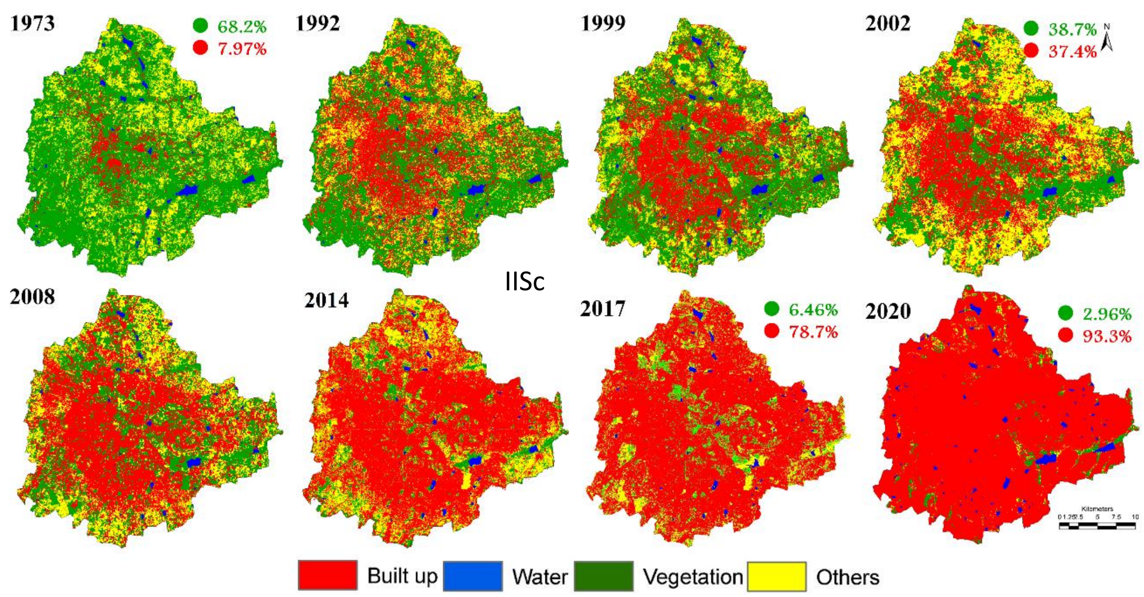


Figure 1: Land use dynamics in Bengaluru

Table 1: Land use dynamics of Bangalore - BBMP

Area	Land use \ Class	1973	1992	1999	2002	2008	2014	2017	2020
Hectare	**Built up**	5683	19452	25202	26890	35301	46626	56046	66455
	Vegetation	48650	32937	32616	27590	20090	5986	4603	2108
	Water	2424	1867	1608	1317	613	527	734	1491
	Others	14503	17004	11834	15462	15256	18121	9877	1206
Percentage	**Built up**	7.97	27.30	35.37	37.74	49.54	65.43	**78.65**	93.26
	Vegetation	**68.27**	46.22	45.77	38.72	28.19	8.40	**6.46**	2.96
	Water	3.40	2.62	2.26	1.85	0.86	0.74	1.03	2.09
	Others	20.35	23.86	16.61	21.70	21.41	25.43	13.86	1.69

LU Dynamics in V Valley

DECONGEST BANGALORE - STOP UNPLANNED & IRRESPONSIBLE URBANISATION

Land use analyses carried using temporal (1970's to 2016) remote sensing data shows an increase in built-up (paved surfaces; buildings, roads) from 5.39% (1973) to 89.56% (2016) with the decline in vegetation cover (92.3% to 8.94%), water bodies (1.05% to 0.26%) and other (open lands, agriculture) land uses (21.86% to 13.97%). There has been 1720% increase in concrete area during 1973 to 2016 with 68.6% loss of vegetation (Table 2). Predication of likely land uses reveals that 95% of the catchment would be concretised by 2020.

Table 2: Land use dynamics of V Valley

Area	Land use \ Year	1973	1992	1999	2003	2008	2012	2016	2020
Hectare	Urban	8451	50405	82904	94113	115523	153348	150316	180621
	Veg	144817	110271	77667	54308	45487	24390	14999	5690
	Water	1645	591	832	180	297	181	439	1488
	Others	34288	27934	21876	40600	27894	11282	23446	1402
Percentage	Urban	5.39	30.87	50.74	62.49	70.74	85.23	89.56	95.15
	Veg	92.31	67.54	47.53	36.06	27.85	13.56	8.94	3.00
	Water	1.05	0.36	0.51	0.12	0.18	0.10	0.26	0.78
	Others	21.86	17.11	13.39	26.96	17.08	16.27	13.97	0.74

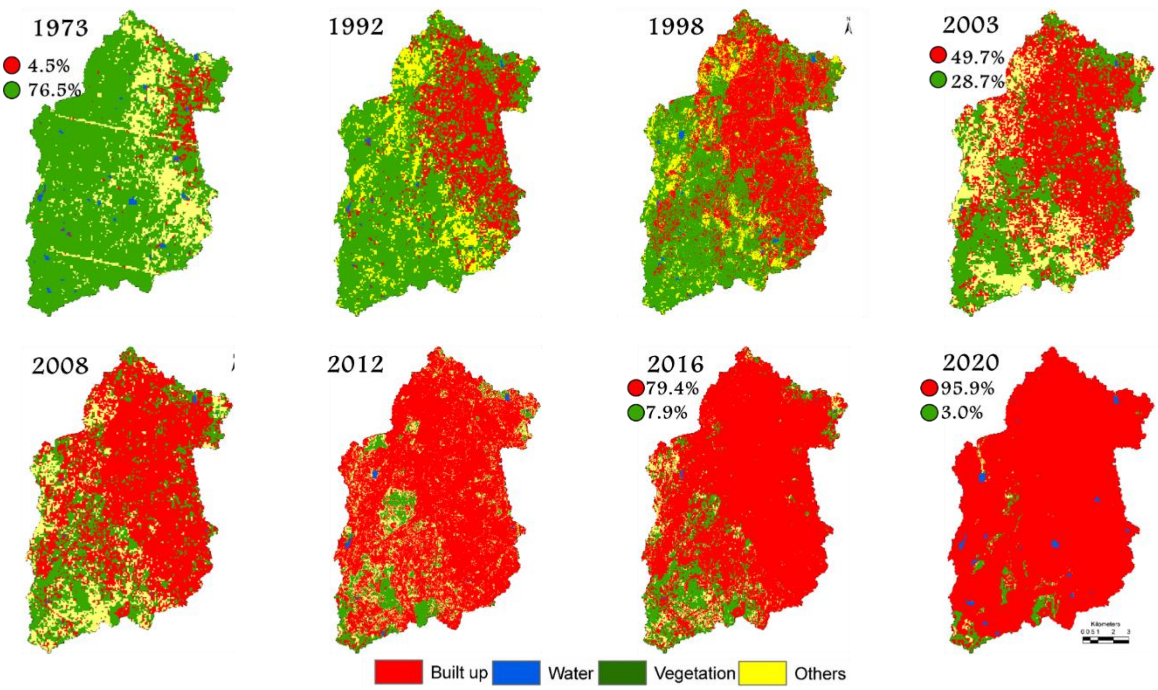


Figure 2: Land use dynamics in V Valley

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3.0 VIOLATIONS IN VALLEY ZONES AND BUFFER ZONES OF WATER BODIES

Solution: evict all encroachments to restore and maintain hydrological integrity of valley zones and flood plains

Valley zones*:* Bangalore has the distinction of having inter connected lake systems. Valley zones connecting two lakes are to be protected to ensure the continuation of hydrological functions of the drains and flood plains. These have been designated as sensitive regions as per the revised master plan 2015 (RMP 2015 of BDA). However, valley zones in Bangalore are being abused despite norms to protect these fragile ecosystems. Wetland ecosystem and valley zones have been experiencing threat due to the large scale catchment alterations with changes in the land use land cover. The region forms a part of primary valley, which is sensitive regions as per the revised master plan 2015 (RMP 2015 of BDA). The landscape forms an integral part of the protected area (as it is in valley zone) as per the CDP 2015. The alterations of these wetlands initiated by filling the low lying areas with excavated earth debris, followed by other construction activities. The land fillings have breached both rajakaluve and lakes. Major violations are:

- LAND USE CHANGES WITH THE CONSTRUCTION ACTIVITIES IN THE PRIMARY VALLEY – SENSITIVE REGIONS (as per RMP, 2015 of BDA: Primary valleys in Bangalore **are sensitive regions** as per sensitive zone notification - Circular/35/BBMP/2008, dated: 26/11/2008) and buffer zone for primary valley is 100 m.
- **KARNATAKA LAKE CONSERVATION AND DEVELOPMENT AUTHORITY ACT, 2014 - KARNATAKA ACT NO. 10 OF 2015; *KAR. ACT 12, pg 462*; *National Wetland Atlas, SAC Ahmedabad, 2009; Wetland rules, MoEF, Govt of India, 2010, 2016; RAMSAR Definition of wetlands.***
- Removal of wetlands affects Intergeneration Equity.
- Depriving local residents of water: Wetlands helps in recharge of groundwater in the region.
- Encroachment of Rajakalve and streams.
- Deprives local residents of clean, air and water (as per Article 21 of the Constitution of India).
- Dumping of building debris and excavated earth in Wetlands.
- Number of lakes in this catchment are reduced by 50% (from 70 to 35)

4.0 LAKES: CONTEMPORARY RELEVANCE

Lakes (wetlands) have been aiding in recharging groundwater resources, moderating micro climate, supported local livelihood (fish, fodder, etc.), irrigation and domestic water demand apart from recreation facilities. Washing, household activities, vegetable cultivation and fishing are the regular activities in the lake for livelihood. Multi-storied buildings have come up on some lake beds intervening the natural catchment flow leading to sharp decline and deteriorating quality of water bodies. Unauthorised construction in valley zones, lakebeds and storm water drains highlight the weak and fragmented governance. This is correlated with the increase in unauthorized constructions violating town planning norms (city development plan) which has affected severely open spaces and in particular water bodies. Problems encountered by Bangaloreans due to mismanagement of water bodies in Bangalore are:

- **Decline in groundwater table:** Water table has declined to 300 m from 28 m and 400 to 500 m in intensely urbanised area such as Whitefield, etc. over a period of 20 years with the decline in wetlands and green spaces.
- **Recurring episodes of fish mortality**: Large-scale fish mortality in recent months further highlights the level of contamination and irresponsible management of water bodies. Sustained inflow of untreated sewage has increased the organic content beyond the threshold of remediation capability of respective water bodies. Increasing temperature (of 34 to 35 °C) with the onset of summer, enhanced the biological activities (evident from higher BOD and Ammonia) that lowered dissolved oxygen levels leading to fish death due to asphyxiation.
- **Floods:** Conversion of wetlands to residential and commercial layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetative cover, reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000. Causal factors and remedial measures to mitigate impacts of flooding are:
    - Loss of interconnectivity among lakes due to encroachment of drains or dumping of solid wastes, Construction and Demolition (C & D) wastes
    - Encroachment of flood plains and wetlands (construction in valley zones, flood plains and lake bed) and de-notifying lakes (under the guise of 'dead lakes' – no lake can be dead as it does the job of ground water recharge at least for few months)
    - Narrowing and concretising storm water drains impairing hydrological functions of the natural drains
    - Loss of pervious areas - reduction of open spaces, wetlands and vegetation cover
    - Increased paved surfaces in the city (78% paved surface and likely to be 94% by 2020) due to unplanned irresponsible urbanisation by senseless decision makers.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water pervious surfaces, which reduce surface temperature through evapotranspiration. An increase of ~2 to 2.5 ºC during the last decade highlights implication of explosive urban growth on local climate, necessitating appropriate strategies for the sustainable management of natural resources.

- **Ecosystem goods and services:** Valuation of tangible benefits (fish, fodder, drinking water, etc.) reveal that wetlands provides goods worth Rs. 10500 per hectare per day (compared to Rs 20 in polluted lake), and sustains the local livelihood. This also emphasises the need for rejuvenation and sustainable management of water bodies.

Recommendations:

Due to the sustained influx of fresh sewage over the last several decades, nutrients in all lakes in the V. valley catchment are now well over safe limits. This valley has been receiving about ~45% of the city sewage for over last 70 years resulting in eutrophication. There are substantial algal blooms, Dissolved Oxygen (DO) depletion and malodor generation, and an extensive growth of water hyacinth that covers about 70–80% of the lake in the dry season. Sewage brings in large quantities of C, N and P which are responsible for eutrophication, profuse growth of macrophytes and algal bloom. The restoration and conservation strategies has to be implemented for maintaining the ecological health of aquatic ecosystems, aquatic biodiversity in the region, inter-connectivity among lakes, preserve its physical integrity (shorelines, banks and bottom configurations) and water quality to support healthy riparian, aquatic and wetland ecosystems. The regular monitoring of water bodies and public awareness will help in developing appropriate conservation and management strategies.

The success of rejuvenation depends on:

- **Good governance** (too many para-state agencies and lack of co-ordination). Single agency with the statutory and financial autonomy to be the custodian of natural resources (ownership, regular maintenance and action against polluters (encroachers as well as those contaminate through untreated sewage and effluents, dumping of solid wastes). Effective judicial system for speedy disposal of conflicts related to encroachment.
- **Digitation of land records** (especially common lands – lakes, open spaces, parks, etc.) and availability of this geo-referenced data with query based information system to public;
- **Removal of encroachment of lakes / wetlands, lake beds and storm water drains** (connecting feeders) after the survey based on reliable cadastral maps; Ensure proper fencing of lakes and to make land grabbing cognizable non-bail offence;
- **Restriction of the entry of untreated sewage and industrial effluents into lakes;** Decentralised treatment of sewage (preferably at ward levels). Letting only treated sewage into the lake (as in **Jakkur lake model**); Ensure that sewage generated in a locality /ward is treated locally;
- **Removal of nutrient rich sediments** – to enhance the storage capacity, improve groundwater recharge, to minimise further contamination of treated water, etc.;
- **Ban on use of phosphates in the manufacture of detergents**; will minimise frothing
- Regular removal of macrophytes (*Eichhornia* sp., *Alternanthera* sp. etc.) in the lakes;
- Implementation of 'polluter pays' principle as per water act 1974;
- Plant native species of macrophytes in open spaces of lake catchment area;
- Stop solid wastes dumping into lakes / in the lake bed; Banning of filling of a portion of lake with building debris.
- Restrictions on the diversion of lake for any other purposes;
- Complete ban on construction activities in the valley zones.
- Decentralised management of lakes through local lake committees involving all stakeholders

Solutions: Ecological Management of Storm Water Drains and Wetlands to Mitigate Frequent Flooding in Bangalore

1. Reestablish interconnectivity among lakes by removing all blockades (encroachments, solid waste dumping)
2. Protect Valley zones and Buffer regions of wetlands: protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
3. Stop narrowing and concretising natural drains
    - Vegetation in the drain takes the load during peak monsoon, there is no need to concretise the channel.
    - Vegetation allows groundwater recharge while treating the water (bioremediation);
    - Drains with vegetation without any bottlenecks (hindrances) would be the best option to mitigate floods.
    - Narrowing channel and concretizing would only increase the quantum of water and velocity, which would be disastrous.
    - Objective should be towards mitigation of floods and not to generate high overland flows (with increased quantum and flow velocity)
    - Experts should think sensibly with holistic knowledge (considering all subject knowledge) than fragmented narrow sectorial knowledge. Advice by pseudo experts would be detrimental as the society would be deprived of ground water, frequent floods and unnecessary livelihood threats.
4. Decongest Bangalore
    - Shift major installations to other cities in Karnataka,
    - Stop further industriaisation and commercial establishments in bangalore.
    - Protect open spaces – lakes, parks, etc.
    - Stop further growth of dying city – with water and oxygen scarcity
    - BWSSB should stop issuing senselessly NOC (no objection certificate) to major building projects as there is not sufficient water in the city.
    - Environment clearance as per the norms of Environment Protection Act (2016), Wetlands (Conservation and Management) Rules, 2016, SWM 2016, C & D Wastes, 2016, Air act 1981, Water (prevention of Pollution) Act, 1974.

5.0 Vrishabhavathi Valley

Bruhat Bengaluru (BBMP) Capital of Karnataka State, know with various names such as Silicon Valley, Garden City, City of Lakes, City of Boiled Beans (Bendakaaluru), City of Heros (Gandu Bhoomi), City of Burning Lakes (https://www.theguardian.com/), City of frothing lakes, *etc*. has an administrative area of 741 sq.km. The topography of Bengaluru is undulating giving rise to 3 major valleys (Vrishabhavathi Valley, K&C Valley, Hebbal Valley) and few minor valleys (Arkavathy Valley, Suvarnamuki Valley). Vrishabhavathi Valley with in the BBMP limits has a catchment area of ~170 sq.km (Figure 5.1), covering nearly 97 Wards of Bengaluru (Figure 5.2, Table 5.1). Vrishabhavathi river catered domestic (drinking water, bathing, etc.) and agricultural needs of West Bengaluru before the industrial evolution in the city (mid of 1970's). The river had numerous interconnected lake systems such as Kempambudi Lake at Basavanagudi, Sankey Lake at Sadashivnagar, Yediyur Kere at Yediyur, etc.

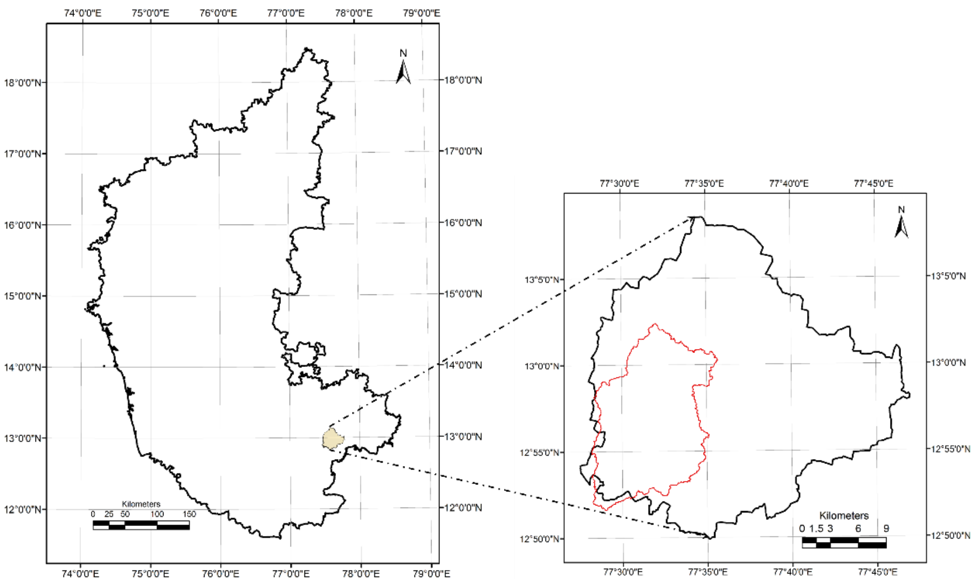


Figure 5.1: Spatial extent of Vrishabhavathi Valley

River origins at Bull temple, a small hillock next to Dodda Ganapathi Temple in Basavanagudi, Bangalore South (Figure 5.3), due to which it is known as Vrishabhavathi river (Vrishabh meaning Bull). Vrishabhavathi has 3 major streams namely Vrishabhavathi, Katriguppe and Kethamaranahalli. Vrishabhavathi valley from Basavanadudi, and its tributary originating at malleshwaram join near pipeline Gali Anjaneya temple and flow south towards Raja Rajeshwari nagar, where it joins a tributary (Kethamaranahalli) which carries sewage in to the sewage treatment. The river further travels down towards Kengeri and joins Suvarnamuhki at Byramangala River in Bidadi. Along the river network there are numerous temples namely (i) Gali Hanumantha Temple (Figure 5.4) on the banks of Vrihshabhavathi, over 600-year-old temple, constructed in 14th century (1425) in accordance with Sri Vyasaraya of Channapattana who was a Rajaguru of Vijayanagara Empire. (ii) Dodda Ganesha Temple: Located in immediate vicinity of Bull temple i.e., Origin of the river. (iii) Gavi Gangadhareshwara temple located at Gavipuram, near Ramakrishna mission Basavanagudi, (iv) Kadu malleswhara temple located at 15th cross malleshwaram, (v) Ishwara Temple at Kengeri which dates back to 1050 AD, etc. Vrishabhavathi River is getting polluted due to the sustained inflow of untreated sewage and industrial effluents.

Table 5.1: Wards along the V.Valley Catchment

Ward ID	Ward Name	Ward ID	Ward Name	Ward ID	Ward Name
16	Jalahalli	98	Prakash Nagar	141	Azad Nagar
17	J.P.Park	99	Rajaji Nagar	142	Sunkenahalli
34	Gangenahalli	100	Basaveshwara Nagar	143	Vishveshwara Puram
35	Aramane Nagara	101	Kamakshipalya	153	Jayanagar
36	Mattikere	102	Vrishabhavathi Nagar	154	Basavanagudi
37	Yeshwanthpura	103	Kaveripura	155	Hanumanth_Nagar
38	HMT ward	104	Govindaraja Nagar	156	Srinagar
41	Peenya Industrial Area	105	Agrahara Dasarahalli	157	Gali Anjenaya Templw Ward
42	Lakshmi Devi Nagar	106	Dr. Raj Kumar Ward	158	Deepanjali Nagar
43	Nandini Layout	107	Shivanagara	159	Kengeri
44	Marappana Playa	108	Sriramamandir	160	Rajarajeshwari Nagar
45	Malleswaram	109	Chickpete	161	Hosakerehalli
46	Jayachamarajendra Nagar	120	Cottonpete	162	Girinagar
62	Ramaswamy Palya	121	Binnipete	163	Katriguppe
64	Rajamahal Guttahalli	122	Kempapura Agrahara	164	Vidyapeeta Ward
65	Kadu Malleshwar	123	Vijayanagar	165	Ganesh Mandir Ward
66	Subramanya Nagar	124	Hosahalli	166	Karisandra
67	Nagapura	125	Marenahalli	167	Yediyur
68	Mahalakshmipuram	126	Maruthi Mandir Ward	168	Pattabhiram Nagar
69	Laggere	127	Mudalapalya	169	Byrasandra
70	Rajagopal Nagar	128	Nagarabhavi	178	Sarakki
71	Hegganahalli	129	Jnana Bharathi Ward	179	Shakambari Nagar
72	Herohalli	130	Ullal	180	Banashankari Temple Ward
73	Kottegapalya	131	Nyandahalli	181	Kumaraswamy Layout
74	Shakthi Ganapathi Nagar	132	Attiguppe	182	Padmanabha Nagar
75	Shankar Matt	133	Hampi Nagar	183	Chikkalsandra
76	Gayathri Nagar	134	Bapuji Nagar	184	Uttarahalli
77	Dattatreya Temple	135	Padarayanapura	185	Yelchenalli
93	Vasanth Nagar	136	Jagajivanaramanagar	186	Jaraganahalli
94	Gandhinagar	137	Rayapuram	197	Vasanthpura
95	Subhash Nagar	138	Chalavadipalya	198	Hemmigepura
96	Okalipuram	139	K R Market		
97	Dayananda Nagar	140	Chamarajapet		

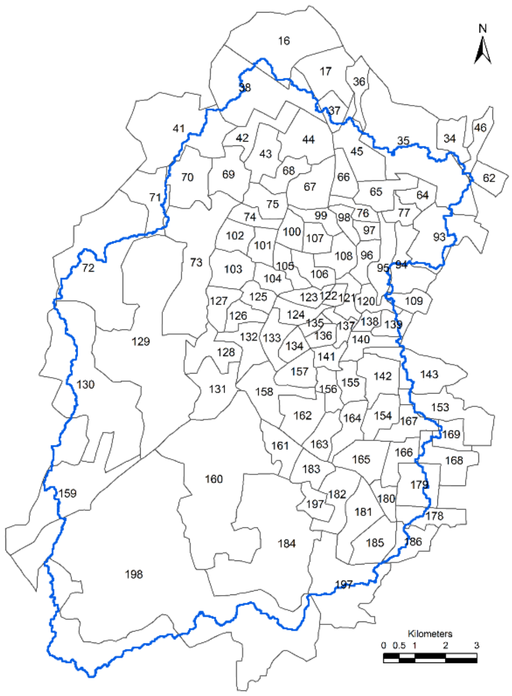


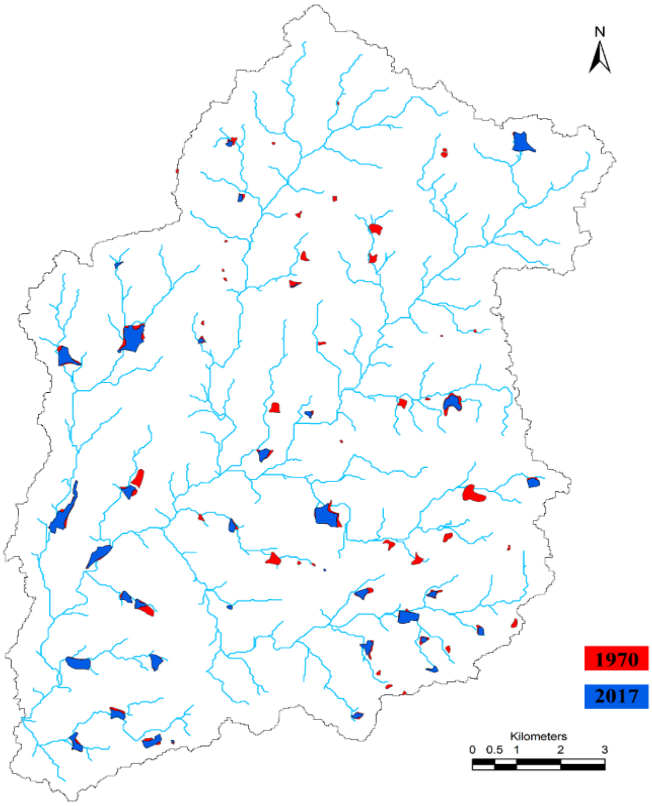
Figure 5.2: Ward boundaries and Catchment of V.Valley

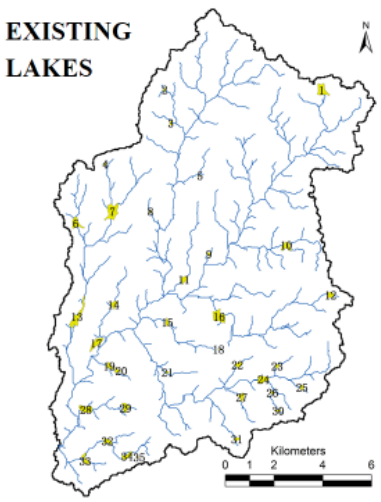
	
Figure 5.3: Bull Temple, Origin of Vrishabhavathi River (Source: https://i.ytimg.com/vi/nSZcgiTTnRw/maxresdefault.jpg)	Figure 5.4: Gali Anjaneeya Temple (Source: http://www.aralikatte.com/wp-content/uploads/2017/04/DSC00120-4.jpg)

Status of Lakes: During 70's, the valley had nearly 71 lakes, which is now reduced to ~35 lakes in 2017 (Figure 5.5). Table 5.2 lists existing Lakes in the Vrishabhavathi valley and most of these existing lakes are encroached and abused (with dumping of solid and liquid wastes). Table 5.3 lists the disappeared lakes, due to unplanned and senseless urbanisation in the city. Anthropogenic activities particularly, indiscriminate disposal of untreated industrial effluents and sewage wastes, dumping of solid waste, dumping of construction and demolition wastes (building debris) have altered the physical and chemical integrity affecting the biological integrity, evident from the profuse growth of macrophytes weeds, exotic species of fish, etc.

Table 5.2: Existing Lakes in Vrishabhavathi valley

Anjanagara kere	Goudanakere	Jettiganahalli	Nayandahalli kere	Sunkalapalya kere 1
Byadralli kere	Hegganahalli kere 1	Kempambudi kere	Prashanthnagar kere	Sunkanapalya kere 2
Chandranagara kere	Hegganahalli kere 2	Kenchenahalli kere	Sankey kere	Thalaghattapura kere
Channasandra Kere	Hemmigepura kere	Kengeri kere	Somapura kere1	Ullal kere
Deepanjalinagara kere	Hosakere	Kodigepalya kere	Somapura kere2	Uttarahalli kere
Dore kere	Hosakerehalli kere	Mallatalli kere	Srinivasapura kere	Vasantpura lake
Dubasipalya	Isro layout kere	Nagarabhavi kere	Subramanya kere	Yediyur kere





1) Sankey kere, 2) Hegganahalli kere,
3) Hegganahalli kere, 4) Anjanagara kere,
5) Baalehannu/Prashanthnagar kere,
6) Ullal kere, 7) Mallatalli kere,
8) Nagarabhavi kere, 9) Deepanjalinagara kere,
10) Kempambudi kere, 11) Nayandahalli kere
12) Yediyur kere, 13) Hosakere,
14) Dubasipalya kere, 15) Kenchenahalli kere,
16) Hosakerehalli kere, 17) Kengeri kere,
18) Srinivasapura kere, 19) Sunkanapalya,
20) Sunkalapalya kere, 21) Channasandra Kere,
22) Uttarahalli kere, 23) Goudanakere,
24) Dorekere, 25) Chandranagara kere,
26) Isro layout kere, 27) Subramanya kere,
28) Kodigepalya, 29) Jettiganahalli,
30) Vasantpura, 31) Thalaghattapura,
32) Hemmigepura, 33) Byadralli,
34)Somapura, 35) Somapura.

Figure 5.5: Distribution of lakes and lost lakes (marked in Red) between 1970 and 2017 in Vrishabhavathi valley

Table 5.3: Disappeared Lakes in Bengaluru in Vrishabhavathi valley

Attikoppe	Garagnutepalya	Hanumantanagar 2	Kenchanahalli	Rajajinagar
Avalhalli	Gottigere	Hegganahalli	Kurubahalli	Sajjepalya
Banashankari	Gublal 1	Jalvadipalya	Laggere	Sivanahalli
Byatrayanapura	Gublal 2	Kadarenahalli	Nagarbhavi	Tyagarajanagar
Chikkakalsandra 1	Gublal 3	Kamakshipalya 1	Oddarapalyam	Uttarahalli 1, 2
Chikkakalsandra 2	Guddadahalli	Kamakshipalya 2	Padarayanapura	Vasantpur
Dasarahalli	Hanumantanagar 1	Karithimmanahalli	Papareddipalya	Yalchenahalli

Figures 5.6 and 5.7 present the population dynamics across time. Population density in the valley has increased from 15 persons per hectare (in 1951) to 177.3 persons per hectare (in 2011). Large scale growth was observed between 1991 and 2001 i.e., from 76 (1991) to 136 (2001) persons per hectare, almost double the growth. Estimation of Population density for the year 2017 and 2021 using Simple interest method (eq 1)

$$P_n = P^* (1 + n.r) \qquad (1)$$

Where P_n : Population at n^{th} year, P : Current population (2011), n : number of decades, r : growth rate per decade.

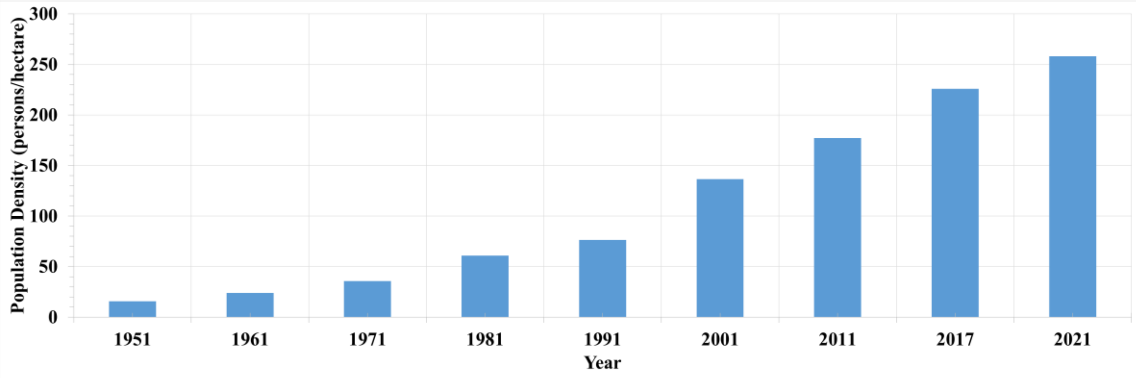


Figure 5.6: Population density dynamics in the Vrishabhavathi Valley Catchment

V.Valley as on 2017 has a population of ~3978862 persons with an annual demand of water of 596 MLD at a rate of 150 lpcd (liter per capita per day), and water demand is expected to reach 682 MLD (by 2021). Ward wise and catchment wise water demand is presented in Figure 5.8.

Sewage generated in the V.Valley is computed based on the water demand, considering to be 80% of the total water demand. Estimation of sewage generated (Figure 5.9) in the city shows, that ~480 MLD of sewage is generated (year 20170. This is expected to increase to 544 MLD by 2021 (based on the likely increase in population).

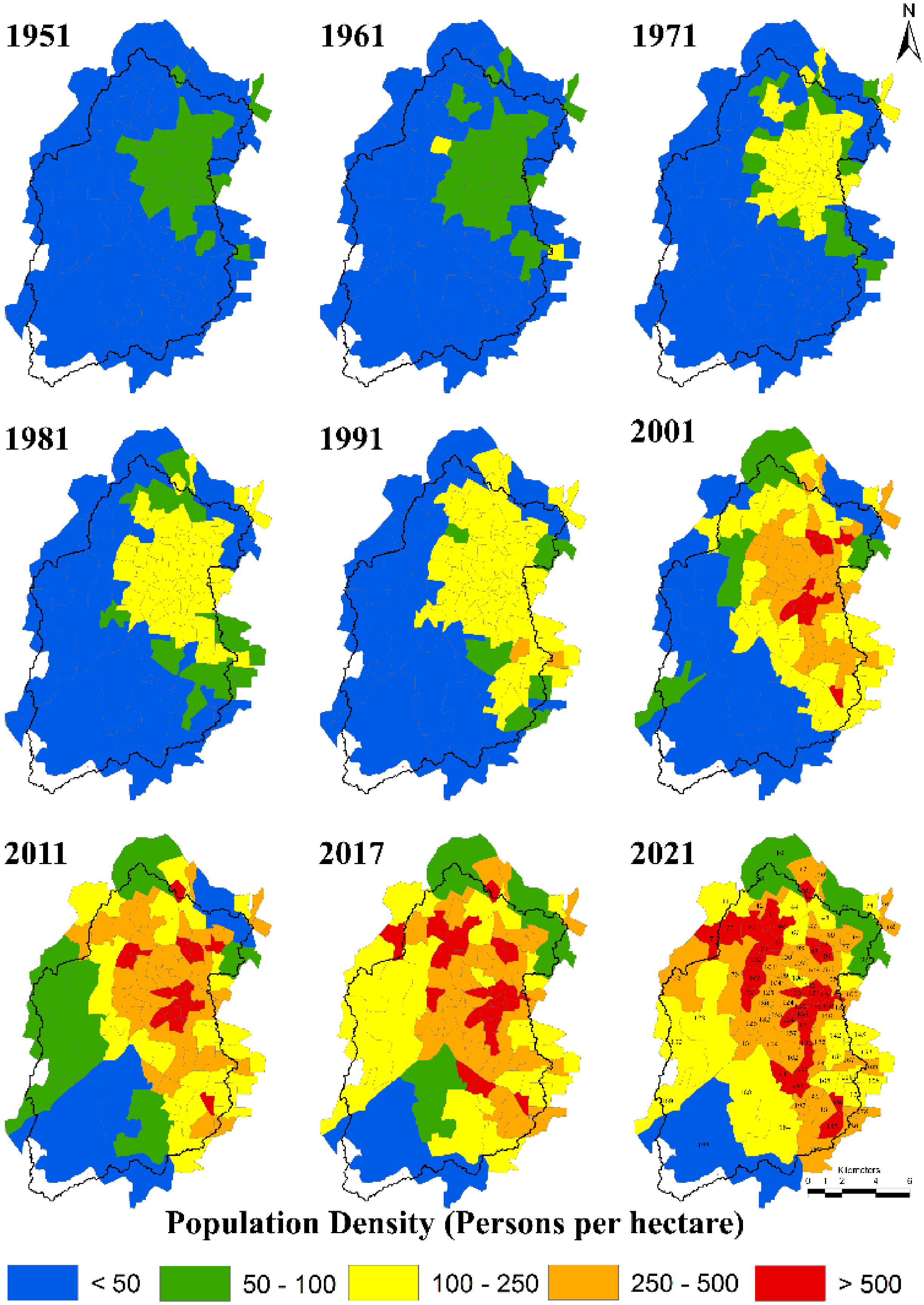


Figure 5.7: Ward wise population dynamics in the Vrishabhavathi Valley Catchment

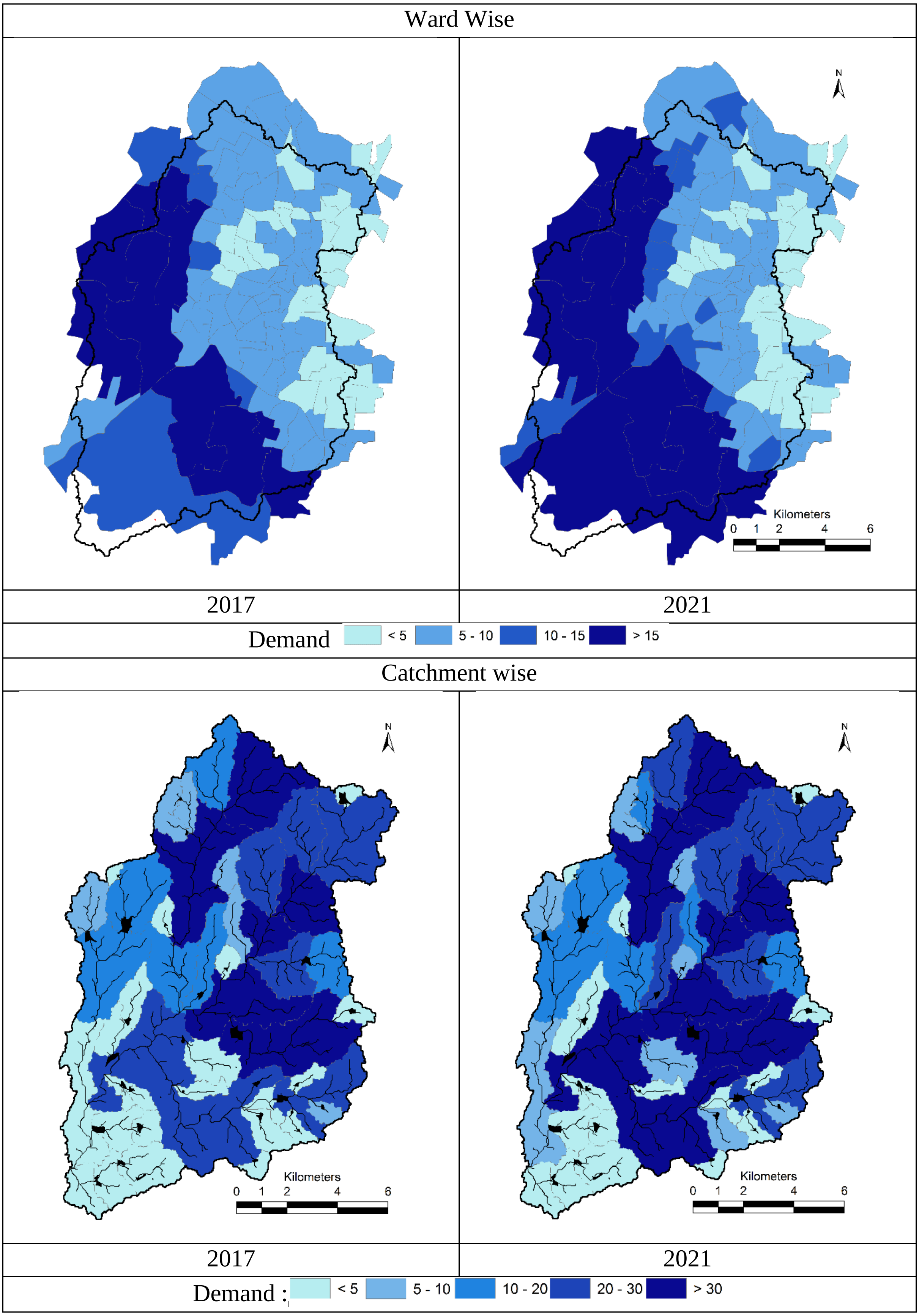


Figure 5.8: Water Demand (MLD) – ward and catchment wise

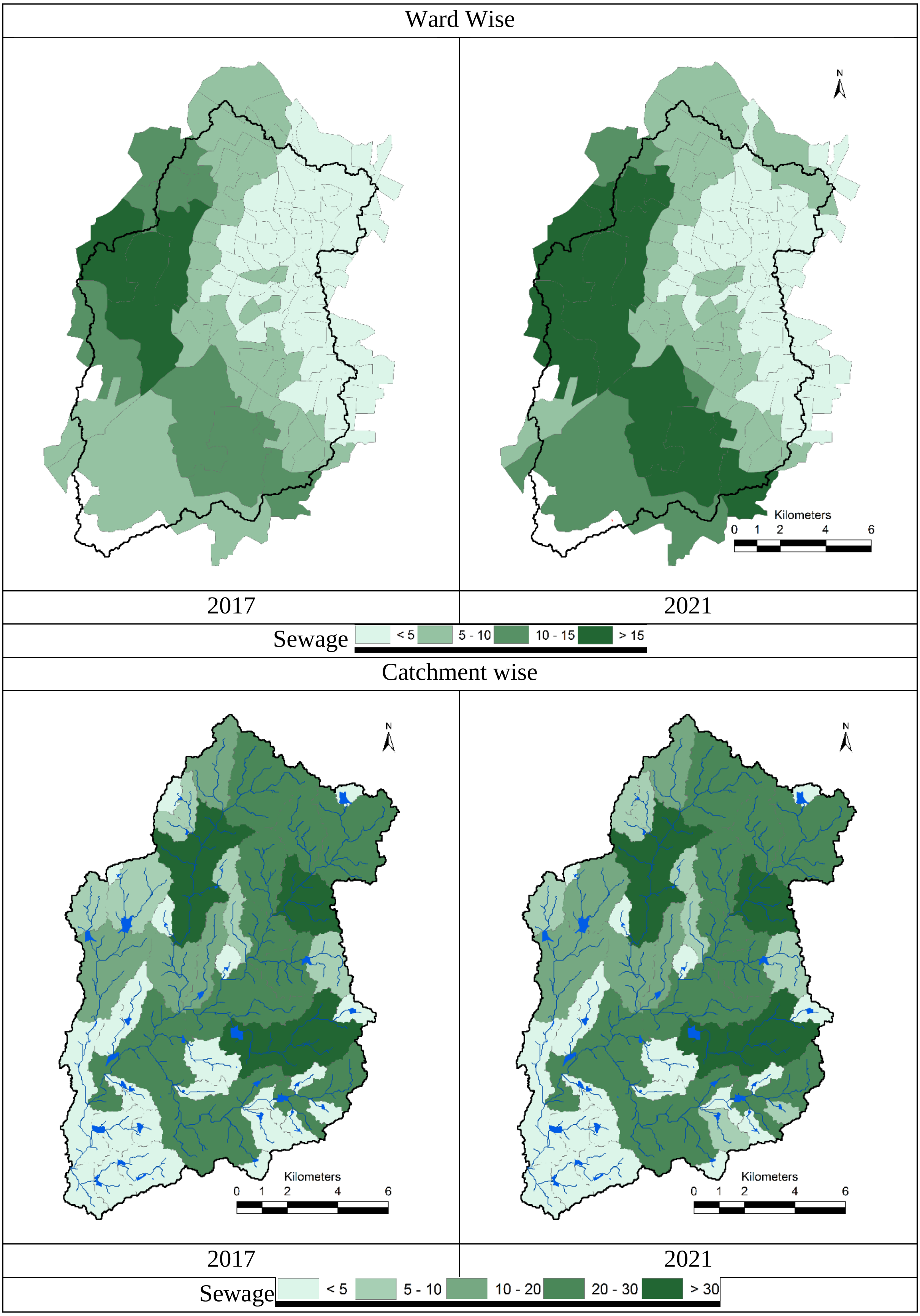


Figure 5.9: Sewage generated (MLD) – catchment wise

5.1 SEWAGE TREATMENT IN V.VALLEY: CURRENT STATUS AND GAPS:

Sewage generated in the catchment are either partially treated or untreated, evident form the prevailing water and sediment quality in the lakes of V. Valley. However, there are some efforts to treat sewage (but lacks option for removal of nutrients, which constitute the major problem of sewage) with 180 MLD (at Rajarajeshwari Nagar) and 75MLD (at Mylasandra) downstream of V.Valley along the Mysore road. Two more treatment plants are being implemented at Kengeri (60 MLD) and Doddabele (20 MLD). Small treatment plans about 1 to 2 MLD scale are present at Uttaralli, Deepanjalinagar, Doraikere, Kempambudi lakes respectively and 5 MLD plant at Mallathalli. Figure 5.10 depicts the location of the existing treatment plants (+ proposed treatment plants) and quantum of sewage generated in each sub-catchment.

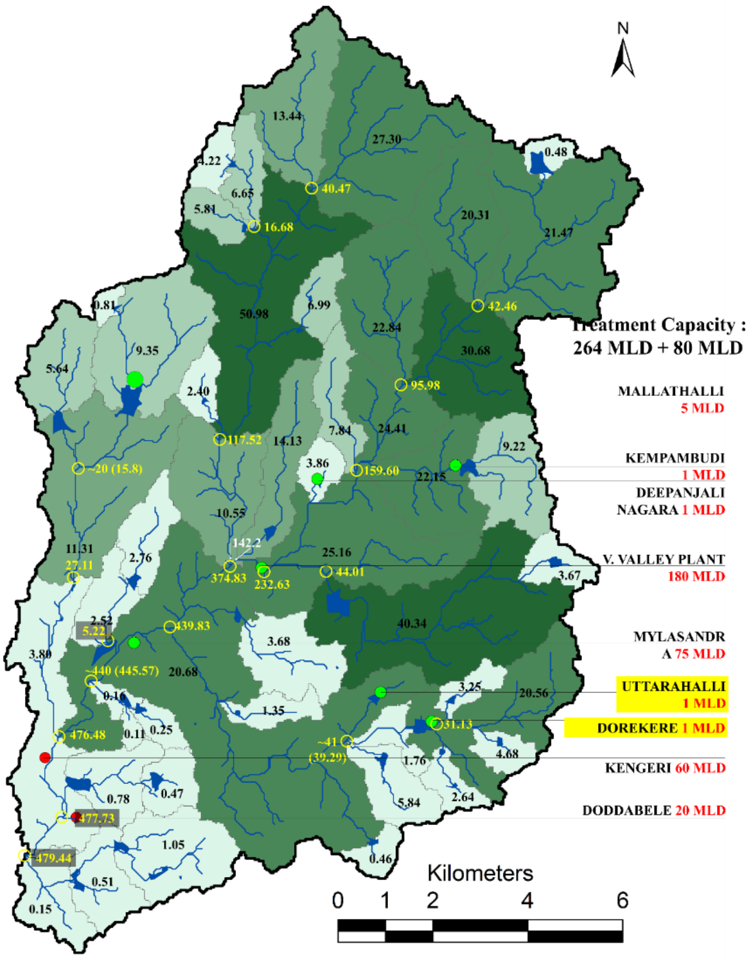


Figure 5.10: Quantum of Sewage Generated and location of STP's

Current treatment capacity is about 260 MLD whereas Sewage generated is about 490 MLD i.e., 54% of the sewage generated is treated when the plants are running at their full potential. Additional 80 MLD is under construction near Doddabele-Kengeri. Catchment wise quantum of sewage generated per day is given in Figure 5.11 with the current treatment capabilities and gaps (deficiencies). Figure 5.12 depicts the location of various treatment plants in the valley.

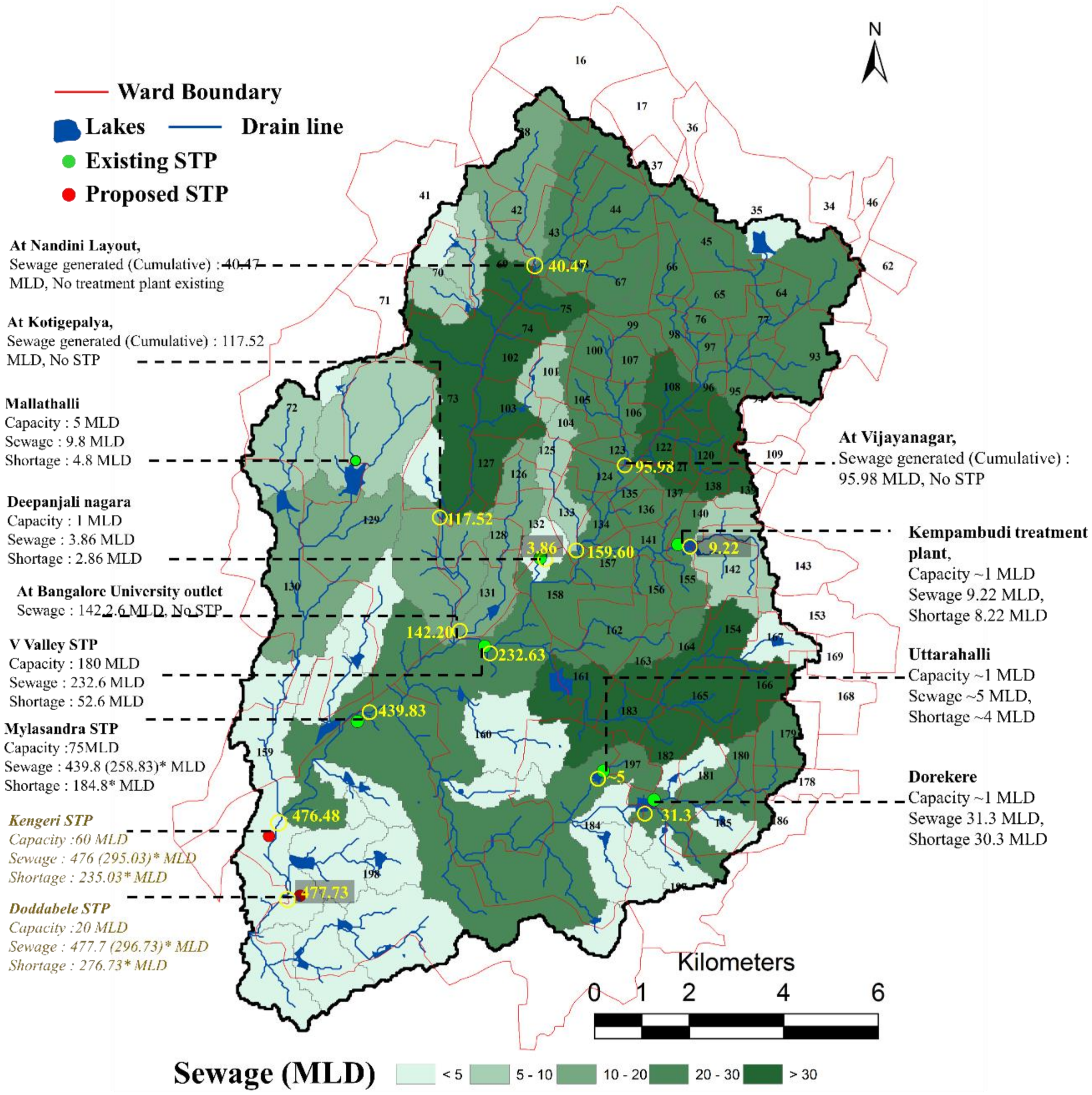
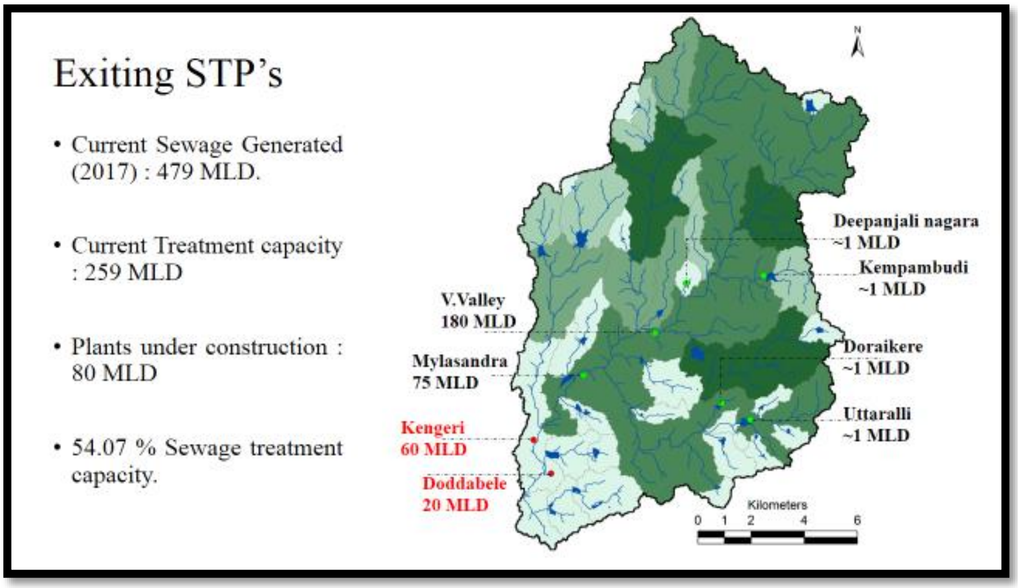


Figure 5.11: STP, Treatment capabilities and deficiencies along the valley



	
Deepanjali Nagar	Kempambudi
	
Doraikere	Uttarahalli
	
V Valley STP 180 MLD	Mylasandra 75 MLD
	
Mallathalli STP 5 MLD	Doddable-Kengeri STP

Figure 5.12: Treatment Plants in Vrishabhavati Valley

In order to treat the sewage generated in the valley, decentralized treatment option needs to be adopted, which helps in the treatment of water and also aids in catering local needs. STP's integrated with constructed wetlands with algae pond help in the removal on nutrients as well as other chemical contaminants. Along the valley, reed beds (wetland plants) and other vegetation cover can further help in the uptake of nutrients. Similar treatment options outside

BMP vicinity would revive Byramangala reservoir which can act as a source of drinking water in future. Figure 5.13 outlines the site requirements for adoption of decentralized treatment plants in the respective catchments. Quantum of sewage that can be treated locally and additional details are given in Table 5.4. Figure 5.14 indicates the sites (Green polygons) and treatment capabilities for the sub catchment of Vrishabhavathi joining at Bengaluru University Gate.

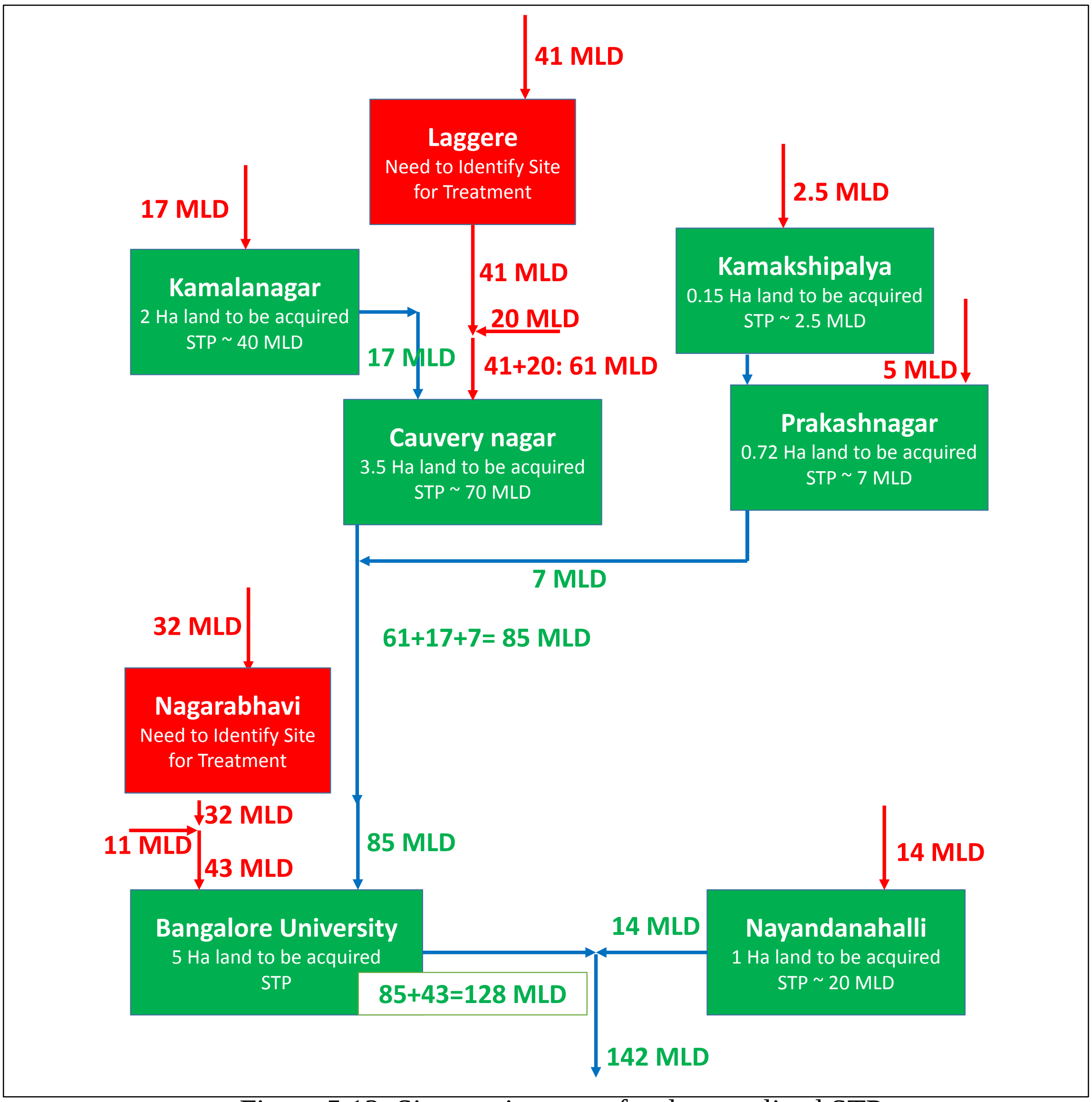
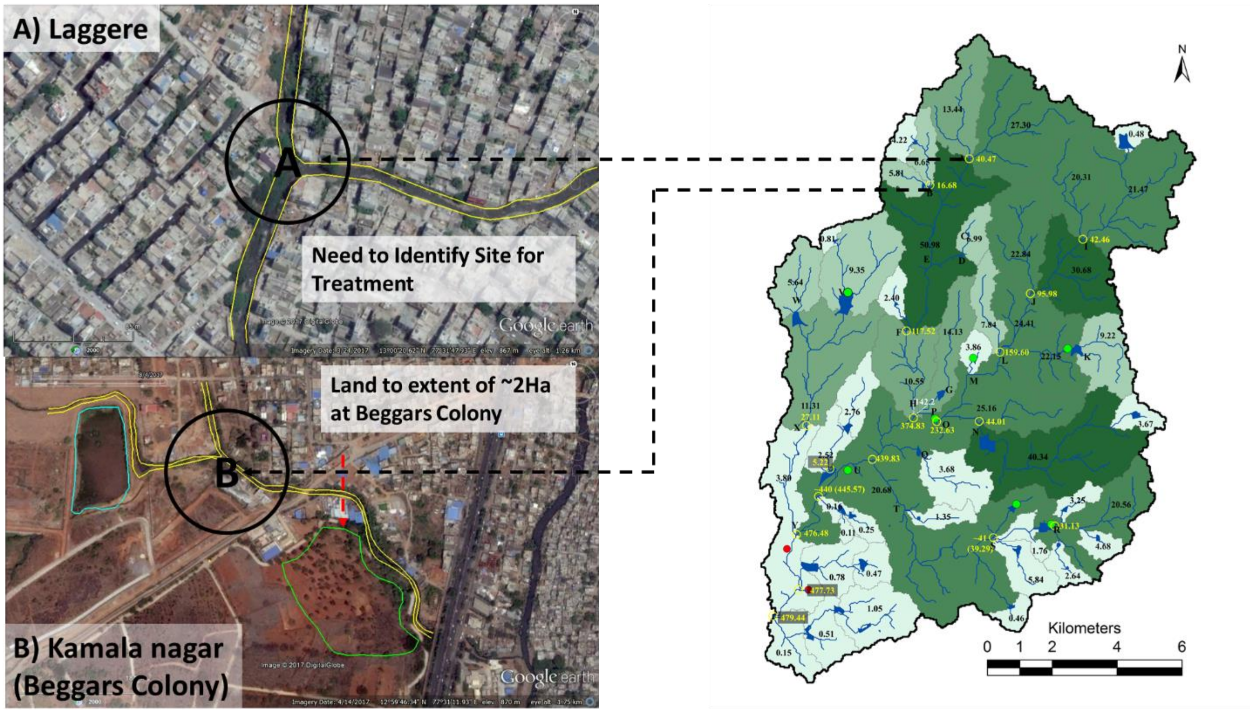
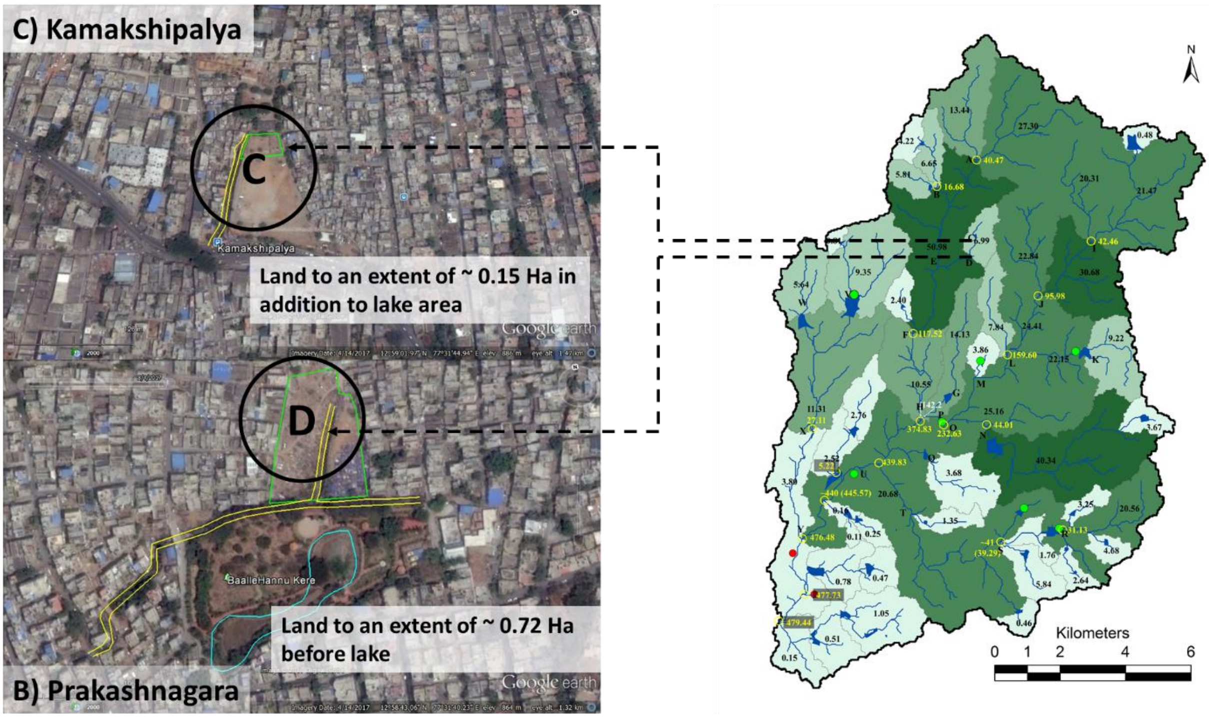


Figure 5.13: Site requirements for decentralized STP


A) Laggere
A
Need to Identify Site for Treatment
Land to extent of ~2Ha at Beggars Colony
B
B) Kamala nagar (Beggars Colony)
Kilometers
0 1 2 4 6


C) Kamakshipalya
C
Land to an extent of ~ 0.15 Ha in addition to lake area
D
Land to an extent of ~ 0.72 Ha before lake
B) Prakashnagara
Kilometers
0 1 2 4 6

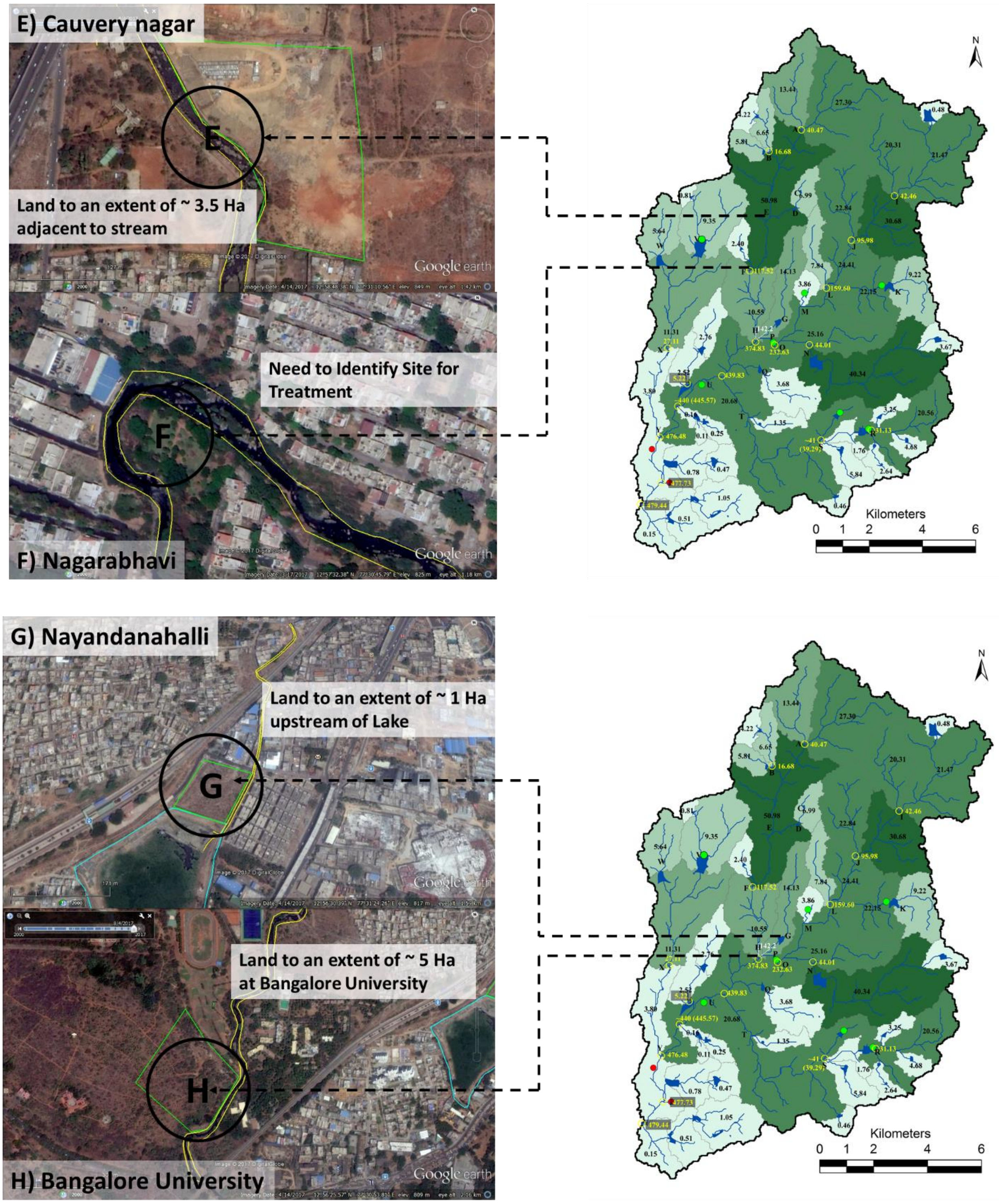


Figure 5.14: Probable sites for setting up sewage treatment plant to ensure zero waste discharge into the valley - Valley running through Bangalore University

Table 5.4: Sewage Treatment along the Valley joining Vrishabhavathi at Bangalore University Gate

	Location	Sewage Generated	Treatment in MLD Current	Land use	Area required	Beneficiaries
1	Laggere	41 MLD	Need to Identify Site for treatment	Urban		
2	Kamalanagara	17 MLD	17	Open	2 Ha at Beggars Colony	Doddanna Industrial Area, Beggars Colony, recharge upstream lakes and Ground water in the vicinity
3	Kamakshipalya	2.5 MLD	2.5	Open Land	0.15 Ha u/s Lake	Kamakshi palya lake can be revived, helps in restoring ground water in the vicinity
4	Prakashnagar (Baalehannu kere)	5 MLD	5	Open Land	0.72 Ha u/s Lake	Prakshnagar lake can be perennial, helps recharging ground water
5	Cauvery Nagar	20 MLD 61 MLD (= 20 MLD + 41 MLD (Laggere))	61	Open Land	3.5 Ha adjacent to Stream	Industries in the vicinity, and other institutions, helps restoring stream and recharge Ground water
6	Nagarabhavi	32 MLD	Need to Identify Site for treatment	Urban		
7	Nayandanahalli	14	14	Open	1 Ha u/s Lake	Industries, Lake would be perennial, Ground water recharge
8	Bangalore University	11 MLD 43 MLD (= 11 MLD + 32 MLD (Nagarabhavi))	43	Scrub	5 Ha next to stream in BU campus	Bangalore university can use water for flushing, greening and other activities, Sports authority of India for various activities, etc.

Figures 5.15 and 5.16 provide the details of probable locations for setting up decentralized treatment options along the Vrishabhavathi valley before it reaches Bangalore university. Table 5.5 provides additional details on the same.

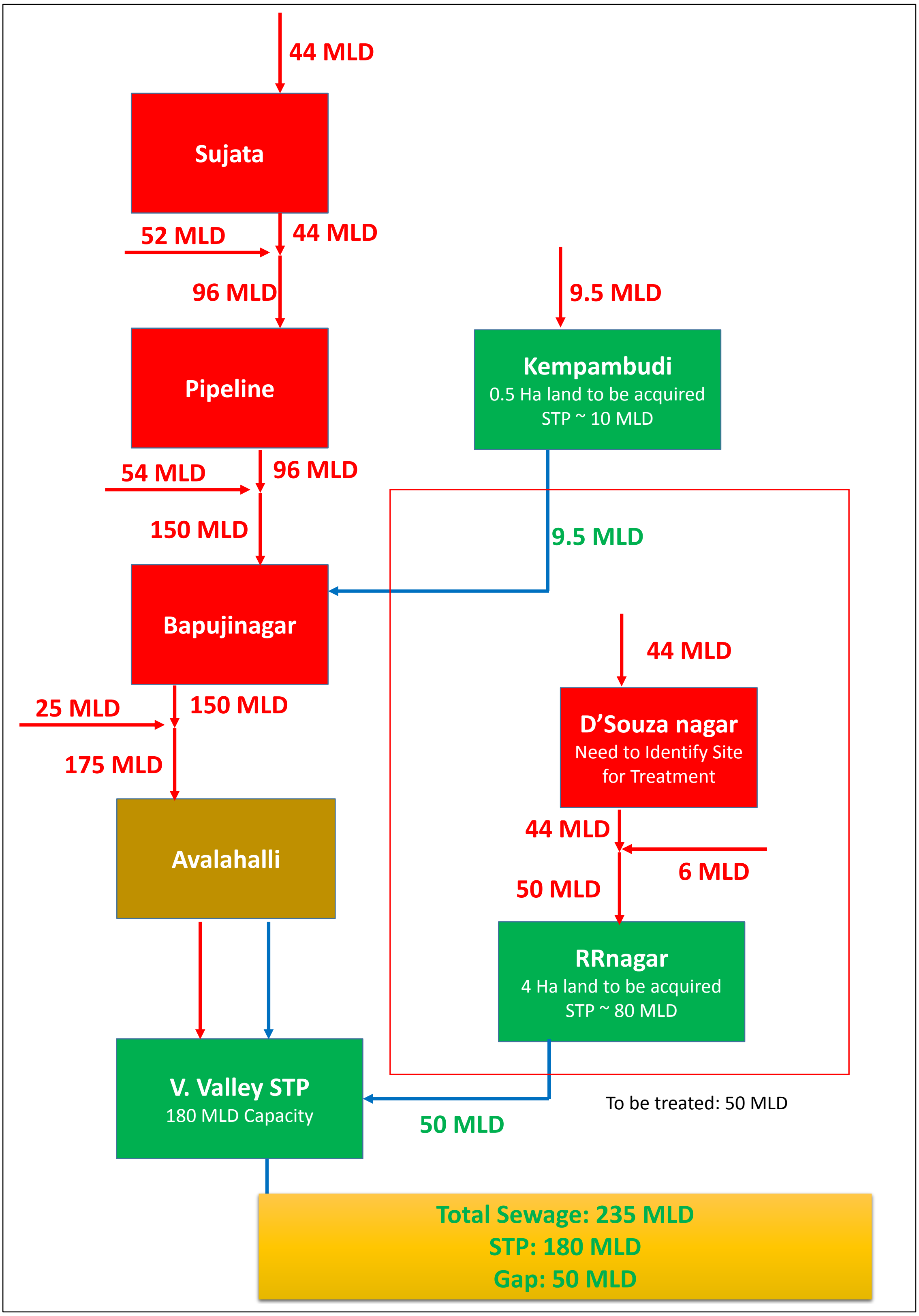


Figure 5.15: Treatment and Site conditions

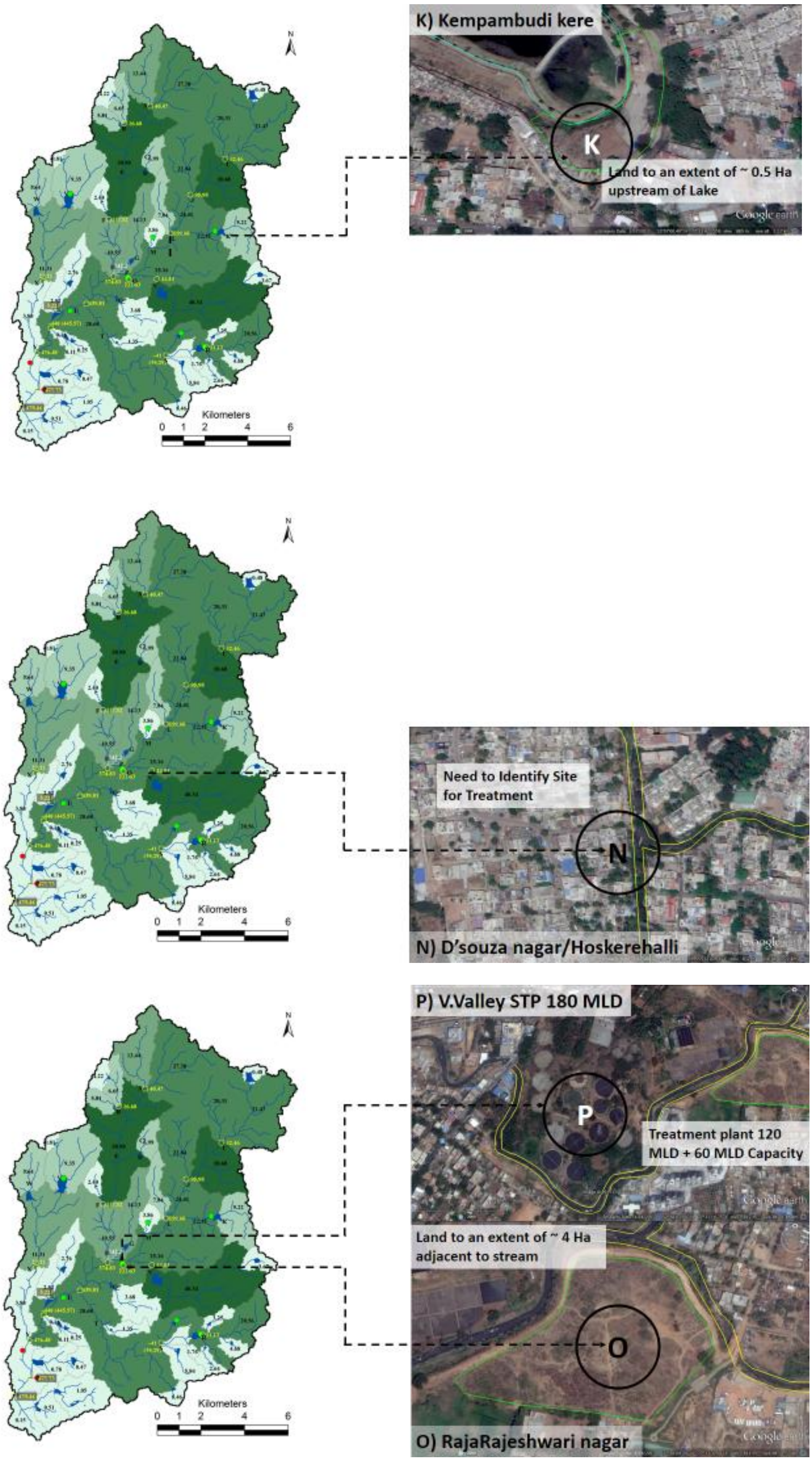


Figure 5.16: Probable sites for setting up sewage treatment plant to ensure zero waste discharge into the valley – V.Valley up to Bangalore University Gate

Table 5.5: Sewage treatment along V valley up to Bangalore University Gate

Sl.no.	Location	Sewage Generated	Treatment in MLD	Landscape	Area requirement	Beneficiaries
1	Sujata	44 MLD	Need to Identify Site for treatment	Urban		
2	Pipeline (Vijayanagar)	52 MLD 96 MLD = 52 MLD + 44 MLD (Sujata)	Need to Identify Site for treatment	Urban		
3	Kempambudi kere	9.5 MLD	1 MLD - -	Open Land	0.5 Ha (upstream of Lake)	Lake can be rejuvinated, Ground water improvement water can be recycled
4	Bapujinagar	54 MLD 150 MLD (= 54 MLD + 96 MLD (Pipeline)	Need to Identify Site for treatment	Urban		
5	Avalahalli	25 MLD 175 MLD (= 25 MLD + 150 MLD (Bapujinagar)	65	Open		
	V.Valley STP	230 MLD	180	Existing STP		
6	D'Souza Nagar	44 MLD		Urban		
7	RR Nagar	6MLD 50 MLD (= 6 MLD + 44 MLD (D'Souza nagar)	50	Open	4 Ha (Opposite to existing STP)	Rejuvenation of stream, Ground water recharge, Construction activities, Flushing

Decentralised treatment options at minor catchments can further cater the downstream users needs such as for agriculture, horticulture, construction, industries (SEZ) *etc.* (Figure 5.17). In addition to these treatments, existing treatment facilities at Mylasandra and Doddabele (Kengeri) can be used to make sure zero waste discharge from the city.

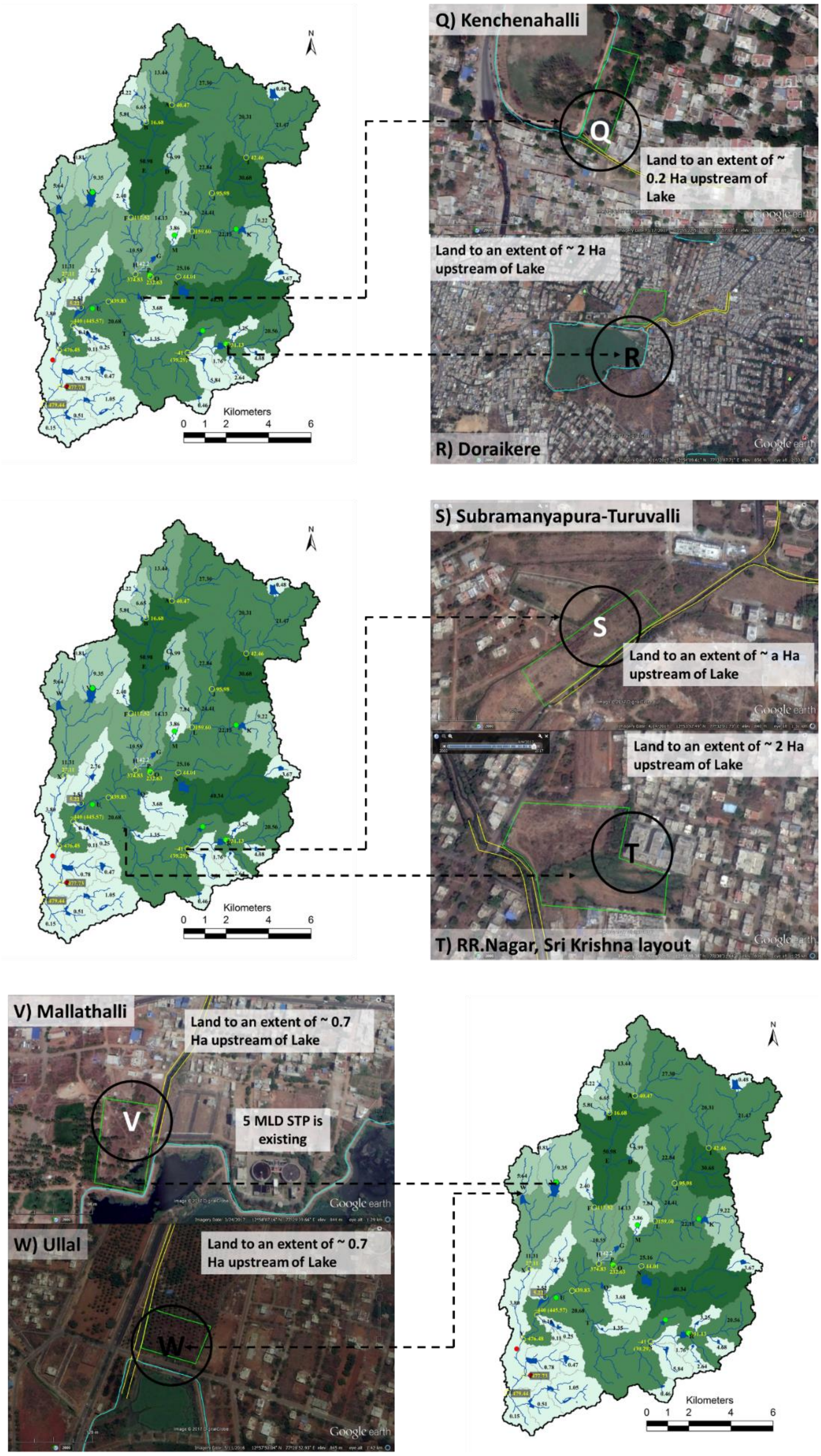


Figure 5.17: Localized treatments at other locations

For optimal treatment and management, entire V Valley catchment is divided into 3 zones (based on topography and to ensure gravity flow) and zone wise scope for setting up decentralized treatment plants are listed in Table 5.6.

Table 5. 6: Optimal sewage management strategy in V.Valley

Zone ID	Node	Location	Sewage Generated (MLD)	STP	Land for setting up STP (Sewage Treatment plants)	Cumulative (in case of lack of land)
Zone 1 (Yeshwanthpur to BU GATE)	1	Laggere	41		Identify	
	3	Cauvery Nagar	20		4 Ha	**61***
	2	Kamalanagar	17		2 Ha	17
	4	Kamakshipalya	2.5		0.1 Ha	2.5
	5	Prakashnagar	4.5		0.25 Ha	4.5
	6	Nagarabhavai	32		Identify	
	7	BU	11		4 Ha	**43***
	8	Nayandahalli	14		1.2 Ha	14
	9	BU Gate				**142***
Zone 2 (Sadashivanagar to BU GATE)	12	Kempambudi	9.5	1	0.5 Ha	9.5
	10	Sujatha	**44**			
	11	Pipeline (Rajajinagar)	**52**			
	13	Bapujinagar	**54.5**			
	14	Avalahalli	**24.5**			
	15	V.Valley STP		**180**	Existing STP	***180$***
	16	D'Souzanagar	**44**		Identify	44
	17	RRNagar	**6**		Identify	6
	20	BU Gate				234.5
Zone 3 (BU GATE to Doddabele)	21	Doraikere	31.5		2 Ha	31.5
	22	Channasandra	10		0.5 HA	10
	23	Global Village	22		2 HA	22
	24	Mylasandra	5	**75**	Existing STP	***75$***
	25	Mallatalli	10	**5**	Existing STP (upgrade)	***5$***
	25	Ullala	10		Identify	10
	27	Kengeri	11	60	STP under construction	***60$***
	28	Doddabele	14	20	STP under Construction	***20$***
	29	Cumulative	113.5			
Summary		Zone 1	**142**		**TREAT SEWAGE TO PREVENT GROUNDWATER CONTAMINATION LAKES HELP IN GROUNDWATER RECHARGE**	
		Zone 2	**234.5**			
		Zone 3	**113.5**			
V VALLEY			**490**	**340**		

Note : * - Cumulative of previous and current node , # - Partial treatment at node, $ - STP (Existing or Under construction)

6. ENCROACHMENT OF LAKES AND NATURAL DRAINS

1. Physical integrity of lakes and storm water drains	1. Surveying and mapping of water body (including flood plains) and buffer zones (30 m as per BDA; 75 m as per NGT) and storm water drains
	2. Surveying and mapping valley zones (eco-sensitive zone as per RMP 2015, and green belt as per CDP 2005). Remove all encroachments without any consideration.
	3. Remove all encroachments (lake bed, Raja kaluves, storm water drains) to prevent calamities related to floods
	4. Identify the common lands, kharab lands, streams, drains, tracks and paths (as per cadastral / revenue maps). This land would be useful to setup waste water treatment plants (STP's) and constructed wetlands.
	5. Identify the areas required for setting up decentralised treatment plants (and if required mechanisms to acquire these lands for public utility)
	6. Stop narrowing and concretising rajakaluve (BBMP's deliberate action to obviate NGT norms (of 50m buffer)
2. Alteration in topography and unplanned concretisation	Refrain from granting any consent for establishment for large scale projects in these catchments with immediate effect (Bangalore is undergoing unplanned, un-realistic urbanisation)
3. Fragmented, un-co-ordinated lake Governance	1. Strengthen KLDCA – single agency / custodian to address all issues related to lakes (including maintenance, monitoring, management and removal of all illegalities) and interconnected drains. This helps in minimising fragmented governance. 2. Scientifically competent committee to address the lake issues.
Encroachment of lakebeds, valley zone and rajakaluves	Evict all encroachments without any considerations (as unauthorized occupation is leading to flooding of the region and affects life and property of many) 1. These common lands would be available for setting up STP, wetlands **2.** Removal of encroachments of Rajakaluves and drains would re-establish interconnectivity among lakes so that water would move from one lake to another, enabling treatment of water (through aeration)

ENCROACHMENT DETAILS OF LAKES

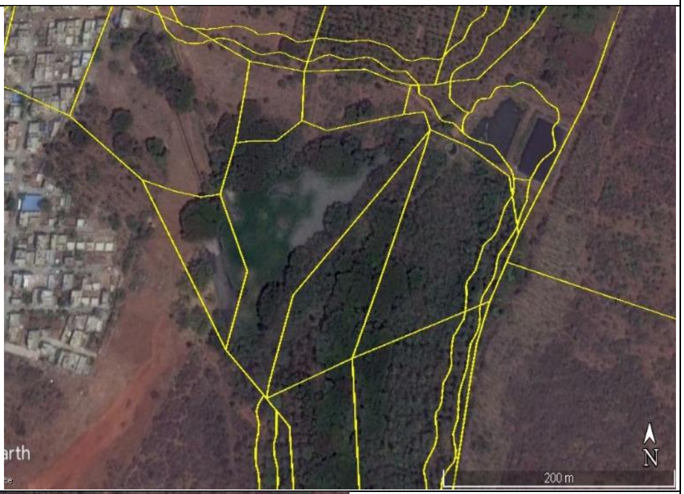
Sl. No	Name of the Lake	Area in Acres	Encroachment area (acres)
1	Anjanangar	5.27	
2	Avalahalli	21.63	1.37
3	Ballehannu	6.65	2.14
4	Bikaspura	7.15	1.55
5	Chandranagar	7.21	1.34
6	Dasarahalli	27.83	6.5
7	Deepanjali nagar	7.55	1.9
8	Doddbidrekallu	40.42	3.03
9	Doddkalsandra	21.4	1.5
10	Doraikere	28.57	0.41
11	Dubasipalya	24.88	2.85
12	Gowdanpalya	9.75	4.1
13	Gubblala	8.01	
14	Halagevaderahalli	17.25	7.33
15	Handrahalli	16.15	1.9
16	Hegganahlli	6.29	2.49
17	Hemmigepura	17.5	5.31
18	Herohalli	34.82	1.7
19	Hoskere	54.14	10.11
20	Hoskerehalli	59.65	4.06
21	H Gollahalli/Varahasandra	19.65	2.01
22	Isro layout	7.15	1.09
23	Kempambudhi	43.45	3.79
24	Kengeri	32.4	1.06
25	Konankunte	10.3	1.3
26	Konasandra	36.68	2.76
27	Mallathhalli	71.15	0.81
28	Mylasandra 1	12.16	
29	Mylasandra 2	16.49	
30	Nagarbhavi	9.18	3.18
31	Nayandahalli	15.45	2.67
32	Sankey	42.35	
33	Sompura	17.95	
34	Srinivaspura	7.5	4.5
35	Subramanyapura	18.06	6.45
36	Ullal	24.3	0.19
37	Uttarahalli	15.4	1.95
38	Yediyur	18.05	0.76

6.0 ENCROACHMENT OF LAKES – Reflects the extent of misappropriation

(POLYGON WITH YELLOW COLOUR REPRESENTS BOUNDARY OF LAKE AND POLYGON WITH RED REPRESENTS ENCROACHMENTS)

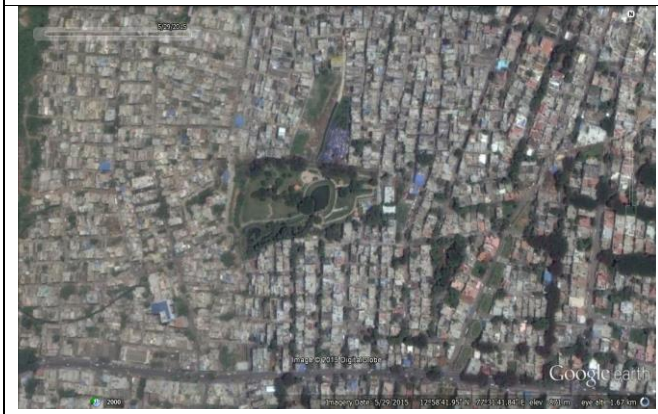
Encroachment of lakebeds, valley zone and rajakaluves	Evict all encroachments without any considerations (as unauthorized occupation is leading to flooding of the region and affects life and property of many) 3. These common lands would be available for setting up STP, wetlands **4.** Removal of encroachments of Rajakaluves and drains would re-establish interconnectivity among lakes so that water would move from one lake to another, enabling treatment of water (through aeration)

ANJANANAGAR	Latitude-12°58'59.50"N to 12°59'01.36"N, 77°29'28.78"E to 77°29'35.87"E Longitude-12°58'54.14"N to12°59'02.12 "N, 77°29'30.5"E to 77°29'34.91"E



Lake spatial extent as per RTC-5.27Acres

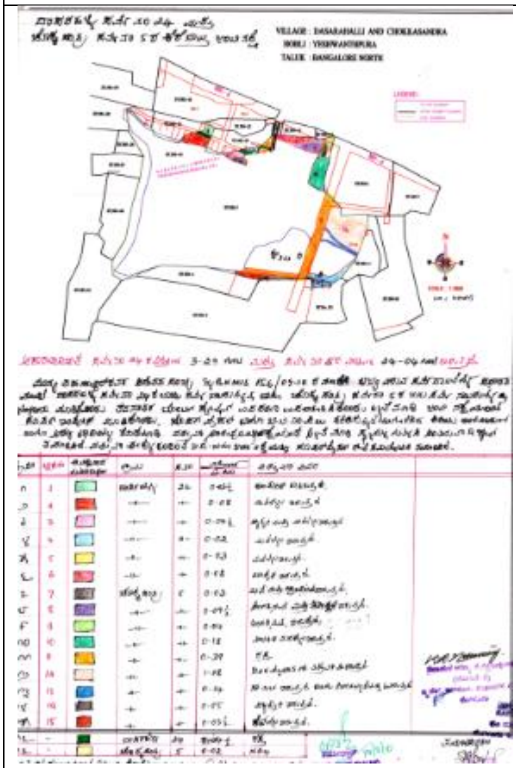
AVALAHALLI	Latitude-12°51'45.32"N to 12°51'55.04"N, 77°33'51.39"E to 77°34'05.60"E Longitude-12°51'44.14"N to 12°52'02.91"N, 77°33'52.20"E to 77°34'01.43"E
	
	
Lake spatial extent as per RTC-21.63Acres Encroachment -1.37Acres	

BALLEHANNUKERE/ MALGALA	Latitude-12°58'42.29"N to 12°58'42.91"N, 77°31'35.31"E to 77°31'45.94"E Longitude-12°58'38.65"N to 12°58'44.67"N, 77°31'35.85"E to 77°31'36.45"E
	
	
Lake spatial extent as per RTC-6.65Acres Encroachment -2.14Acres	

BIKASIPURA/VASANTNAGAR	Latitude-12°53'26.99"N to 12°53'28.42"N, 77°33'16.74"E to 77°33'27.73"E Longitude-12°53'25.37"N to12°53'32.19 "N, 77°33'24.11"E to 77°33'24.52"E
	
	
Lake spatial extent as per RTC-7.15Acres Encroachment - 1.55Acres	

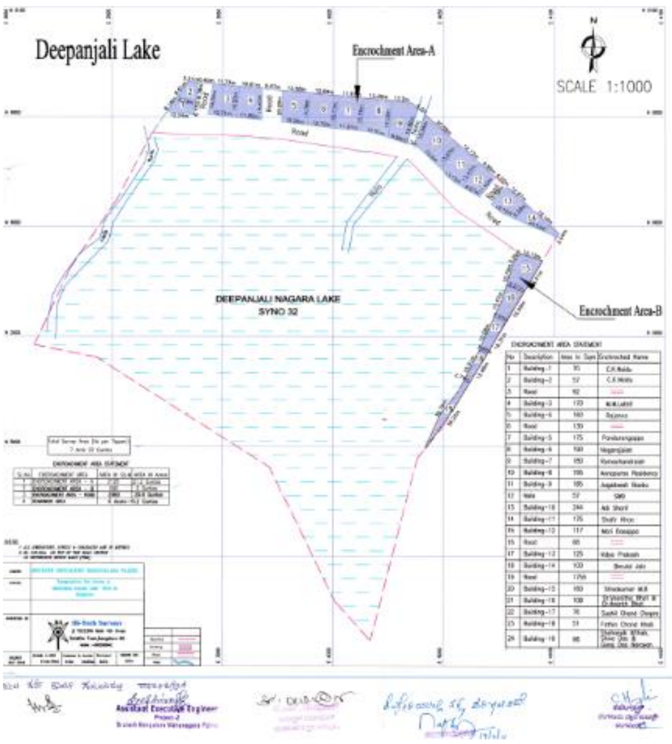
CHANDRANAGAR	Latitude-12°53'55.05"N to 12°54'01.86"N, 77°33'52.54"E to 77°33'58.57"E Longitude-12°53'54.68"N to12°54'02.19 "N, 77°33'51.96"E to 77°33'56.09"E

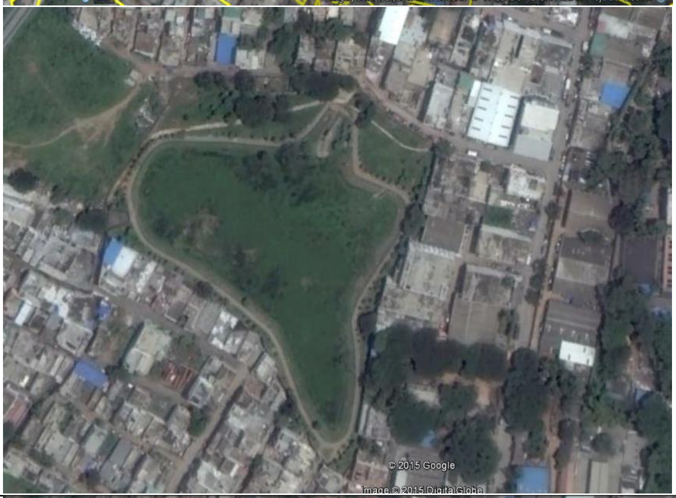
Lake spatial extent as per RTC-7.21Acres
Encroachment -1.34 Acres

DASARAHALLI	Latitude-13°02'22.53"N to 12°02'27.30"N, 77°30'37.81"E to 77°30'55.56"E Longitude-13°02'21.92"N to 13°02'32.94"N, 77°30'39.68"E to 77°30'42.97"E
 Lake spatial extent as per RTC-27.83 Acres Encroachment as per BBMP-4.55Acres	 
	
Encroachment as per our calculation-6.5Acres	

DEEPANJALI NAGAR

Latitude-12°56'58.21''N to 12°56'58.88''N, 77°31'47.89''E to 77°31'56.16''E
Longitude-12°56'53.54''N to 12°57'02.08''N, 77°31'50.33''E to 77°31'52.26''E

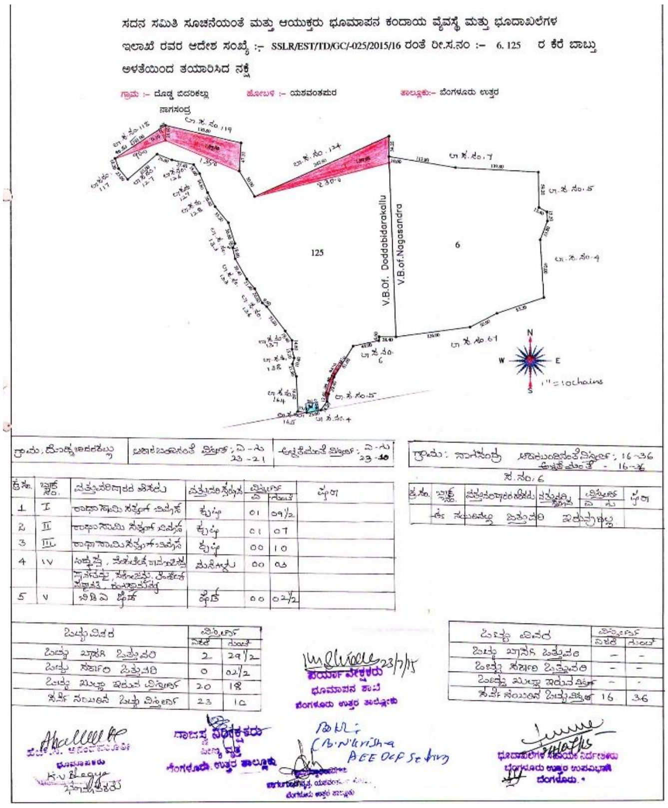




Lake spatial extent as per RTC-7.55Acres
Encroachment as per BBMP-1.18 Acres
Encroachment as on Sept 2017-1.9Acres

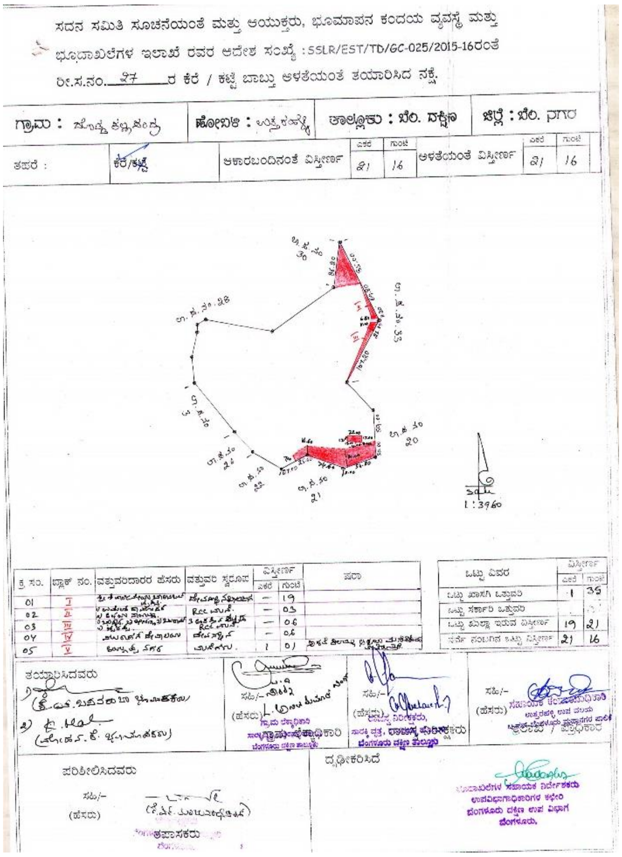
DODDABIDAREKALLU

Latitude-13°02'39.01"N to 13°02'41.49"N, 77°29'29.41"E to 77°29'54.40"E
Longitude-13°02'26.29"N to 13°02'43.31"N, 77°29'33.27"E to 77°29'39.41"E



Lake spatial extent as per RTC-40.42Acres
Encroachment - 3.03Acres
Encroachment as per SSLR-2.8 Acres

DODDKALSANDRA

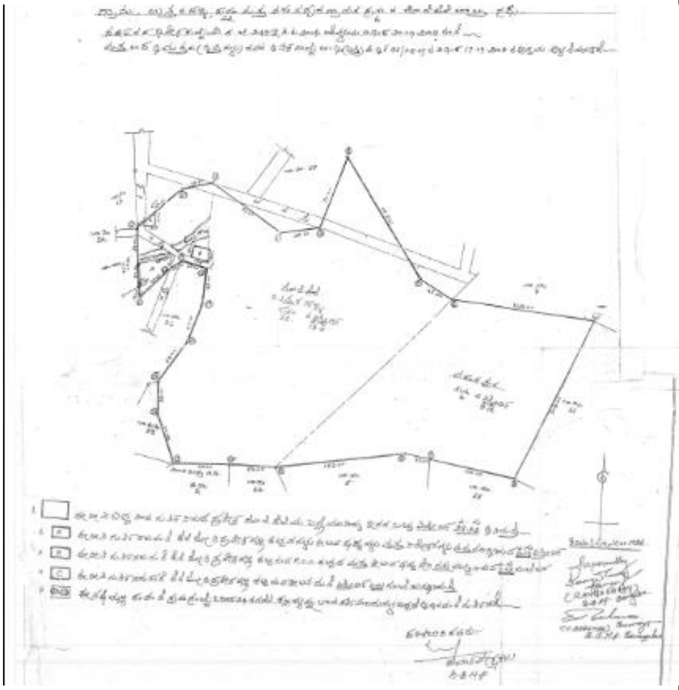


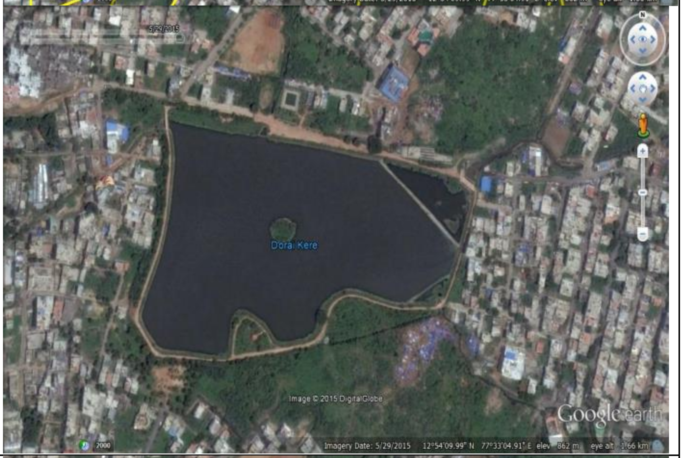
Lake spatial extent as per RTC-21.4Acres
Encroachment - 1.5Acres
Encroachment as per SSLR-1.87Acres

Latitude-12°52'51.03"N to 12°52'55.43"N,
77°33'35.42"E to 77°33'47.73"E
Longitude-12°52'49.61"N to 12°53'04.31"N,
77°33'41.72"E to 77°33'44.87"E

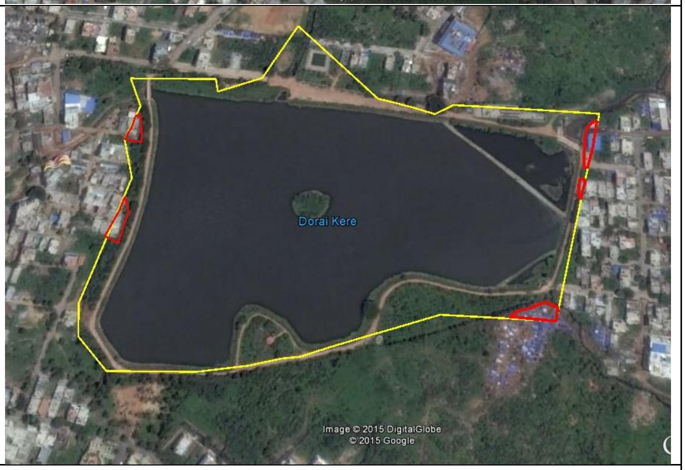
DORAIKERE

Latitude-12°54'07.35''N to 12°54'12.84''N, 77°32'55.00''E to 77°33'12.36''E
Longitude-12°54'04.71''N to 12°54'16.66''N, 77°32'56.44''E to 77°33'02.06''E





Lake spatial extent as per RTC-28.57Acres
Encroachment as per BBMP-0.35Acres



Encroachment as per our calculation-0.41Acres

<table>
<tr><td>DUBASIPALYA</td><td>Latitude-12°55'53.25"N to 12°55'54.11"N,
77°29'35.33"E to 77°29'48.58"E
Longitude-12°55'43.23"N 12°56'01.36"N,
77°29'42.40"E to 77°29'42.64"E</td></tr>
<tr><td>
</td><td>
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<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Lake spatial extent as per RTC- 24.88Acres
Encroachment - 2.85Acres</td></tr>
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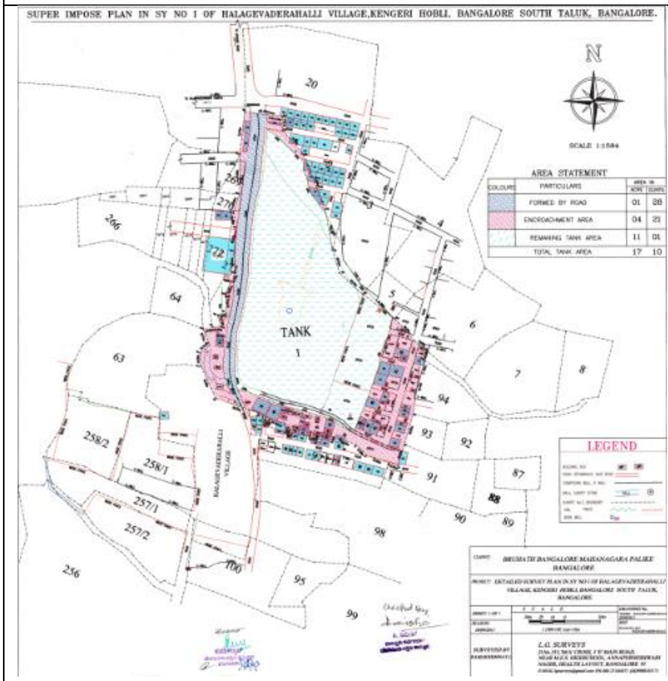
GOWDANPALYA	Latitude-12°54'24.61"N to 12°54'29.37"N, 77°33'15.56"E to 77°33'29.41"E Longitude-12°54'23.30"N to 12°54'31.65"N, 77°33'23.98"E to 77°33'26.13"E
	
	
Lake spatial extent as per RTC - 9.75Acres Encroachment - 4.1Acres	

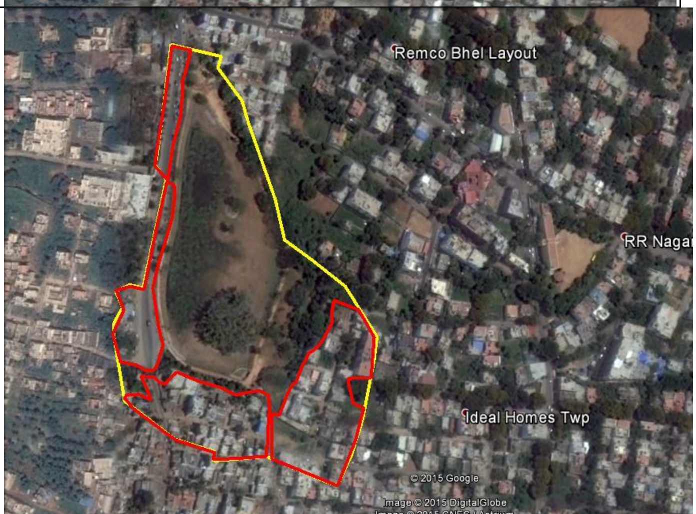
GUBBALALA	Latitude-12°52'48.92"N to 12°52'52.00"N, 77°32'21.00"E to 77°32'31.33"E Longitude-12°52'47.25 "N to 12°52'53.69"N, 77°32'26.47"E to 77°32'28.4"E
	
	
Lake spatial extent as per RTC-8.01Acres	

HALAGEVADERAHALLI

Latitude-12°55'23.73"N to 12°55'25.31"N, 77°30'49.93"E to 77°31'00.23"E
Longitude-12°55'18.27"N to 12°55'34.19"N, 77°30'52.37"E to 77°30'58.38"E

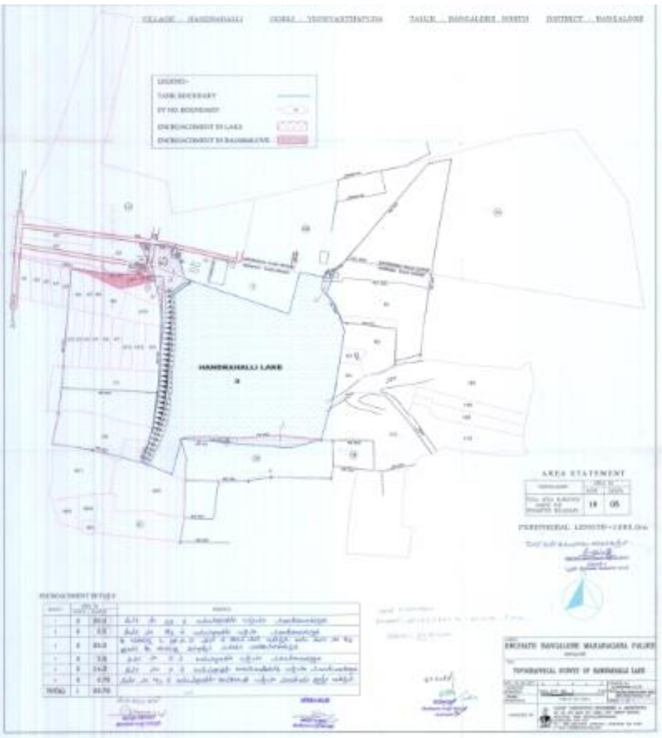


Lake spatial extent as per BBMP-17.25 Acres
Encroachment as per BBMP-4.52Acres



Encroachment - 7.33Acres

HANDRAHALLI

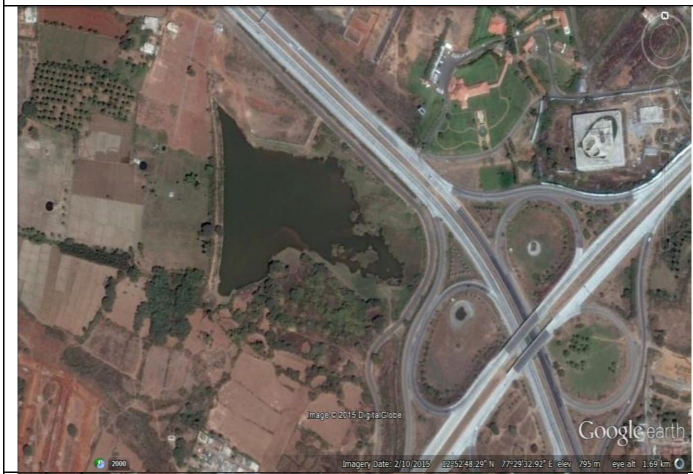
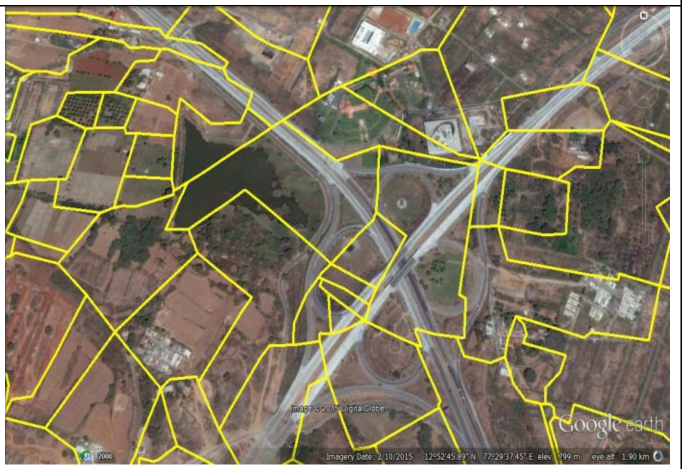
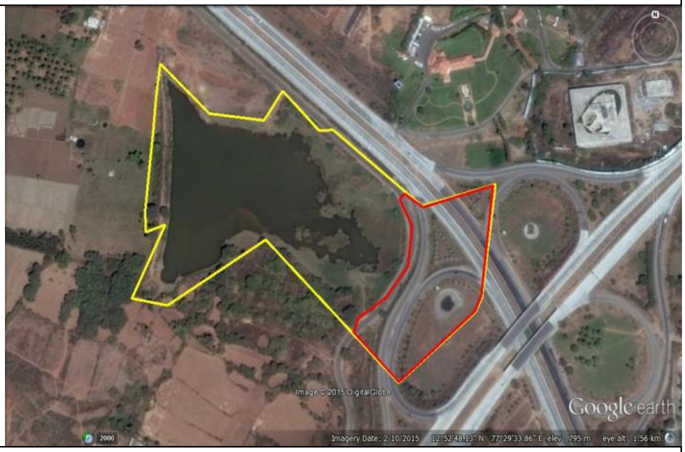


Lake spatial extent as per RTC-16.15Acres
Encroachment - 0.53Acres

Latitude-13°00'34.11"N to 13°00'40.88"N,
77°29'05.11"E to 77°29'15.89"E
Longitude-13°00'33.69"N to 13°00'45.32"N,
77°29'07.14"E to 77°29'07.24"E

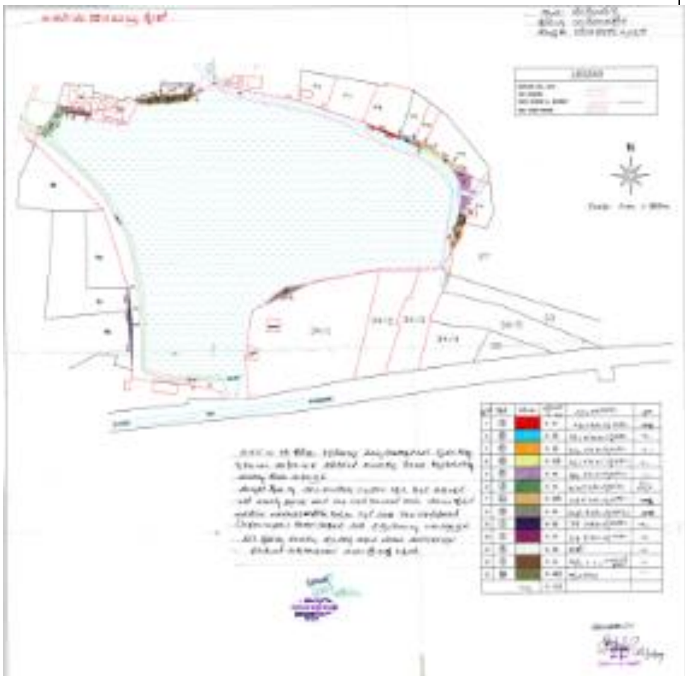
Encroachment as per our calculation-1.9Acres

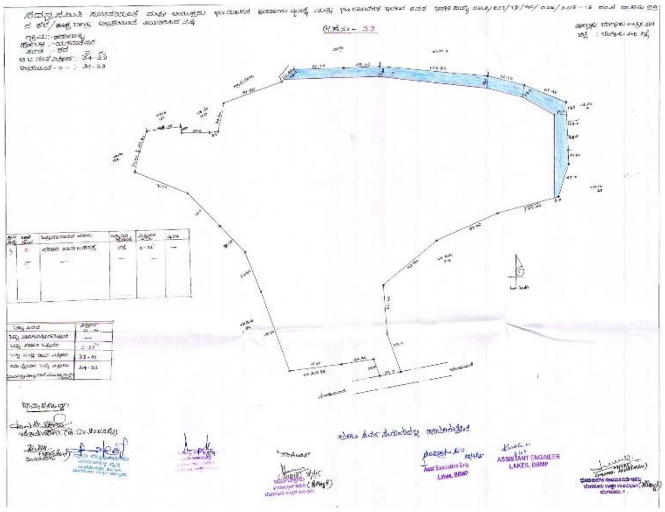
HEGGANAHALLI	Latitude-13°00'37.37"N to 13°00'38.5"N, 77°30'48.82"E to 77°30'56.91"E Longitude-13°00'40.61"N to 13°00'33.96"N, 77°30'53.99"E to 77°30'54.69"E
	
	
Lake spatial extent as per RTC-6.29Acres Encroachment as per our calculation-2.49 Acres	

HEMMIGEPURA/VARAHASANDRA	Latitude-12°52'45.49"N to 12°52'49.68"N, 77°29'24.61"E to 77°29'40.89"E Longitude-12°52'42.00"N to 12°52'54.95"N, 77°29'25.68"E to 77°29'36.16"E
	
	
Lake spatial extent as per RTC-17.5Acres Encroachment - 5.31Acres	

HEROHALLI

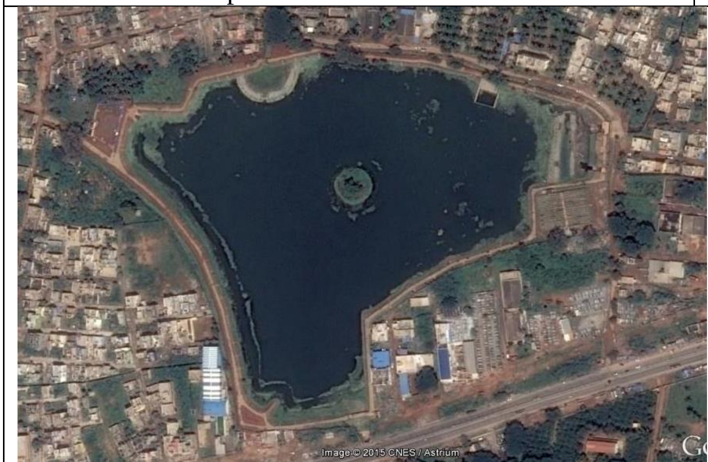
Latitude-12°59'21.23"N to 12°59'23.48"N, 77°29'14.97"E to 77°29'34.23"E
Longitude-12°59'12.35"N to 12°59'26.15"N, 77°29'23.36"E to 77°29'25.49"E





Encroachment as per SSLR-1.8Acres
Encroachment as per our calculation-1.7Acres

Lake spatial extent as per RTC-34.82Acres
Encroachment as per BBMP-0.8Acres



<table>
<tr><td>HOSKERE</td><td>Latitude-12°55'31.71"N to 12°55'49.16"N, 77°28'45.69"E to 77°29'03.68"E Longitude- 12°55'20.81"N to 12°56'01.92"N, 77°28'50.03"E to 77°29'02.08"E</td></tr>
<tr><td>
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<tr><td>
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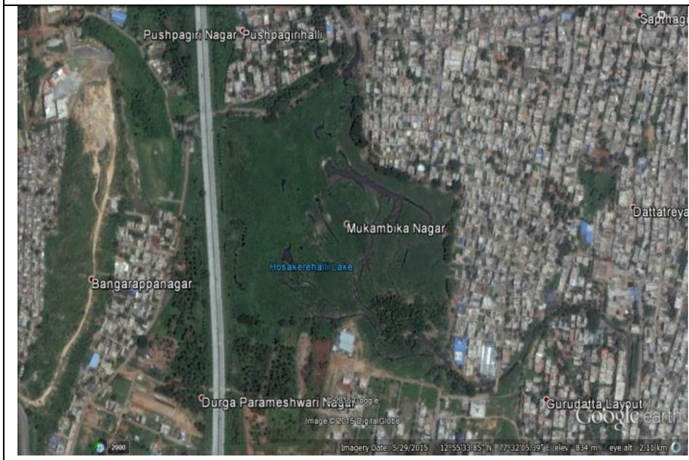
<tr><td colspan="2">Lake spatial extent as per RTC-54.14Acres
Encroachment - 10.11Acres</td></tr>
</table>

<table>
<tr><td>HOSAKEREHALLI</td><td>Latitude-12°55'25.25''N to 12°55'40.04''N, 77°31'51.86''E to 77°32'15.28''E Longitude-12°55'23.60''N to 12°55'46.22''N, 77°32'05.26''E to 77°32'13.06''E</td></tr>
<tr><td>
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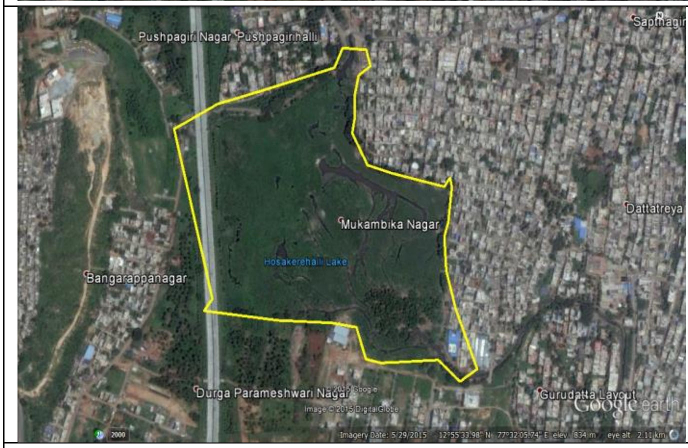
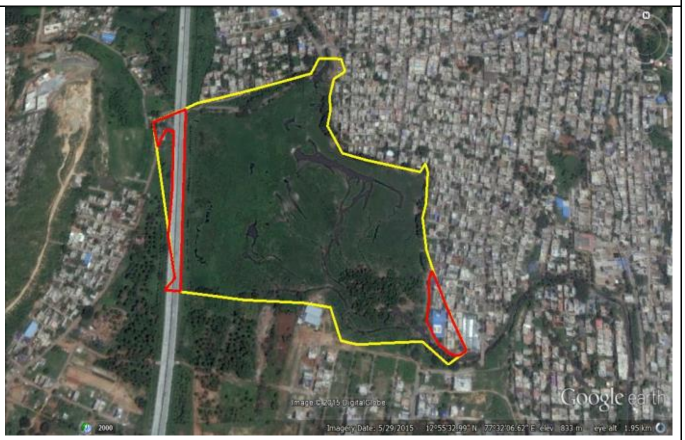
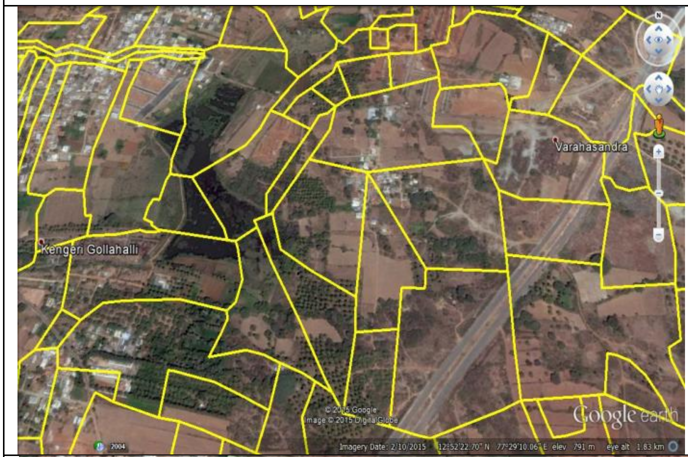
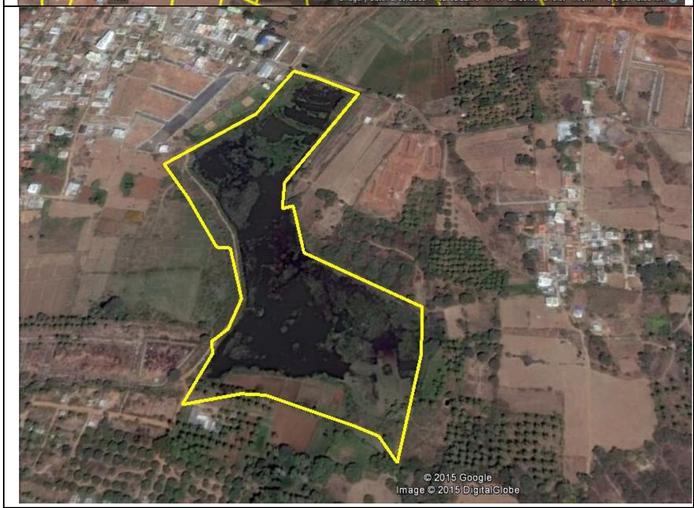
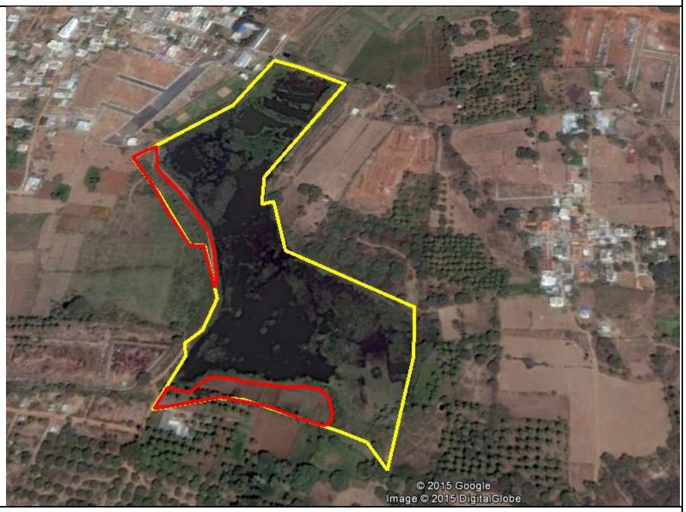
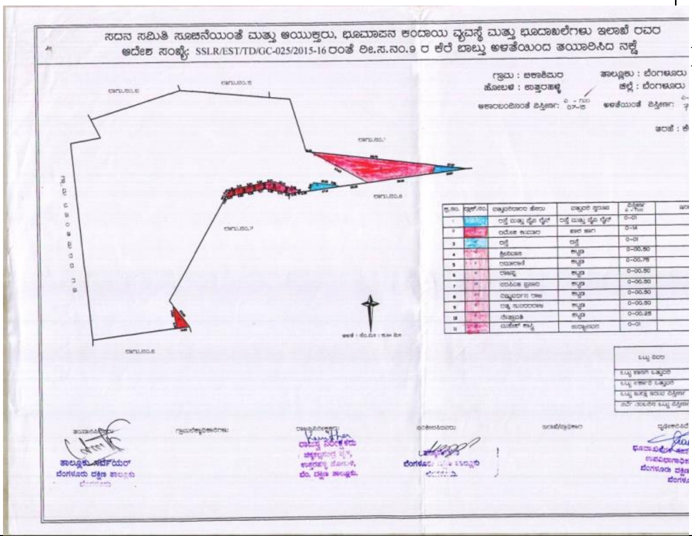
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Lake spatial extent as per RTC-59.65Acres
Encroachment as per our calculation-4.06Acres</td></tr>
</table>

H-GOLLAHALLI (VARAHASANDRA)	Latitude-12°52'23.57"N to 12°52'30.00"N, 77°28'53.81"E to 77°29'05.80"E Longitude-12°52'17.65"N to 12°52'35.28"N, 77°28'59.24"E to 77°29'04.54"E
	
	
Lake spatial extent as per RTC-19.65Acres	Encroachment - 2.01Acres

ISRO LAYOUT

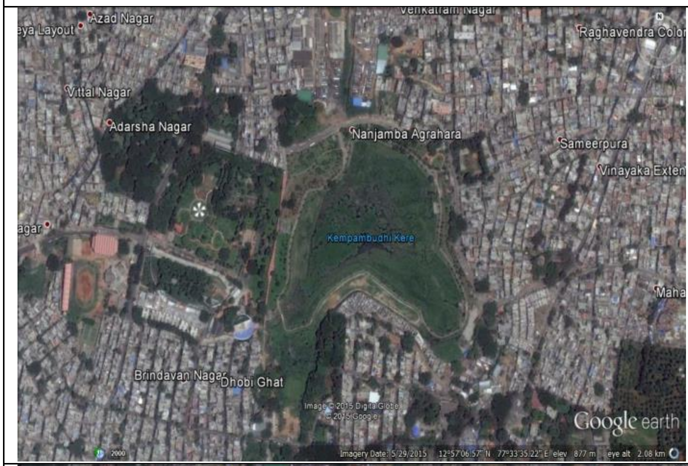
Latitude-12°53'49.45"N to 12°57'03.85"N, 77°33'13.44"E to 77°33'18.36"E
Longitude- 12°53'48.24"N to 12°53'54.34"N, 77°33'15.12"E to 77°33'16.00"E

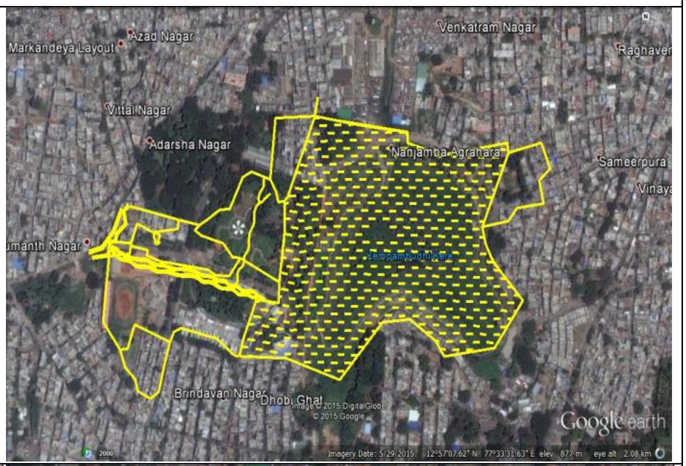


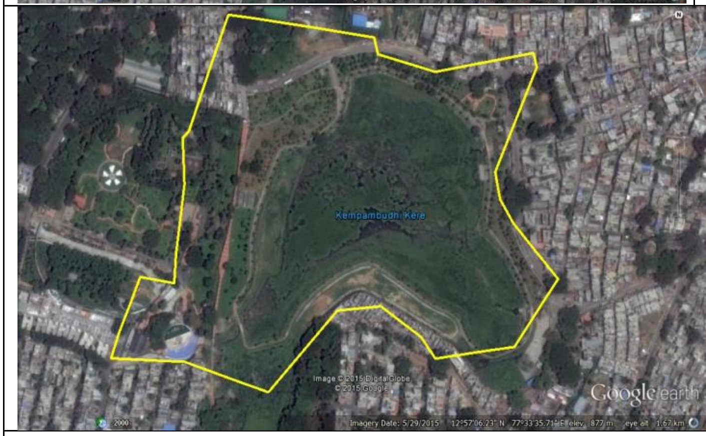
Area as per our calculation-7.15Acres
Encroachment – 1.09Acres

KEMPAMBUDHI

Latitude-12°57'00.57"N to 12°57'03.85"N,
77°33'24.33"E to 77°33'44.59"E
Longitude-12°56'58.93"N to 12°57'14.58"N,
77°33'29.98"E to 77°33'31.79"E







Area as per our calculation-43.45Acres
Encroachment - 3.79Acres

KENGERI	Latitude-12°54'49.13"N to 12°55'06.69"N, 77°29'06.05"E to 77°29'25.33"E Longitude-12°54'47.21"N to 12°55'07.93"N, 77°29'08.08"E to 77°29'23.26"E
	
	
Lake spatial extent as per RTC-32.4Acres Encroachment - 1.06Acres	

<table>
<tr><td>KONANKUNTE</td><td>Latitude-12°53'24.62"N to 12°53'31.89"N, 77°34'02.91"E to 77°34'10.11"E
Longitude-12°52'23.98 "N to 12°53'34.49"N, 77°34'08.07"E to 77°34'09.77"E</td></tr>
<tr><td>
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<tr><td>
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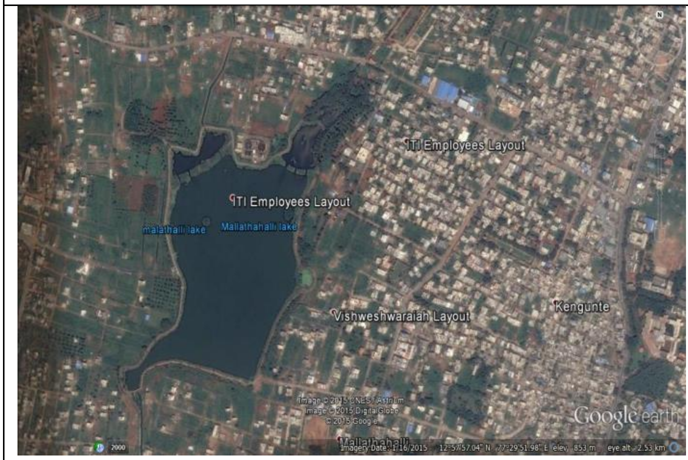
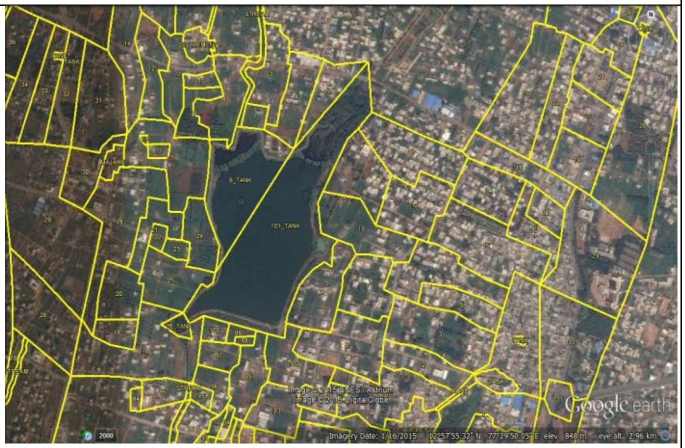
</td></tr>
<tr><td colspan="2">Lake spatial extent as per RTC-10.3Acres
Encroachment - 1.3Acres</td></tr>
</table>

KONASANDRA	Latitude-12°53'28.17"N to 12°53'34.46"N, 77°28'51.47"E to 77°29'12.4"E Longitude-12°53'26.92"N to 12°53'37.78"N, 77°29'05.95"E to 77°29'06.02"E

Lake spatial extent as per RTC-36.68Acres
Encroachment - 2.76Acres

MALLATHHALLI	Latitude-12°57'45.00''N to 12°58'07.34''N, 77°29'27.89''E to 77°29'54.86''E Longitude-12°57'42.17''N to 12°58'13.78''N, 77°29'32.24''E to 77°29'52.69''E





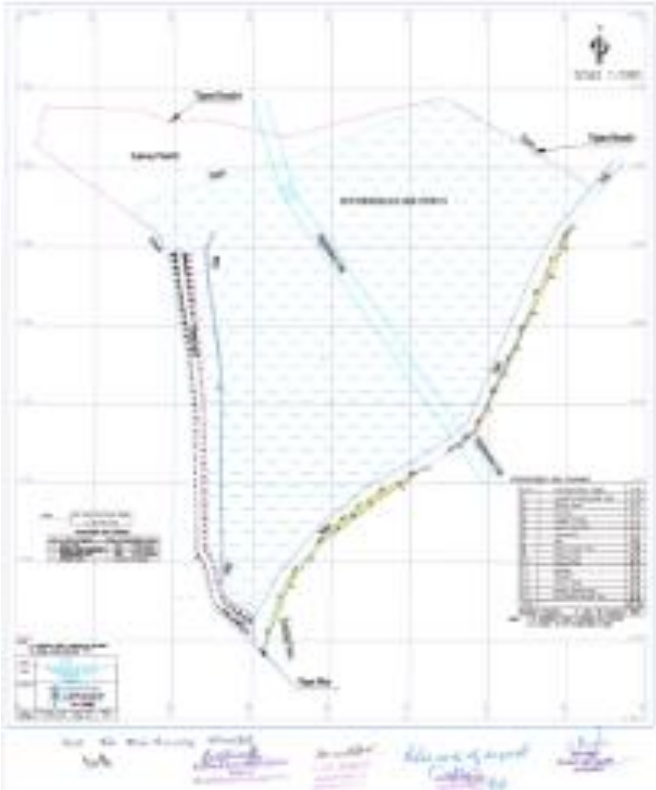
Lake spatial extent as per RTC-71.15Acr
Encroachment - 0.81Acres

MYLASANDRA 1	Latitude-12°54'24.15"N to 12°54'27.51"N, 77°29'29.82"E to 77°29'39.53"E Longitude- to 12°54'23.79"N 12°54'35.95"N, 77°29'32.89"E to 77°29'39.07"E
	
	
Area as per our calculation-12.16 Acres	

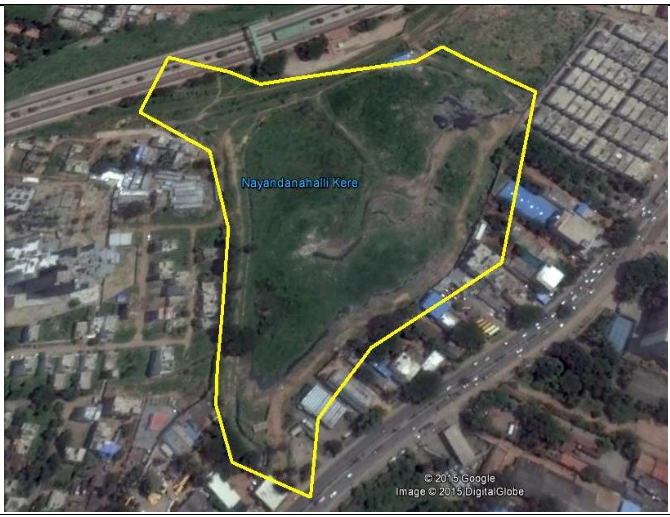
MYLASANDRA 2	Latitude-12°54'17.03"N to 12°54'21.08"N, 77°29'40.44"E to 77°29'54.83"E Longitude-12°54'18.27"N to 12°54'28.90"N, 77°29'42.26"E to 77°29'54.72"E
	
	
Area as per our calculation-16.49 Acres	

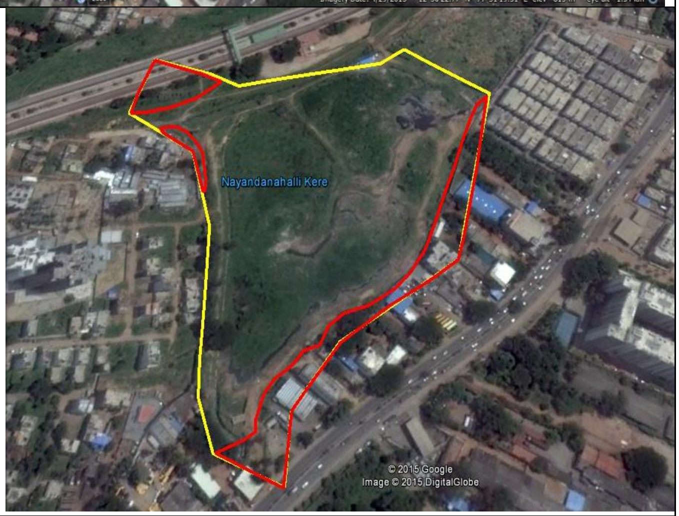
NAGARBHAVI	Latitude-12°57'53.65"N to 12°57'56.33"N, 77°30'27.49"E to 77°30'36.09"E Longitude-12°57'50.68"N to 12°58'00.28"N, 77°30'28.92"E to 77°30'30.80"E
	
	
Area as per our calculation- 9.18 Acres Encroachment -3.18 Acres	

NAYANDAHALLI	Latitude-12°56'26.11"N to 12°56'26.71"N, 77°31'10.83"E to 77°31'22.34"E Longitude-12°56'16.26"N to 12°56'28.78"N, 77°31'16.74"E to 77°31'19.39"E



Lake spatial extent as per RTC-15.45Acres
Encroachment as per BBMP -2.14Acres





Encroachment - 2.67Acres

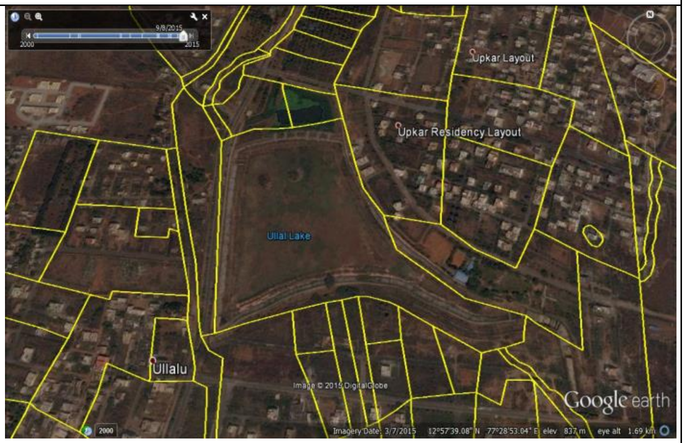
SANKEY	Latitude-13°00'28.50"N to 13°00'30.30"N, 77°34'18.73"E to 77°34'38.42"E Longitude-13°00'26.18"N to 13°00'46.38"N, 77°34'22.76"E to 77°34'37.07"E
	
Lake spatial extent as per RTC-42.35Acres	

SOMPURA	Latitude-12°52'27.23"N to 12°52'30.49"N, 77°29'50.42"E to 77°30'04.81"E Longitude-12°52'23.80"N to 13°52'36.63"N, 77°29'53.76"E to 77°30'02.87"E
	
	
Lake spatial extent as per RTC-17.95Acres	

SRINIVASPURA	Latitude-12°54'51.64"N to 12°54'53.37"N, 77°32'01.84"E to 77°32'08.90"E Longitude-12°54'46.31"N to 12°54'54.21"N, 77°32'02.51"E to 77°32'08.66"E
	
	
Lake spatial extent as per RTC-7.5Acres Encroachment -4.5 Acres	

SUBRAMANYAPURA	Latitude-12°53'50.20"N to 12°53'43.35"N, 77°32'26.38"E to 77°32'39.47"E Longitude-12°53'52.36"N to 12°53'37.58"N, 77°32'35.48"E to 77°32'32.84"E
	
	
Lake spatial extent as per RTC-18.06Acres Encroachment - 6.45Acres	

ULLAL	Latitude-12°57'33.26"N to 12°57'34.06"N, 77°28'46.26"E to 77°29'03.20"E Longitude-12°57'31.86"N to 12°57'46.47"N, 77°28'53.25"E to 77°29'00.47"E



Lake spatial extent as per RTC-24.3Acres
Encroachment -0.19Acres

<table>
<tr><td>UTTARAHALLI</td><td>Latitude-12°54'27.81"N to 12°54'34.63"N, 77°32'21.87"E to 77°32'38.74"E
Longitude-12°54'23.39"N to 12°54'35.73"N, 77°32'30.20"E to 77°32'38.01"E</td></tr>
<tr><td>
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<tr><td>
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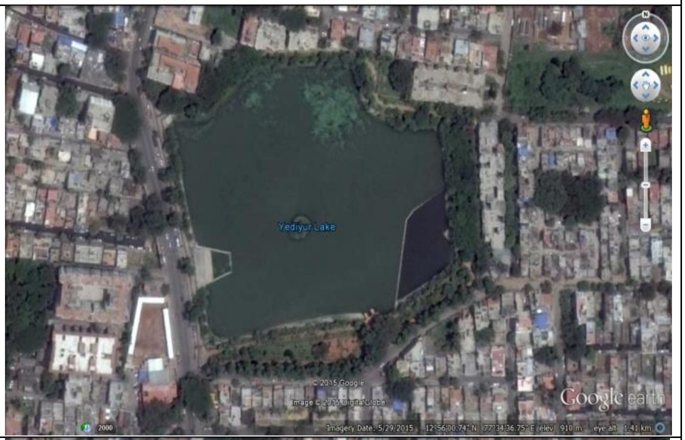
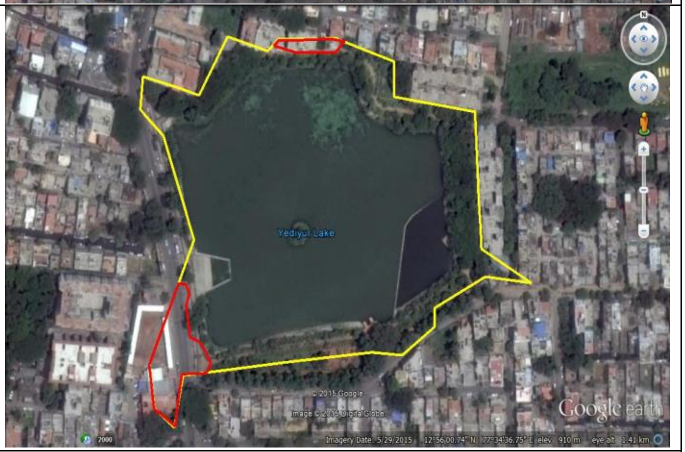
<tr><td>Lake spatial extent as per RTC-15.4Acres</td><td>Encroachment as per our calculation-1.95Acres</td></tr>
</table>

YEDIYUR	Latitude-12°55'57.35"N to 12°55'59.31"N, 77°34'31.22"E to 77°34'42.41"E Longitude-12°55'55.66"N to 12°56'05.62"N, 77°34'32.29"E to 77°34'33.61"E
	
	
Area as per our calculation-18.05 Acres Encroachment - 0.76Acres	

7. STATUS OF LAKES IN VRISHABHAVATHI VALLEY

Current Status	Recommendations
Poor water quality	1. Regular harvesting of macrophytes – helps in curtailing nutrients accumulation. 2. Improve aeration – (i) installing fountains, removing all blockages, (ii) widening and increasing number of channels / removal of blockades at outlets (refer page 19 – comparative assessment of aerators), 3. Stop dumping of municipal solid waste 4. Evict all waste processing units (in the vicinity of lakes and lake bed) 5. Stop dumping of construction and demolition (C & D) wastes in Rajakaluve, Valley zones and Lake beds 6. Strengthen legal cell (at BBMP, BDA, Forest Department, KLCDA) to address all illegalities and evolve fast track mechanism to speedy disposal and eviction of encroachers and for penalising polluters 7. No diversion of sewage from one locality to another. Decentralised treatment plants to handle sewage in the city (section 5). 8. Ensure that all apartments let only treated water to the lake. Implement mechanisms such as separate electric meters (net metering) and updating of details at respective resident association websites (including a copy at BWSSB web site) 9. Providing water quality details (each apartment discharge) – inflow to the lake at respective resident association websites (including a copy at BWSSB web site) 10. Functional ETP's to ensure zero untreated effluent discharges by industries. KSPCB to ensure zero untreated effluent discharges. 11. Evolving surprise environment audit mechanisms to ensure zero untreated effluent discharges to storm water drains (and lakes). Vetting of inspection report by the respective resident lake association. 12. Installation of surveillance cameras at the outlet of BWSSB STP (inlet of the lakes) and availability of electricity consumption details and surveillance camera streaming details to the public (through cloud sourcing or any other efficient and optimal mechanisms) 13. Formation of local residents association for each lake involving of all stakeholders to aid in regular monitoring and management. 14. Evolve mechanisms to make respective elected members (councillors, MLA and MP) and local ward engineers and bureaucrats accountable for lakes and open area status in their respective jurisdiction.

Current Status	Recommendations	Benefits
1. Untreated or partially treated Sewage	1. No more untreated sewage diversions in the city. 2. Decentralised treatment of sewage (city sewage as well as local sewage in the vicinity of the lake). Model similar to Jakkur Lake – STP with constructed wetlands and algal ponds.	1. Removal of nutrients; 2. Helps in reuse of water; 3. Removal of contaminants; 4. Regulates nutrient enrichment; 5. Recharge of groundwater without any contaminants

2. Untreated Industrial Effluents	Enforcement of 'Polluter pays principle'. Ensure zero discharge through efficient effluent treatment plants.	1. Heavy metal will not get into food chain. Currently vegetables grown with the lake water has higher heavy metals 2. Less kidney failures and instances of cancer in the city
3. Nutrient enriched sediments	De-silting of lake (wet dredging / excavation).	1. Efficient mechanism of rainwater harvesting. Water yield in the catchment is 5.6 TMC and storage capacity of lakes is about 7TMC. 2. Increase the storage capacity 3. Enhances the groundwater recharging potential
4. Regular maintenance of macrophytes	Macrophytes harvesting at regular interval	1. Helps in further treatment of water as macrophytes uptake nutrients and regular harvesting would prevent accumulations 2. Supports livelihood of local people 3. Scope for generating energy (biogas)
5. Frothing	i. Ban Phosphorus use in detergents or regulate detergent with Phosphorous in market ii. Decentralised treatment of sewage (city sewage as well as local sewage in the vicinity of the lake). Model similar to Jakkur Lake – STP with constructed wetlands and algal ponds.	1. Reduces eutrophication of lakes (nutrient enrichment 2. Minimises the instance of frothing 3. Minimises health issues (skin, respiratory, etc.) related to contaminated air; 4. Reduces accident instances

EWRG, IISc Monitored lakes during 2016-17

Sl.No.	Lake Name
1	Ballehannu
2	Deepanjalinagarakere
3	Doraikere
4	Dubasipalya
5	Hemmigepura
6	Hosakerehallikere
7	ISRO layout
8	Kempambudhi
9	Mallathhalli
10	Sankeykere
11	Shrinivasapura
12	Sompura
13	Ullal lake
14	Uttarahalli
15	Yediyurkere

1. BAALLEHANNU LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	BAALLEHANNU KERE/ MALGALA
GEOGRAPHIC DETAILS	Latitude: 12°58'42.29"N to 12°58'42.91"N; 12°58'38.65"N to 12°58'44.67"N Longitude: 77°31'35.31"E to 77°31'45.94"E; 77°31'35.85"E to 77°31'36.45"E
AREA AS PER RTC	6.65 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Malgala - 46
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Moderately Polluted
RESTORATION	Restored
WATER CONDITION	Poor, Light green colour
CLASS (As per CPCB)	Class D – Water for fish culture and wild life propagation. Class E – Water for irrigation, industrial cooling and controlled waste disposal.
Baallehannukere lies in the Sampige Layout, Prashantnagar, Bengaluru, Karnataka. It is a shallow, restored lake with well maintained garden. The lake has a well maintained garden with shady trees, sitting arrangements, good pathway and provides facilities for recreation for kids and joggers. The lake is inside residential areas, buildings etc.	
 **Baallehannu Lake**	 **Macrophyte cover**
 **Inlet point**	 **Park area**
Problems: Untreated sewage flow, weed growth near the shorelines	**Importance:** Recreational purposes, ground water recharge, supports growth of aquatic organisms (algae, zooplankton, macrophytes and fishes)

Water Quality Analysis of Baallehannu Lake

Parameters	Baallehannu	Water quality Standard IS 10500, 1991-2011	
		Desirable	Permissible
Water Temperature (°C)	30.2	-	-
TDS (mg/l)	317	500	2000
EC (µS/cm)	585	-	-
pH	7.96	6.5-8.5	No relaxation
DO (mg/l)	4.23	-	-
BOD (mg/l)	28.46	-	-
COD (mg/l)	68	-	-
Total Alkalinity (mg/l)	486.67	200	600
Chloride (mg/l)	77.15	250	1000
Total Hardness (mg/l)	199.33	300	600
Calcium (mg/l)	44.09	75	200
Magnesium (mg/l)	21.77	30	100
Ortho-Phosphate (mg/l)	0.117	-	-
Nitrate (mg/l)	0.349	45	100
Sodium (mg/l)	92	-	-
Potassium (mg/l)	11.6	-	-

The lake has high sodium and organic contents due to sewage water entry.

Inference:
As per Classification of Inland Surface Water (CPCB), Baallehannu lake falls under D and E.
Class D – Water for fish culture and wild life propagation
Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Asterococcus* sp.; *Coelastrum* sp.; *Pinnularia* sp.; *Oscillatoria* sp.; *Synedra* sp.; *Cocconeis* sp.; *Navicula* spp.; *Nitzschia* spp.; *Scenedesmus* spp.; *Oocystis* sp.; *Cymbella* sp.; *Achnanthes* sp.; *Phacus* spp.; *Trachelomonas* sp.; *Pediastrum* sp. and *Euglena* spp.

ZOOPLANKTON: *Paramecium aurelia*; *Amoeba* sp.; *Mesocyclops leuckarti*; Nauplius larvae; *Asplanchna priodonta*; *Brachionus calicyflorus*; *Brachionus rotundiformis* and Chironomid larvae.

MACROPHYTE: *Cyperus rotundus* and *Alternanthera philoxeroides*.

2. DEEPANJALI NAGARA LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**DEEPANJALI NAGARA**
GEOGRAPHIC DETAILS	Latitude: 12°56'58.21"N to 12°56'58.88"N; 12°56'53.54"N to 12°57'02.08"N Longitude: 77°31'47.89"E to 77°31'56.16"E; 77°31'50.33"E to 77°31'52.26"E
AREA AS PER RTC	7.55 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Devatige Ramanahalli-32
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi valley
STATUS	Less Polluted
RESTORATION	Newly restored lake
WATER CONDITION	Grey coloured water
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Deepanjali Nagara Kere is situated in NayandaHalli, Bengaluru, Karnataka. It is a newly restored lake. Presently, lake is fully covered with macrophyte and very less water. This lake will have a public park and a lake together. There is a drainage adjacent to this lake that ensures continuous water supply.

Deepanjali Nagara Kere

Covered with macrophytes

A shallow lake

Buildings near the lake

Problems: Entry of untreated sewage, covered with macrophytes	**Importance:** Recreational purposes

Water Quality Analysis of Deepanjali Nagara Kere

Parameters	Deepanjali Nagarakere	Water quality Standard IS 10500, 1991-2011	
		Desirable	Permissible
Water Temperature (˚C)	24.8	-	-
TDS (mg/l)	395	500	2000
EC (μS/cm)	656	-	-
pH	7.2	6.5-8.5	No relaxation
DO (mg/l)	0	-	-
COD (mg/l)	10	-	-
Total Alkalinity (mg/l)	336	200	600
Chloride (mg/l)	81.89	250	1000
Total Hardness (mg/l)	302	300	600
Calcium (mg/l)	73.75	75	200
Magnesium (mg/l)	28.75	30	100
Ortho-Phosphate (mg/l)	0.097	-	-
Nitrate (mg/l)	0.239	45	100
Sodium(mg/l)	116.4	-	-
Potassium(mg/l)	8.4	-	-

The dissolved oxygen level in the lake is zero as it is fully covered with macrophytes that obstructs light penetration and reduces photosynthesis. The reduction in the ion and nutrient contents is due to their uptake by macrophytes for growth.

Inference:
As per Classification of Inland Surface Water (CPCB), Deepanjali Nagara Kere falls under E.
Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Nitzschia* sp.; *Synedra* sp.; *Cymbella* sp.; *Fragilaria* sp.; *Pinnularia* sp.; *Phormidium* sp.; *Navicula* sp.; *Pediastrum* sp.; *Surirella* sp.; *Anabaena* sp.; *Closterium* sp. and *Spirogyra* sp.

ZOOPLANKTON: *Thermocyclops oithonoides*; *Chydorus sphaericus*; *Brachionus angularis*; *Mesocyclops leuckarti*; *Filinia terminalis*; *Macrocyclops* sp.; *Brachionus calyciflorus*; *Lecane* sp.; *Keratella* sp.; *Diaphanosoma* sp.; Nauplius larvae; *Arcella* sp. and *Daphnia longispina*.

MACROPHYTE: *Lemna gibba*; *Lemna minor*; *Cyperus* sp.; *Ludwigia adscendens*; *Alternanthera philoxeroides*; *Eichhornia crassipes* and *Polygonum glabrum*.

3. DORAIKERE LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**DORAIKERE**
GEOGRAPHIC DETAILS	Latitude-12°54'07.35"N to 12°54'12.84"N; 12°54'04.71"N to 12°54'16.66"N Longitude: 77°32'55.00"E to 77°33'12.36"E; 77°32'56.44"E to 77°33'02.06"E
AREA AS PER RTC	28.57 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Uttarahalli - 16, Vasanthpura - 6
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored
WATER CONDITION	Light green coloured water with algae growth
CLASS	Class D – Water for fish culture and wild life propagation. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Doraikere lake Dorekere Lake (Doraikere) is located in Uttarahalli, Bangalore. The lake is surrounded by Bharat Housing Society in the North and West, by Maruthi and ISRO Layouts in the South and East respectively. The wastewater of all these layouts is let into the lake.

Doraikere lake

Treatment plant

Effluent water

1st part of the lake

Sewage water entering the lake

Lake outlet

Problems: Untreated sewage entry and plastic wastes floating at lake surface	**Importance:** The lake supports lot of birds, algae, zooplankton and fishes.

Water Quality Analysis of Doraikere Lake

Parameters	Effluent	Ist part	Lake	Outlet	Water quality Standard IS 10500, 1991-2011	
					Desirable	Permissible
Water temperature (^{0}C)	24.70	24.30	24.60	24.70	-	-
TDS (mg/l)	560	665	222	323	500	2000
EC (µS/cm)	879	1028	536	538	-	-
pH	7.05	7.27	6.94	7.05	6.5-8.5	No relaxation
DO (mg/l)	7.32	3.33	4.47	3.82	-	-
COD (mg/l)	24	100	68	88	-	-
Total Alkalinity (mg/l)	184	630	204	214	200	600
Chloride (mg/l)	128.51	77.39	59.64	60.35	250	1000
Total Hardness (mg/l)	222	312	168	174	300	600
Calcium (mg/l)	64.93	103.41	51.7	53.31	75	200
Magnesium (mg/l)	14.61	13.13	9.49	9.98	30	100
Ortho-Phosphate (mg/l)	1.31	5.12	1.31	0.87	-	-
Nitrate (mg/l)	6.57	0.99	1.14	1.59	45	100
Sodium (mg/l)	179.5	93	81	83.5	-	-
Potassium (mg/l)	37	33	18.5	18	-	-

The dissolved oxygen levels in the lake are less because of algal (*Microcystis* sp.) bloom that obstructs light penetration and promotes higher decomposition rates. The reduction in the ionic and nutrient contents is due to their uptake by phytoplankton for growth. A STP (1 MLD) was constructed in 2010 which discharges treated water into the lake. Drying and desilting of the water body, fencing (to prevent encroachments) and removal of existing encroachments were done as part of lake rejuvenation work. In late 2012 or early 2013, the lake was de-weeded to improve its water quality.

Inference: As per Classification of Inland Surface Water (CPCB), Doraikere lake falls under D and E. (Class D - Fish culture and wild life propagation; Class E – Water for irrigation, industrial cooling and controlled waste disposal)

AQUATIC BIODIVERSITY

ALGAE: *Microcystis* sp.; *Trachelomonas* sp.; *Dictyosphaerium* sp.; *Scenedesmus* spp.; *Melosira* sp.; *Nitzschia* sp.; *Schroederia* sp.; *Closterium* sp.; *Monoraphidium* sp.; *Golenkinia* sp.; *Coelastrum* sp.; *Synedra* sp.; *Pediastrum* sp.; *Crucigenia* sp.; *Actinastrum* sp.; *Tetrastrum* sp.; *Cyclotella* sp.; *Phacus* sp.; *Staurastrum* sp.; *Spirulina* sp.; *Phormidium* sp.; *Euglena* sp. and *Chlorella* sp.

ZOOPLANKTON: *Brachionus falcatus*; *Brachionus caudatus*; *Mesocyclops leuckarti*; *Brachionus calyciflorus*; *Brachionus angularis*; *Filinia terminalis*; *Polyarthra vulgaris*; *Keratella* sp.; *Diaphanosoma* sp.; Nauplius larvae; *Brachionus quadridentatus* and *Thermocyclops oithonoides*.

MACROPHYTE: *Alternanthera philoxeroides*; *Ludwigia adscendens* and *Cyperus* sp.

4. DUBASIPALYA LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**DUBASIPALYA**
GEOGRAPHIC DETAILS	Latitude: 12°55'53.25"N to 12°55'54.11"N; 12°55'43.23"N 12°56'01.36"N Longitude: 77°29'35.33"E to 77°29'48.58"E; 77°29'42.40"E to 77°29'42.64"E
AREA AS PER RTC	24.88 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Valagerehalli - 43
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi valley
STATUS	Highly Polluted
RESTORATION	Restored
WATER CONDITION	Less water with macrophyte growth
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Odegerahalli Dobasipalya Lake/ Dubasipalya or Valagerahalli Lake in Ullalu ward is spread across 23 acres 35 guntas. The lake is fenced and maintained by the Forest department. It is just half a kilometer from Kengeri lake and the satellite bus stand. The lake is surrounded by residential areas. Inlet to the lake is seen towards north eastern side and western side. A bund is found towards south western side of the lake. A UGD system from the nearby localities is connected to the lake on southern side. Now this lake is under restoration.

Dubasipalya lake

A shallow lake

Macrophytes cover

Buildings near to the lake

Dumping of building debris

Sewage water entering the lake

Problems:
Entry of untreated sewage, dumping of solid waste and building debris, macrophyte growth

Importance:
The lake will serve all the wetland function if maintained properly.

Water Quality Analysis of Dubasipalya Lake

Parameters	Dubasipalya		Water quality Standard IS 10500, 1991-2011	
	Lake	Inlet	Desirable	Permissible
Water temperature (^{0}C)	28	30	-	-
TDS (mg/l)	658	825	500	2000
EC (µS/cm)	975	1195	-	-
pH	6.96	7.34	6.5-8.5	No relaxation
DO (mg/l)	1.79	0	-	-
COD (mg/l)	44	100	-	-
Total Alkalinity (mg/l)	430	574	200	600
Chloride (mg/l)	134.19	150.52	250	1000
Total Hardness (mg/l)	369	327	300	600
Calcium (mg/l)	98.6	85.77	75	200
Magnesium (mg/l)	29.96	27.53	30	100
Ortho-Phosphate (mg/l)	0.36	5.79	-	-
Nitrate (mg/l)	0.22	0.41	45	100
Sodium (mg/l)	183	244	-	-
Potassium (mg/l)	23	46	-	-

Water is polluted with sewage water so water has higher ionic and nutrient content which supports profuse growth of macrophytes in the lake. This causes depletion of dissolved oxygen in the lake.

Inference: As per Classification of Inland Surface Water (CPCB), Dubasipalya lake falls under E. [Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Trachelomonas* sp.; *Scenedesmus* spp.; *Micractinium* sp.; *Euglena* sp.; *Fragilaria* sp.; *Monoraphidium* sp.; *Chlorella* sp.; *Synedra* sp.; *Pediastrum* sp.; *Crucigenia* sp.; *Staurastrum* sp.; *Tetraedron* sp.; *Golenkinia* sp.; *Dictyosphaerium* sp.; *Gomphonema* sp.; *Phacus* sp.; *Pinnularia* sp.; *Closterium* sp.; *Euglena* sp.; *Stigeoclonium* sp.; *Coelosphaerium* sp. and *Oscillatoria* sp.

ZOOPLANKTON: *Macrocyclops* sp.; *Mesocyclops leuckarti*; *Thermocyclops oithonoides*; *Lecane* sp.; *Brachionus falcatus* and *Brachionus forficula*.

MACROPHYTE: *Cyperus alternifolius*; *Cyperus rotundus*; *Polygonum glabrum*; *Polygonum* sp.; *Typha angustifolia*; *Lemna gibba*; *Lemna minor*; *Spirodela polyrrhiza*; *Pistia stratiotes*; *Ipomea carnea*; *Alternanthera philoxeroides*; *Ludwigia adscendens* and *Eichhornia crassipes*.

5. HEMMIGEPURA LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	HEMMIGEPURA/VARAHASANDRA
GEOGRAPHIC DETAILS	Latitude-12°52'45.49"N to 12°52'49.68"N; 12°52'42.00"N to 12°52'54.95"N Longitude: 77°29'24.61"E to 77°29'40.89"E; 77°29'25.68"E to 77°29'36.16"E
AREA AS PER RTC	17.5 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Hemigepura - 4, Varahasandra - 24
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Moderately Polluted
RESTORATION	Restored
WATER CONDITION	Clear water
CLASS (As per CPCB)	Class D – Water for fish culture and wild life propagation. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Hemmigepura lake is located near NICE Ring Road, Hemmigepura, Bengaluru, Karnataka. It is a non-restored lake. Lake water is used for domestic purposes, irrigation and cultural practices.


Hemmigepura lake


A shallow lake


No boundary and fencing


Lake is getting dried


Plastics and building debris near the lake


Macrophyte cover in the lake

Problems:	Importance: Supports mollusks, fish and bird diversity, recreational purposes, ground water recharge. Lake is used as a traditional place of

Lake is poorly maintained, dumping of solid wastes and plastics, open defecation, water is used for washing clothes	rituals and pujas (offerings) during religious and social festivals

Water Quality Analysis of Hemmigepura Lake

Parameters	Hemmigepura	Water quality Standard IS 10500, 1991-2011	
		Desirable	Permissible
Water Temperature (˚C)	29.8	-	-
TDS (mg/l)	522	500	2000
EC (µS/cm)	887	-	-
pH	8.18	6.5-8.5	No relaxation
DO (mg/l)	7.15	-	-
BOD (mg/l)	4.07	-	-
COD (mg/l)	6	-	-
Total Alkalinity (mg/l)	241.33	200	600
Chloride (mg/l)	153.83	250	1000
Total Hardness (mg/l)	232	300	600
Calcium (mg/l)	56.91	75	200
Magnesium (mg/l)	21.93	30	100
Ortho-Phosphate (mg/l)	0.076	-	-
Nitrate (mg/l)	0.273	45	100
Sodium (mg/l)	236.4	-	-
Potassium (mg/l)	14.8	-	-

The nutrients in Hemmigepura lake support the growth of algae, zooplankton, mollusks, aquatic insects, fishes, birds and macrophytes. All the parameters are within the permissible limits according to the Indian drinking water standards.

Inference: As per Classification of Inland Surface Water (CPCB), Hemmigepura lake falls under D and E

Class D – Water for fish culture and wild life propagation.

Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Closterium* sp.; *Merismopedia* sp.; *Aulacoseira* sp.; *Nitzschia* spp.; *Achnanthes* sp.; *Scenedesmus* spp.; *Planktothrix* sp.; *Oscillatoria* sp.; *Coelastrum* sp.; *Pandorina* sp.; *Cyclotella* sp.; *Navicula* spp.; *Pediastrum* sp.; *Euglena* spp.; *Phacus* spp. and *Trachelomonas* sp.

ZOOPLANKTON: *Chydorus sphaericus*; *Mesocyclops aspericornis* and *Brachionus calyciflorus*.

MACROPHYTE: *Alternanthera philoxeroides*; *Cyperus articulates*; *Cyperus rotundus*; *Cyperus* spp.; *Typha angustata*; *Bacopa monnieri*; *Ipomea aquatic*; *Ipomea carnea*; *Echinochloa* sp. and *Eleocharis* sp.

6. HOSKEREHALLI LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**HOSKEREHALLI**
GEOGRAPHIC DETAILS	Latitude: 12°55'25.25"N to 12°55'40.04"N; 12°55'23.60"N to 12°55'46.22"N Longitude: 77°31'51.86"E to 77°32'15.28"E; 77°32'05.26"E to 77°32'13.06"E
AREA AS PER RTC	59.65 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Hosakerehalli -15
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Now restoration started
WATER CONDITION	Light green coloured water with algae growth
CLASS	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Hoskerehalli lake is situated at Mookambika Nagar, Hosakerehalli, Bengaluru. Sewage from Jayanagar, Chennamma Kere, Achchukattu area, Padmanabhanagar, Chikkalsandra, Ittamadu, IGS Layout, etc. flow to this lake through *Raja Kaaluve*.

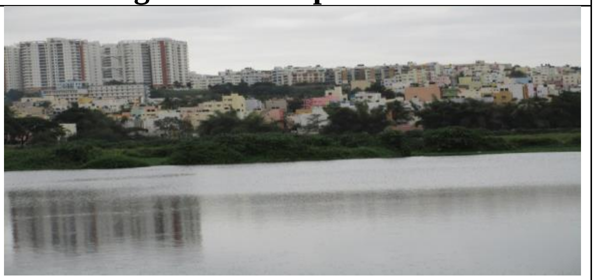
Hoskarehalli lake

Macrophyte cover

Solid wastes dumped near the lake

Building debris dumped near the lake

Lake has no boundary/fence



Buildings near the lake

Problems: Untreated sewage entry, Solid waste dumping near lake bed, A poorly maintained lake, Macrophyte growth, Cattle grazing, Damaged fencing	**Importance:** The lake will serve all the wetland function if maintained properly.

Water Quality Analysis of Hoskerehalli Lake

Parameters	Hoskerehalli	Water quality Standard IS 10500, 1991-2011	
	Lake	Desirable	Permissible
Water temperature (^{0}C)	24.6	-	-
TDS (mg/l)	356	500	2000
EC (µS/cm)	564	-	-
pH	7.55	6.5-8.5	No relaxation
DO (mg/l)	6.18	-	-
COD (mg/l)	68	-	-
Total Alkalinity (mg/l)	240	200	600
Chloride (mg/l)	46.86	250	1000
Total Hardness (mg/l)	236	300	600
Calcium (mg/l)	70.94	75	200
Magnesium (mg/l)	14.36	30	100
Ortho-Phosphate (mg/l)	0.65	-	-
Nitrate (mg/l)	0.26	45	100
Sodium (mg/l)	56	-	-
Potassium (mg/l)	9	-	-

The lake is fully covered with macrophytes that obstruct light penetration. The low ionic contents in lake water are due to dilution with rain water and their uptake by macrophytes for growth.

Inference: As per Classification of Inland Surface Water (CPCB), Hoskerehalli lake falls under E [Class E – Water for irrigation, industrial cooling and controlled waste disposal].

AQUATIC BIODIVERSITY

ALGAE: *Coelastrum* sp.; *Cyclotella* sp.; *Melosira* sp.; *Scenedesmus* spp.; *Phacus* sp.; *Micractinium* sp.; *Dictyosphaerium* sp. and *Pediastrum* sp.

ZOOPLANKTON: *Brachionus angularis*; *Mesocyclops leuckarti*; *Keratella* sp.; *Brachionus plicatilis*; *Filinia terminalis*; *Brachionus quadridentatus*; *Brachionus calyciflorus*; Nauplius larvae; *Polyarthra vulgaris*; *Macrocyclops* sp.; *Thermocyclops oithonoides*; *Brachionus forficula* and *Brachionus diversiconis*.

MACROPHYTE: *Colocasia esculenta*; *Alternanthera philoxeroides*; *Eichhornia crassipes*; *Cyperus* sp. and *Polygonum glabrum*.

7. ISRO LAYOUT LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**ISRO LAYOUT**
GEOGRAPHIC DETAILS	Latitude: 12°53'49.45"N to 12°57'03.85"N; 12°53'48.24"N to 12°53'54.34"N Longitude: 77°33'13.44"E to 77°33'18.36"E; 77°33'15.12"E to 77°33'16.00"E
AREA AS PER RTC	7.15Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Bikashipura-5
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Restored
WATER CONDITION	Light green coloured water with algae growth
CLASS	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

ISRO Layout lake: ISRO Layout Lake/**Devarakere Tank in the ISRO Layout near Banashankari in Bengaluru South.** The lake has a well maintained garden with shady trees, sitting arrangements, good pathway and provides facilities for recreation for kids and joggers. The lake is inside residential areas, buildings etc.

ISRO Layout lake

Macrophyte cover

Temple at the lake

Buildings near the lake

Profuse algae growth in the lake

Park side

Problems: Untreated sewage entry, A poorly maintained lake, Macrophyte growth	**Importance:** The lake will serve all the wetland function if maintained properly.

Water Quality Analysis of ISRO Layout Lake

Parameters	ISRO layout	Water quality Standard IS 10500, 1991-2011	
	Lake	Desirable	Permissible
Water temperature (^{0}C)	26.1	-	-
TDS (mg/l)	269	500	2000
EC (µS/cm)	452	-	-
pH	7.57	6.5-8.5	No relaxation
DO (mg/l)	9.84	-	-
COD (mg/l)	92	-	-
Total Alkalinity (mg/l)	186	200	600
Chloride (mg/l)	66.03	250	1000
Total Hardness (mg/l)	136	300	600
Calcium (mg/l)	31.26	75	200
Magnesium (mg/l)	14.14	30	100
Ortho-Phosphate (mg/l)	0.45	-	-
Nitrate (mg/l)	0.16	45	100
Sodium (mg/l)	62	-	-
Potassium (mg/l)	18.5	-	-

The organic matter in the lake is high because of macrophytes degradation and shallow nature of the lake. The reductions in the ionic and nutrient contents are due to their uptake by macrophytes and algae for growth.

Inference: As per Classification of Inland Surface Water (CPCB), ISRO Layout lake falls under E [Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Microcystis* sp.; *Nitzschia* sp.; *Cyclotella* sp.; *Micractinium* sp.; *Golenkinia* sp.; *Pediastrum* sp.; *Synedra* sp.; *Dictyosphaerium* sp.; *Scenedesmus* sp.; *Monoraphidium* sp. and *Chroococcus* sp.

ZOOPLANKTON: *Polyarthra vulgaris*; *Mesocyclops leuckarti*; *Brachionus rotundiformis*; *Philodina* sp.; Nauplius larvae; *Lecane* sp.; *Vorticella* sp. and *Arcella* sp.

MACROPHYTE: *Polygonum glabrum*; *Polygonum* sp.; *Cyperus alternifolius*; *Cyperus papyrus*; *Alternanthera philoxeroides* and *Typha angustifolia*.

8. KEMPAMBUDHI KERE	Vrishabhavathi Valley
NAME OF THE LAKE	**KEMPAMBUDHI KERE**
GEOGRAPHIC DETAILS	Latitude:12°57'00.57"N to 12°57'03.85"N; 12°56'58.93"N to 12°57'14.58"N Longitude: 77°33'24.33"E to 77°33'44.59"E; 77°33'29.98"E to 77°33'31.79"E
AREA AS PER RTC	43.45 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Kempambudhi - 2
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored
WATER CONDITION	Light green coloured water with algae growth
CLASS	Class D – Water for fish culture and wild life propagation. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Kempambudhi kere: Kempambudhi lake is located in Nanjamba Agrahara, Chamrajpet, Bengaluru, Karnataka. The founder of Bangalore, Kempegowda, constructed the lake. It served as drinking water source to the people living in the surrounding areas.


Kempambudhi kere


Restoration activities


Burning of solid wastes near the lake


Sewage water flowing near the lake


Restoration activities


Shallow lake

Problems: Untreated sewage entry Solid waste dumping near lake, A poorly maintained lake, Macrophyte growth, Open defecation, Cattle grazing	**Importance:** The lake will serve all the wetland function if maintained properly.

Water Quality Analysis of Kempambudhi Lake

Parameters	Kempambudhi	Water quality Standard IS 10500, 1991-2011	
	Lake	Desirable	Permissible
Water temperature (^{0}C)	24.9	-	-
TDS (mg/l)	537	500	2000
EC (µS/cm)	822	-	-
pH	8.5	6.5-8.5	No relaxation
DO (mg/l)	18.29	-	-
COD (mg/l)	128	-	-
Total Alkalinity (mg/l)	450	200	600
Chloride (mg/l)	124.25	250	1000
Total Hardness (mg/l)	298	300	600
Calcium (mg/l)	69.34	75	200
Magnesium (mg/l)	30.47	30	100
Ortho-Phosphate (mg/l)	3.7	-	-
Nitrate (mg/l)	1.32	45	100
Sodium (mg/l)	202	-	-
Potassium (mg/l)	29	-	-

With development of the city, sewerage began flowing into the lake through the storm water drains leading to pollution. The lake has little water and uncontrolled growth of weeds and grasses. The 36-acre Kempambudhi lake is now restored and has pathways, lighting facilities and a well maintained garden. A mini STP of 1 MLD is present near the lake. The dissolved oxygen level in the lake is so high with algal photosynthesis. The ionic, nutrient contents and high organic matter helped in growth of macrophytes and algae.

Inference: As per Classification of Inland Surface Water (CPCB), Kempambudhi lake falls under E [Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Cyclotella* sp.; *Pandorina* sp.; *Scenedesmus* sp.; *Navicula* sp.; *Tetraedron* sp.; *Schroederia* sp.; *Tetrastrum* sp.; *Euglena* sp.; *Pinnularia* sp.; *Phacus* sp.; *Monoraphidium* sp., *Oscillatoria* sp.; *Pediastrum* sp.; *Closterium* sp.; *Crucigenia* sp. and *Nitzschia* sp.

ZOOPLANKTON: *Asplanchna* sp.; Nauplius larvae; *Filinia terminalis*; *Mesocyclops leuckarti*; *Macrocyclops* sp.; *Thermocyclops oithonoides*; *Brachionus quadridentatus*; *Brachionus rubens*; *Brachionus forficula*; *Polyarthra vulgaris*; *Brachionus angularis* and *Lecane* sp.,

MACROPHYTE: *Sagittaria sagittifolia*; *Alternanthera philoxeroides*; *Ludwigia adscendens* and *Eichhornia crassipes*.

9. MALLATHHALLI LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**MALLATHHALLI**
GEOGRAPHIC DETAILS	Latitude-12°57'45.00"N to 12°58'07.34"N, 77°29'27.89"E to 77°29'54.86"E Longitude-12°57'42.17"N to 12°58'13.78"N, 77°29'32.24"E to 77°29'52.69"E
AREA AS PER RTC	71.15 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Mallathahalli -101, Giddadakonenahalli - 6
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Highly Polluted
RESTORATION	Restored
WATER CONDITION	Very poor, Grey coloured water
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Mallathahalli lake falls in the Vrishabhavathi valley and Byramangala lake series and is located on the western fringe of Bangalore city. Inlets are at the north and north-east corners of the lake while an outlet is located in the north-western corner. The lake covers approximately 25.9 Ha surface area and perimeter being approximately 2,900 m. Mallathahalli lake water is being used for washing of clothes, animals, vehicles and even bathing, especially on the northern and eastern banks of the lake.

Open defecation is prevalent in the region leading to unhygienic environment and increasing the organic load in the lake. To the south of the lake, its banks are used as crematorium. Dumping of solid wastes around the lake is polluting the lake water. To the west of the lake, there is an Areca plantation and unauthorized construction activities. The sewage line enters the lake from north-east and eastern banks of the lake. In Mallathhalli lake, BDA has established a STP of 5 MLD capacity and, still sewage enters the lake.


Mallathhalli lake


A restored lake


Sewage water that enters the lake


Lake water black in colour

Second sewage water inlet

Third sewage water inlet

Plastics floating at the inlet

Macrophytes at the shoreline

Outlet of the lake

Pathway not properly maintained

Cattle grazing

Damaged fence

Problems: Entry of untreated sewage, Solid waste and building debris dumps, Encroachment, Plastic waste, Kalyani not properly maintained, Open defecation, Cattle grazing, Macrophyte growth at the shoreline, Profuse algal (Cyanophyceae) growth

Importance: Lake water is used for domestic purposes, Recreational purposes, Supports huge fish and bird diversity, Bird watching, Ground water recharge, Lake water is a source of livelihood to fisherman.

Mallathhalli lake has mainly 3 sewage entry points. Lake is full of sewage water, stinking with Cyanophyceae growth. Solid waste dumping and cattle grazing were observed. The continuous sewage water inflow had depleted the dissolved oxygen levels and increased the oxygen demand in the lake. Lake water has high ionic and nutrient contents.

Water Quality Analysis of Mallathhalli Lake

Parameters	Mallathhalli					Water quality Standard IS 10500, 1991-2011	
	Inlet1	Inlet2	Inlet3	Kalyani	Outlet	Desirable	Permissible
Water temperature(^{0}C)	22	25.4	25.5	24.2	23.1	-	-
TDS (mg/l)	1076	1029	698	826	823	500	2000
EC (µS/cm)	1430	1462	1182	1208	1147	-	-
pH	7.7	7.7	7.52	7.82	7.39	6.5-8.5	No relaxation
DO (mg/l)	0.98	0	0	3.25	1.55	-	-
BOD (mg/l)	20.33	28.46	77.24	12.2	8.13	-	-
COD (mg/l)	112	184	168	16	24	-	-
Total Alkalinity (mg/l)	794	744	566	662	642	200	600
Chloride (mg/l)	384.82	374.17	178.45	263.65	262.7	250	1000
Total Hardness (mg/l)	562.67	666	360	464.67	462.67	300	600
Calcium (mg/l)	202.54	241.28	81.36	162.73	159.79	75	200
Magnesium (mg/l)	13.89	15.50	38.27	14.23	15.54	30	100
Ortho-Phosphate (mg/l)	1.597	1.158	1.193	1.149	1.599	-	-
Nitrate (mg/l)	0.451	0.47	0.736	0.264	0.483	45	100
Sodium (mg/l)	366	317.2	234.4	318.8	316	-	-
Potassium (mg/l)	62	51.2	37.6	46.8	46.4	-	-

Inference: As per Classification of Inland Surface Water (CPCB), Mallathhalli lake falls under E [Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Euglena* spp.; *Closterium* sp.; *Oocystis* sp.; *Asterococcus* sp.; *Phacus* spp.; *Micractinium* sp.; *Coelastrum* sp.; *Actinastrum* sp.; *Ankistrodesmus* sp.; *Nitzschia* spp; *Navicula* spp.; *Lepocinclis* sp.; *Stauroneis* sp.; *Pinnularia* sp.; *Gomphonema* sp.; *Oocystis* sp.; *Golenkinia* sp.; *Scenedesmus* spp. and *Merismopedia* sp.

ZOOPLANKTON: *Euglena acus*; *Vorticella convallaria*; *Moina macrocopa*; *Brachionus plicatilis*; *Filinia terminalis*; *Brachionus quadridentatus*; *Brachionus calyciflorus*.

MACROPHYTE: *Eichhornia crassipes*; *Alternanthera philoxeroides*; *Lemna gibba*; *Lemna minor*; *Pistia stratiotes*; *Cyperus articulates*; *Cyperus rotundus*; *Cyperus* spp.; *Typha angustata*; *Bacopa monnieri* and *Ipomea aquatica.*

10. SANKEY LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	SANKEY
GEOGRAPHIC DETAILS	Latitude:13°00'28.50"N to 13°00'30.30"N; 13°00'26.18"N to 13°00'46.38"N Longitude: 77°34'18.73"E to 77°34'38.42"E; 77°34'22.76"E to 77°34'37.07"E
AREA AS PER RTC	42.35 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Vyalikaval - 21
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Moderately Polluted
RESTORATION	Restored
WATER CONDITION	Green coloured water with algae
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Sankey Lake is an artificial tank or lake, built by Col. Richard Hieram Sankey of the Madras Sappers Regiment in the western part of Bangalore city, Karnataka in the year 1882, to meet the water supply demand of Bangalore. It is located closely to the middle of the suburbs of Vyalikaval, Malleshwaram and Sadashivanagar. Since the Government Sandalwood Depot is located close to the lake, the Sankey Tank was earlier known as Gandhadhakotikere. Bangalore Water Supply and Sewerage Board (BWSSB) and Bruhut Bengaluru Mahanagara Palike (BBMP) had now changed Sankey Tank from a reservoir to a park. Sankey Tank also includes a park and a swimming pool toward its south, along with a Forest Department nursery in the northern direction and an exclusive tank for idol immersion during Ganesh Chaturthi festival. Inorder to improve dissolved oxygen levels, increase the aesthetic beauty and recreational values, two fountains are installed in the lake.

Sankey lake

A restored lake

 **Sewage inlet to the lake**	 **Fountain fixed in the lake**
 **Kalyani of Sankey lake**	 **Fountain fixed in the lake**
Problems Untreated sewage entry, Solid waste dumping Massive algal growth	**Importance:** Recreational purposes, Supports huge fish and bird diversity, Ground water recharge

Water Quality Analysis of Sankey Lake

Parameters	Sankey				Water quality Standard IS 10500, 1991-2011	
	S1_inlet	S2	S3	S4	Desirable	Permissible
Water temperature (^{0}C)	26	30.7	31.7	26	-	-
TDS (mg/l)	273	256.67	291	275	500	2000
pH	8	8.44	8.36	8.08	6.5-8.5	No relaxation
DO (mg/l)	5.69	13.01	7.7	6.18	-	-
BOD (mg/l)	20.33	20.33	16.26	10.16	-	-
COD (mg/l)	44	20	40	52	-	-
Total Alkalinity (mg/l)	184	170.67	185.33	193.33	200	600
Chloride (mg/l)	79.52	80	81.89	80.94	250	1000
Total Hardness (mg/l)	121.33	117.33	125.33	114	300	600
Calcium (mg/l)	22.44	19.51	21.91	20.57	75	200
Magnesium (mg/l)	15.93	16.74	17.23	15.28	30	100
Ortho-Phosphate (mg/l)	0.232	0.1	0.217	0.175	-	-
Nitrate (mg/l)	0.492	0.429	0.422	0.281	45	100
Sodium (mg/l)	84.33	77.83	93.5	101.33	-	-
Potassium (mg/l)	17.33	16.17	20.67	25.33	-	-

Sankey lake is a stagnant water body with sewage entering the lake, so water has alkaline pH due to growth of algae. Nutrients were removed through algal uptake. With the help of aerators, dissolved oxygen in water has improved.

Inference: As per Classification of Inland Surface Water (CPCB), Sankey lake falls under E. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Cylindriospermopsis* sp.; *Merismopedia* sp.; *Microcystis* sp.; *Planktothrix* sp.; *Ankistrodesmus* sp.; *Chlorella* sp.; *Closterium* sp.; *Cosmarium* sp.; *Crucigenia* sp.; *Monoraphidium* sp.; *Pediastrum* sp.; *Scenedesmus* sp.; *Tetraedron* sp.; *Nitzschia* sp. and *Navicula* sp.

ZOOPLANKTON: *Philodina citrina*; *Polyarthra vulgaris*; *Lecane acus*; *Brachionus forficula*; *Brachionus havanaensis*; *Brachionus quadridentatus*; *Keratella cochlearis*; *Lepocinclis* sp.; *Keratella tropica* and *Vorticella convallaria*.

MACROPHYTE: *Polygonum glabrum, Ipomea aquatica, Alternanthera philoxeroides, Cyperus* spp.*, Typha angustata*

11. SRINIVASAPURA LAKE	**Vrishabhavathi Valley**
NAME OF THE LAKE	**SRINIVASAPURA**
GEOGRAPHIC DETAILS	Latitude: 12°54'51.64"N to 12°54'53.37"N; 12°54'46.31"N to 12°54'54.21"N Longitude: 77°32'01.84"E to 77°32'08.90"E; 77°32'02.51"E to 77°32'08.66"E
AREA AS PER RTC	7.5 Acres
CUSTODIAN	-
VILLAGE NAME & SURVEY NO	Arehalli
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored
WATER CONDITION	Black coloured water with macrophyte cover
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Srinivasapura lake is situated at Saptagiri Layout, Hosakerehalli, Bengaluru, Karnataka. The lake is not maintained properly with no boundary and pathways.

Srinivasapura lake

Macrophyte cover

Lake outlet

Outlet channel

Pathway covered with weeds

Lake has no boundary/fence

Problems: Untreated sewage entry, Solid waste dumping near lake bed, A poorly maintained lake, Macrophyte growth, Open defecation, Cattle grazing, Damaged fence

Importance: The lake will serve all the wetland function if maintained properly.

Water Quality Analysis of Srinivasapura Lake

Parameters	Srinivasapura	Water quality Standard IS 10500, 1991-2011	
	Lake	Desirable	Permissible
Water temperature (^{0}C)	27.7	-	-
TDS (mg/l)	320	500	2000
EC (µS/cm)	499	-	-
pH	7.75	6.5-8.5	No relaxation
DO (mg/l)	5.2	-	-
COD (mg/l)	88	-	-
Total Alkalinity (mg/l)	204	200	600
Chloride (mg/l)	57.51	250	1000
Total Hardness (mg/l)	144	300	600
Calcium (mg/l)	40.08	75	200
Magnesium (mg/l)	10.72	30	100
Ortho-Phosphate (mg/l)	2.52	-	-
Nitrate (mg/l)	0.01	45	100
Sodium (mg/l)	81.5	-	-
Potassium (mg/l)	19.5	-	-

The organic and nutrient contents are higher in Srinivasapura lake. This lake is shallow with no outflow. The lake is not maintained properly and sludge from the bottom releases to surface even with small disturbance. High alkalinity, organic matter and ortho-phosphate supported algal growth, especially Euglenophyceae.

Inference:
As per Classification of Inland Surface Water (CPCB), Srinivasapura lake falls under E.
[Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Trachelomonas* sp., *Euglena* sp., *Chlorella* sp. and *Phacus* sp.

ZOOPLANKTON: *Lecane* sp.; *Macrocyclops* sp.; *Brachionus calyciflorus* and *Arcella* sp.

MACROPHYTE: *Echinochloa* sp. and *Alternanthera philoxeroides*.

12. **SOMPURA LAKE**	**Vrishabhavathi Valley**
NAME OF THE LAKE	**SOMPURA**
GEOGRAPHIC DETAILS	Latitude: 12°52'27.23"N to 12°52'30.49"N; 12°52'23.80"N to 13°52'36.63"N Longitude: 77°29'50.42"E to 77°30'04.81"E; 77°29'53.76"E to 77°30'02.87"E
AREA AS PER RTC	17.95 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Sompura-11
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Less Polluted
RESTORATION	Restored
WATER CONDITION	Muddy water with high turbidity
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Sompura lake is located near to NICE ring road. It is a restored lake with shallow water. Lake water is muddy. Lake is divided into two parts, one part near to the inlet and another is lake part. The main source of water to the lake is rainwater.

 **Sompura lake**	 **A shallow restored lake**
 **Inlet of the lake**	 **Lake water is muddy**
 **Outlet of the lake**	 **Damaged fencing**
Problems: Encroachment of boundary, Untreated sewage entry, Weed growth along shoreline and pathways	**Importance:** Supports huge bird diversity, Recreational purposes, Ground water recharge, serves as livelihood for fishermen

Water Quality Analysis of Sompura Lake

Parameters	Sompura	Water quality Standard IS 10500, 1991-2011	
		Desirable	Permissible
Water temperature (°C)	27	-	-
TDS (mg/l)	254	500	2000
EC (µS/cm)	506	-	-
pH	8.46	6.5-8.5	No relaxation
DO (mg/l)	9.59	-	-
BOD (mg/l)	20.33	-	-
COD (mg/l)	26	-	-
Total Alkalinity (mg/l)	281.33	200	600
Chloride (mg/l)	73.37	250	1000
Total Hardness (mg/l)	78	300	600
Calcium (mg/l)	16.73	75	200
Magnesium (mg/l)	8.84	30	100
Ortho-Phosphate (mg/l)	0.17	-	-
Nitrate (mg/l)	0.637	45	100
Sodium (mg/l)	149.6	-	-
Potassium (mg/l)	11.2	-	-

Lake water is muddy and has high turbidity. All the parameters are within the permissible limits according to the Indian drinking water standards except turbidity.

Inference:
As per Classification of Inland Surface Water (CPCB), Sompura lake falls under E.
Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Gomphonema* sp.; *Cocconeis* sp.; *Scenedesmus* spp.; *Nitzschia* spp.; *Navicula* spp.; *Kirchneriella* sp.; *Fragilaria* sp.; *Cymbella* sp.; *Pinnularia* sp.; *Oocystis* sp.; *Euglena* spp.; *Phacus* spp. and *Trachelomonas* sp.

ZOOPLANKTON: *Keratella tropica*; *Brachionus falcatus* and *Mesocyclops leuckarti*.

MACROPHYTE: *Ipomea carnea*; *Typha angustata*; *Alternanthera philoxeroides*; *Polygonum glabrum* and *Cyperus* spp.

13. ULLAL LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	ULLAL
GEOGRAPHIC DETAILS	Latitude:12°57'33.26"N to 12°57'34.06"N; 12°57'31.86"N to 12°57'46.47"N Longitude: 77°28'46.26"E to 77°29'03.20"E; 77°28'53.25"E to 77°29'00.47"E
AREA AS PER RTC	24.3 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Ullal - 93
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Highly Polluted
RESTORATION	Restored
WATER CONDITION	Poor, Green coloured water with algal growth
CLASS (As per CPCB)	Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Ullal Lake belongs to Byramangala lake series in the Vrishabhavathi lake valley and is situated in Hullalu village of South-Western part of Bangalore city. It is surrounded by Muddinapalya in the North, Mangana Halli in the South, Mallathalli in the East and Ullalu in the West. The input channel is from North i.e. from Muddinapalya and the outlet is from Southeast, which is an inlet to Hosakere Lake. Ullal lake is triangular, covering an area of about 11.03 Ha. and the perimeter is approximately 1870 meters. The lake was rejuvenated and developed by the BDA in 2009-2010, which includes fencing of the lake, installation of streetlights, building of walkers and joggers track. A few sewage lines from the neighbouring areas have been polluting one side of the lake, while weeds have completely covered the other side.

Ullal lake

Wetland part of Ullal lake

Buildings near the lake

Macrophytes growing at the shoreline

Floating macrophytes in the surface water

Sewage water entering the lake

Problems: Entry of untreated sewage, Growth of macrophytes and algae

Importance: Recreational purposes, Supports bird diversity, Ground water recharge

Water Quality Analysis of Ullal Lake

Parameters	Ullal		Water quality Standard IS 10500, 1991-2011	
	Inlet	Lake	Desirable	Permissible
Water Temperature (˚C)	23.6	25.9	-	-
TDS (mg/l)	688	634	500	2000
EC (µS/cm)	1062	1023	-	-
pH	8.05	8.26	6.5-8.5	No relaxation
DO (mg/l)	13.01	17.56	-	-
BOD (mg/l)	24.39	12.2	-	-
COD (mg/l)	44	20	-	-
Total Alkalinity (mg/l)	598	592	200	600
Chloride (mg/l)	201.17	186.49	250	1000
Total Hardness (mg/l)	440.67	413	300	600
Calcium (mg/l)	146.69	104.61	75	200
Magnesium (mg/l)	18.15	37.04	30	100
Ortho-Phosphate (mg/l)	1.004	0.89	-	-
Nitrate (mg/l)	0.51	0.346	45	100
Sodium (mg/l)	226.8	218.8	-	-
Potassium (mg/l)	46.8	42.8	-	-

Lake water receives direct untreated sewage water so the lake has high ionic and organic contents, which supports pollution tolerant aquatic organisms like algae and macrophytes. All the parameters are within the permissible limits according to the Indian drinking water standards.

Inference: As per Classification of Inland Surface Water (CPCB), Ullal lake falls under E. [Class E – Water for irrigation, industrial cooling and controlled waste disposal]

AQUATIC BIODIVERSITY

ALGAE: *Phacus* spp.; *Lepocinclis* sp.; *Euglena* spp.; *Nitzschia* spp.; *Gomphonema* sp.; *Asterococcus* sp.; *Navicula* spp.; *Oscillatoria* sp.; *Actinastrum* sp.; *Scenedesmus* spp.; *Closterium* sp. and *Coelastrum* sp.

ZOOPLANKTON: Chironomid larvae; *Ostracoda* sp.; Nauplius larvae; *Mesocyclops leuckarti*; *Mesocyclops edax*; *Brachionus plicatilis* and *Microcyclops varicans*.

MACROPHYTE: *Alternanthera philoxeroides*; *Lemna gibba*; *Lemna minor*; *Pistia stratiotes*; *Cyperus* spp.; *Typha angustata* and *Eichhornia crassipes.*

14. UTTARAHALLI LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**UTTARAHALLI**
GEOGRAPHIC DETAILS	Latitude: 12°54'27.81"N to 12°54'34.63"N; 12°54'23.39"N to 12°54'35.73"N, Longitude: 77°32'21.87"E to 77°32'38.74"E; 77°32'30.20"E to 77°32'38.01"E
AREA AS PER RTC	15.4 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Uttarahalli -111
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Less Polluted
RESTORATION	Restored
WATER CONDITION	Clear water with macrophyte cover
CLASS	Class E – Water for irrigation, industrial cooling and controlled waste disposal.
Uttarahalli Lake in South Bangalore is spread over about 15 acres and 15 guntas, and is being maintained by United Way of Bengaluru, with the support of local groups and corporates. More than half of its surface is covered by macrophytes/weeds.	
 **Uttarahalli lake**	 **Lake surface fully covered with *Lemna* sp.**
 **Macrophyte cover**	 **A shallow restored lake**
 **Buildings near the lake**	 **Sewage water inflow**
Problems: Untreated sewage inlet, Poor maintenance, Solid waste dumping in lake bed, Unchecked macrophyte growth	**Importance:** Recreational purposes; Ground water recharge Supports huge bird diversity, Bird watching

Water Quality Analysis of Uttarahalli Lake

Parameters	Uttarahalli	Water quality Standard IS 10500, 1991-2011	
		Desirable	Permissible
Water Temperature (˚C)	27.7	-	-
TDS (mg/l)	219	500	2000
EC (µS/cm)	444	-	-
pH	7.43	6.5-8.5	No relaxation
Turbidity	10.01	5	10
DO (mg/l)	1.3	-	-
BOD (mg/l)	8.13	-	-
COD (mg/l)	14	-	-
Total Alkalinity (mg/l)	225.33	200	600
Chloride (mg/l)	79.05	250	1000
Total Hardness (mg/l)	136	300	600
Calcium (mg/l)	32.87	75	200
Magnesium (mg/l)	13.16	30	100
Ortho-Phosphate (mg/l)	0.067	-	-
Nitrate (mg/l)	0.28	45	100
Sodium (mg/l)	69.6	-	-
Potassium (mg/l)	12.4	-	-

The lake water has low ionic and nutrient contents even though sewage enters the lake. The uptake of nutrients by algae and macrophytes in the lake has resulted in nutrient removal. The macrophyte cover in the lake had obstructed the light penetration, resulting in low photosynthetic rates and low dissolved oxygen levels.

Inference: As per Classification of Inland Surface Water (CPCB), Uttarahalli lake falls under E. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

AQUATIC BIODIVERSITY

ALGAE: *Surirella* sp.; *Nitzschia* spp.; *Monoraphidium* sp.; *Scenedesmus* spp.; *Navicula* spp.; *Golenkinia* sp.; *Gleocapsa* sp.; *Chroococcus* sp.; *Cocconeis* sp.; *Merismopedia* sp.; *Phacus* spp.; *Dictyosphaerium* sp.; *Pediastrum* sp.; *Oocystis* sp.; *Aphanocapsa* sp.; *Pinnularia* sp.; *Gonium* sp. and *Trachelomonas* sp.

ZOOPLANKTON: *Lecane luna*; *Centropyxis* sp.; *Arcella gibbosa*; Nauplius larva; *Brachionus calyciflorus*; *Trichocerca capucina*.

MACROPHYTE: *Alternanthera philoxeroides*; *Cyperus* spp.; *Nelumbo nucifera*; *Lemna gibba*; *Lemna minor* and *Ludwigia perennis*.

15. YEDIYUR LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	YEDIYUR
GEOGRAPHIC DETAILS	Latitude: 12°55'57.35"N to 12°55'59.31"N; 12°55'55.66"N to 12°56'05.62"N Longitude: 77°34'31.22"E to 77°34'42.41"E; 77°34'32.29"E to 77°34'33.61"E
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Dasarahalli - 01,Yediyur - 59
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Moderately Polluted
RESTORATION	Restored
WATER CONDITION	Light green coloured water with algae growth
CLASS	Class D – Water for fish culture and wild life propagation. Class E – Water for irrigation, industrial cooling and controlled waste disposal.

Yediyur lake with an area of about 18 acres, 2 guntas is located at Basavangudi area of the city. Encroachments have reduced the lake to 15 acres, 23 guntas.


Yediyur lake


A restored lake


The lake is divided into 2 parts


Buildings in the lake


Inlet to the lake


Fishes in Yediyur lake

Problems: Entry of untreated sewage, Macrophyte growth near shorelines, Solid waste dumping, Over feeding of fishes

Importance: Recreational purposes, Supports huge bird diversity, Bird watching, Ground water recharge, fish is a source of livelihood to fisherman.

Water Quality Analysis of Yediyur Lake

Parameters	Yediyur		Water quality Standard IS 10500, 1991-2011	
	Middle	Near inlet	Desirable	Permissible
Water Temperature (˚C)	27.4	26.6	-	-
TDS (mg/l)	202	99	500	2000
EC (µS/cm)	404	218	-	-
pH	7.44	7.02	6.5-8.5	No relaxation
DO (mg/l)	3.74	3.41	-	-
BOD (mg/l)	20.33	16.26		
COD (mg/l)	44	44	-	-
Total Alkalinity (mg/l)	132	96	200	600
Chloride (mg/l)	68.16	25.56	250	1000
Total Hardness (mg/l)	86	72	300	600
Calcium (mg/l)	24.05	22.71	75	200
Magnesium (mg/l)	6.33	3.73	30	100
Ortho-Phosphate (mg/l)	0.145	0.226	-	-
Nitrate (mg/l)	0.291	0.485	45	100
Sodium (mg/l)	83.6	27.6	-	-
Potassium (mg/l)	28.8	15.2	-	-

This lake is one of the oldest lakes of Bangalore, dating back to the Hoysala period i.e. 1,400 years ago. It is now a restored lake with a walkway and garden around it for joggers and walkers. The place is now a picnic spot. The centre of attraction of the lake is a small beautiful garden and a beautiful statue of girl by John Irving that stood amidst the centre of the lake.

The lake has high organic content and low dissolved oxygen because of high rate of bacterial decomposition. All the parameters are within the permissible limits according to the Indian drinking water standards.

Inference: As per Classification of Inland Surface Water (CPCB), Yediyur lake falls under D and E [Class D – Water for fish culture and wild life propagation; Class E – Water for irrigation, industrial cooling and controlled waste disposal].

AQUATIC BIODIVERSITY

ALGAE: *Kirchneriella* sp.; *Scenedesmus* spp.; *Nitzschia* spp.; *Closterium* sp.; *Golenkinia* sp.; *Chlorella* sp.; *Tetraedron* sp.; *Merismopedia* sp.; *Pediastrum* sp.; *Pandorina* sp.; *Oscillatoria* sp.; *Schroederia* sp.; *Crucigenia* sp.; *Phacus* spp.; *Monoraphidium* sp.; *Microcystis* sp.; *Cosmarium* sp.; *Cyclotella* sp.; *Navicula* spp.; *Chlorococcum* sp.; *Aulacoseira* sp. and *Coelastrum* sp.

ZOOPLANKTON: *Brachionus caudatus*; *Mesocyclops leuckarti*; *Brachionus diversicornis*; *Brachionus forficula*; *Amoeba* sp.; Nauplius larvae; *Vorticella convallaria*; *Ostracoda* sp. and *Thermocyclops oithonoides*.

MACROPHYTE: *Alternanthera philoxeroides*; *Lemna gibba*; *Lemna minor*; *Nelumbo nucifera*; *Typha angustata*; *Polygonum glabrum* and *Cyperus rotundus*.

MACROPHYTES COVERED LAKES

Lakes covered with macrophytes were inaccessible for water sampling.

Sl. No	Lake Name
1	Bikaspura Lake
2	Goudanakere
3	Hegganahalli Lake
4	Nayandanahalli Lake
5	Subramanyapura Lake
6	Sunkadakatte Lake

Bikaspura lake

Macrophyte cover

Goudanakere

Growth of macrophyte/weeds in the lake

Hegganahalli/Basappanakatte lake

Macrophyte cover

Nayandanahalli Lake

Building inside the lake

1. BIKASPURA LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**BIKASPURA**
GEOGRAPHIC DETAILS	Latitude-12°53'26.99"N to 12°53'28.42"N, 77°33'16.74"E to 77°33'27.73"E Longitude-12°53'25.37"N to12°53'32.19"N, 77°33'24.11"E to 77°33'24.52"E
AREA AS PER RTC	7.15 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Bikashipura-5
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored
Bikaspura lake is situated at Seenappa layout, VasanthaVallabhanagar, Bangalore.	
 **Bikaspura lake**	 **Macrophyte cover**
 **Construction activities near the lake**	 **Inflow channel**
 **Solid waste dumping near the lake**	 **Lake has no boundary/fence**
Problems: Untreated sewage entry Solid waste dumping near lake bed, A poorly maintained lake, macrophyte growth, open defecation, cattle grazing, damaged fence	**Importance:** The lake will serve all the wetland function if maintained properly.
AQUATIC BIODIVERSITY **MACROPHYTE:** *Alternanthera philoxeroides, Eichhornia crassipes.*	

2. GOUDANAKERE	Vrishabavathi Valley
NAME OF THE LAKE	**GOUDANAKERE**
GEOGRAPHIC DETAILS	Latitude-12°54'24.61"N to 12°54'29.37"N, 77°33'15.56"E to 77°33'29.41"E Longitude-12°54'23.30"N to 12°54'31.65"N, 77°33'23.98"E to 77°33'26.13"E
AREA AS PER RTC	9.75 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Kadirenahalli-33
VALLEY TO WHICH LAKE BELONGS	Vrishabavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored
Goudanakere is located in Gowdanapalya, Uttarahalli Hobli, Bengaluru, Karnataka. The area of Goudanakere is about 9 acres and 30 guntas.	
 **Goudanakere**	 **Growth of macrophyte/weeds in the lake**
 **Pigs resting on building debris**	 **Buildings inside the lake**
 **Dumping of solid wastes**	 **Apartments near the lake**
Problems: Untreated sewage entry from apartments, macrophyte growth, open defecation, cattle grazing, fence of the lake is damaged, solid waste dumping	**Importance:** The lake will serve all the wetland function if maintained properly.
AQUATIC BIODIVERSITY **MACROPHYTE:** *Alternanthera philoxeroides*; *Colocasia esculenta*; *Cyperus* sp.; *Polygonum glabrum*; *Typha angustifolia*; *Eichhornia crassipes*	

3. HEGGANAHALLI LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**HEGGANAHALLI**
GEOGRAPHIC DETAILS	Latitude: 12°55'23.73"N to 12°55'25.31"N; 12°55'18.27"N to 12°55'34.19"N Longitude: 77°30'49.93"E to 77°31'00.23"E; 77°30'52.37"E to 77°30'58.38"E
AREA AS PER RTC	6.29 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Laggere-121
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored

Hegganahalli lake is located at Bhyraveshwara Nagar, Hegganahalli, Bengaluru, Karnataka.

Hegganahalli/Basappanakatte lake

Macrophyte cover

Construction activities near the lake

Buildings near the lake

Sewage water entering the lake

Lake has no boundary/fence

Problems: Untreated sewage entry, Solid waste dumping near lake bed, cattle grazing, macrophyte growth, open defecation, damaged fence, a poorly maintained lake

Importance: The lake will serve all the wetland function if maintained properly.

AQUATIC BIODIVERSITY

MACROPHYTE: *Alternanthera philoxeroides*; *Cyperus* sp; *Ipomea carnea*; *Polygonum glabrum*; *Typha angustifolia*

4. NAYANDANAHALLI LAKE	Vrishabavathi Valley
NAME OF THE LAKE	**NAYANDANAHALLI**
GEOGRAPHIC DETAILS	Latitude-12°56'26.13"N to 12°56'26.79"N, 77°31'10.67"E to 77°31'22.51"E Longitude-12°56'16.08"N to 12°56'28.33"N, 77°31'11.58"E to 77°31'16.83"E
AREA AS PER RTC	15.45 Acres
CUSTODIAN	BBMP
VILLAGE NAME & SURVEY NO	Nayadahali-31
VALLEY TO WHICH LAKE BELONGS	Vrishabavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored

Nayandanahalli Kere is located in ITI Layout 3rd Phase, NayandaHalli, Bengaluru, Karnataka. Lake is now in a very bad state with a foul smell. The lake receives all the untreated sewage water and is a dumping ground of solid wastes. This lake needs immediate action.

 **Nayandanahalli Lake**	 **Building inside the lake**
 **Solid waste dumping**	 **Macrophyte growth**
 **Buildings in the lake**	 **Sewage inflow to the lake**
Problems: Untreated sewage entry, solid waste dumping near lake bed	Poor maintenance Macrophyte growth

AQUATIC BIODIVERSITY

MACROPHYTE: *Alternanthera philoxeroides*; *Ludwigia adscendens*; *Cyperus* sp; *Paspalum* sp.

5. SUBRAMANYAPURA LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**SUBRAMANYAPURA**
GEOGRAPHIC DETAILS	Latitude: 12°53'50.20"N to 12°53'43.35"N; 12°53'52.36"N to 12°53'37.58"N, Longitude: 77°32'26.38"E to 77°32'39.47"E; 77°32'35.48"E to 77°32'32.84"E
AREA AS PER RTC	18.06 Acres
CUSTODIAN	BDA
VILLAGE NAME & SURVEY NO	Uttarahalli-64
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored

Subramanyapura lake is located near Jayanagar housing society layout, Subramanyapura, Bengaluru. Subramanyapura lake at Uttarahalli and Vasantpura was once a source of drinking water and spread over 5.22 hectares.

Subramanyapura lake

Macrophyte cover

Construction activities near the lake

Buildings near the lake

Sewage water entering the lake

Lake has no boundary/fence

Problems: Untreated sewage entry, solid waste dumping near lake bed, a poorly maintained lake, macrophyte growth, open defecation, cattle grazing, damaged fence

Importance:
The lake will serve all the wetland function if maintained properly.

AQUATIC BIODIVERSITY

MACROPHYTE: *Colocasia esculenta*; *Alternanthera philoxeroides*; *Ludwigia adscendens*; *Cyperus* sp; *Polygonum glabrum; Typha angustifolia*; *Eichhornia crassipes*; *Lemna gibba*; *Lemna minor*.

6. SUNKADAKATTE LAKE	Vrishabhavathi Valley
NAME OF THE LAKE	**SUNKADAKATTE**
GEOGRAPHIC DETAILS	Latitude **:**12°59'49.33"N- 12°59'55.24"N; 12°59'49.56"N-12°59'55.34"N Longitude :77°30'59.19"E - 77°31'0.33"E; 77°31'2.51"E- 77°31'2.79"E
VALLEY TO WHICH LAKE BELONGS	Vrishabhavathi Valley
STATUS	Eutrophic
RESTORATION	Non-restored

Sunkadakatte/ Pillappanakatte lake is located at Kareemsab Nagar, Hegganahalli, Bengaluru, Karnataka.

Sunkadakatte/ Pillappanakatte lake

Macrophyte cover

Construction activities near the lake

Buildings near the lake

Sewage water entering the lake

Lake has no boundary/fence

Problems: Untreated sewage entry, Solid waste dumping near lake bed, A poorly maintained lake, Macrophyte growth, open defecation, cattle grazing, damaged fence

Importance:
The lake will serve all the wetland function if maintained properly.

AQUATIC BIODIVERSITY

MACROPHYTE: *Typha angustifolia*; *Alternanthera philoxeroides*; *Cyperus* sp.; *Eichhornia crassipes*.

7.0 SUSTAINABLE WATER TO BANGALORE: STRATEGIES AND CHALLENGES

Sufficient water is available to meet everyone's requirement, provided (i) water harvesting is undertaken through surface water bodies; this requires rejuvenation of lakes and reestablishment of interconnectivity; harvesting of rainwater (at decentralized levels), treatment; (ii) treatment and reuse of sewage. However, the success of sustainable water path depends on the political will, bureaucracy shedding their colonial style of functioning and more importantly citizen's assertion for their right for equal quantity and quality of water.

Availability	Water yield (rain)	14.80 TMC
	Sewage (generation 20.05 TMC) if treated	16.04 TMC
	Total	30.84 TMC
Demand	Domestic purposes (@ 150 lpcd) If @ 135 lpcd	20.05 TMC 18.34 TMC
Status	Surplus	10.79 -12.50 TMC

Average annual rainfall in Bangalore is about 787 mm with 75% dependability and return period of 5 years. Catchment wise water yield analysis indicates about 49.5% (7.32 TMC) of water yield in the Vrishabhavathi valley (including Arkavathi and Suvarnamukhi), followed by 35.2% (5.2 TMC) in Koramangala Challaghatta valley and 15.3% (4.2 TMC) in Hebbal valley and the total annual water yield in Bengaluru is about **14.80 TMC.** Domestic demand of water (at 150 lpcd) is 20.05 TMC per year (1573 MLD). This means about 73% of Bangalore's water demand can be met by efficient harvesting of rain water. Quantification of sewage generated shows that about 16.04 TMC (1258 MLD) of sewage is generated in the city.

Sewage treatment with complete removal of nutrients and chemical contaminants can be achieved by adopting decentralized treatment plants similar to the success model (secondary treatment plant integrated with constructed wetlands and algae pond) at Jakkur lake. In addition to this, water available with efficient rainwater harvesting is about 14.8 TMC. This accounts to total of 30.85 TMC of water that is available annually would cater the demand of 20.05 TMC, provided the city administration opts for decentralized optimal water management through (i) rainwater harvesting by rejuvenating lakes - the best option to harvest rain water is through interconnected lake systems, (ii) treatment of sewage generated in households in each locality (opting the model functional since 2010 at Jakkur lake – STP (Sewage Treatment Plant) integrated with constructed wetlands and algal pond; (iii) conservation of water by avoiding the pilferages (due to faulty distribution system); (iv) ensuring water supply 24x7 and (v) ensuring all sections of the society get equal quantity and quality of water. Rejuvenating lakes in the region helps in retaining the rain water. Treating sewage and options to recycle and reuse would minimize the demand for water from outside the region.

However, this model of decentralised harvesting of water and reuse of treated sewage is not an attractive proposition for the current breed of decision makers with the colonial style of functioning/mind-set. The financial gain is much higher in the case of mega projects (such as water diversion) compared to these decentralised models. This is the sole reason for the local administrators to degrade decentralised water harvesting structures and alienating local community. The main reason for deliberate inefficient management of water resources is to maximise the net return for the ruling class themselves than the overall growth of the region with water security. The analysis illustrates that the city has at least 30 TMC (Bangalore city) of water, which is higher than the existing demand (20.08 TMC, at 150 lpcd and 2016 population), if the city adopts 5R's (Rejuvenate, Retain, Recycle - Reuse, and Responsible citizens' active participation with good governance).

Scope for decentralized rainwater harvesting: During 1800, the storage capacity of Bangalore was 35 TMC. In 70's, lakes covered an area of nearly 3180 hectares and now the spatial extent of lakes cover an area of 2792 hectares. The current capacity of lakes is about 5 TMC and due to siltation, the current storage capacity of the lakes is just about 1.2 TMC, i.e., nearly 387 hectares of water bodies disappeared besides reduction in the storage capacity by 60%. Bangalore being located on the ridge, forms three watersheds – Koramangala Challagatta valley, Vrishbhavathi Valley and Hebbal Nagavara Valley. Earlier rulers of the region, created interconnected lake systems taking advantage of undulating terrain. Number of lakes in the Koramangala Challaghatta Valley is about 81, followed by the Vrishabhavathi Valley (56) and the Hebbal Nagavara Valley (46). In order to enhance the water retaining capability in the catchment, it is essential to rejuvenate lakes and undertake large scale watershed programme (soil and water conservation). Lakes are the optimal means of rainwater harvesting at community level. This entails

(i) Reestablishing interconnectivity among lakes (requires removal of all encroachments without any consideration, as the water security of a region is vital than the vested interests, who have unauthorisedly occupied without respecting future generation's food and water security). This would also reduce the frequency of floods and consequent damage to life and property,
(ii) removal of all encroachments of lakes and lake bed, and maintaining buffer region with the good riparian vegetation cover (without any artifacts),
(iii) rejuvenation and regular maintenance of water bodies. This involves de-silting of lakes to (a) enhance the storage capacity to retain rainwater, (b) increase the recharge potential – will improve groundwater table, (c) ensure recharging without any contamination,
(iv) allowing only treated sewage (removal of chemical and biological contaminants) through adoption of integrated wetlands ecosystem (Jakkur lake model),
(v) creation of wetlands with native vegetation and regular harvesting of macrophytes; food and fodder, which supports local people's livelihood, and
(vi) maintaining at least 33% green cover with native vegetation (grass, trees, shrubs) in the catchment and planting riparian vegetation in the buffer region. This would help infiltration of water and retain this water.

Land use analysis in Bangalore City shows 1028% increase in urban (built-up) area between 1973 and 2017 i.e., from 8.0% (in 1973) to 78% (in 2017). Land use prediction using Agent

Based Model showed that built up area would increase to 93.3% by 2020, and the landscape is almost at the verge of saturation.

Background: Water is one of the fundamental elements of the universe from which early life originated millions of years ago on earth. Every life on the earth is primarily dependent on water which hosts innumerable aquatic species from single cell creatures to gigantic blue whales. As the evolution of human took place, civilized human settled down on the fertile river banks. In other words, river banks are the motherhood for civilized human and most of the civilization around the world. These river or lake banks gave water for drinking and also for cropping along with mineral rich soil. Civilized men knew the importance of water and respected these water bodies. Advantages of traditional water harvesting structures are:

- water made to stand for a period so as to allow infiltration / percolation and recharging of groundwater aquifers to sustain good water levels in the surrounding wells;
- a saturated sub soil/top soil, enhances the green cover in the surroundings;
- green cover in the catchment reduces soil erosion and hence sedimentation of rivers; and
- mitigation of floods and reduces the velocity of runoff.

However, these practices took backseat, during the imperial period (1800 till independence i.e. 1947) of British rule with the push for large scale river valley and canal projects and also due to lack of maintenance and management of small water harvesting structures. Apart from this, high and oppressive taxes and irrigation cess (towards the repair works of these structures) led to the decimation of irrigation tanks during the period of colonial rulers.

The centralized irrigation systems coupled with increased incidences of untimely rainfall and higher temperature, lack of annual maintenance, deforestation in the catchment and receding community participation, led to the decline of thousands of traditional water harvesting systems. As a consequence of these, the thousands of lakes and tanks are silted with the decrease in the overall storage capacities and groundwater recharge. Unplanned urbanization has led to the increase in urban conglomerates, with drastic reduction in land cover of the catchment, which substantially reduced the water holding capacity of the catchment. Higher incidences of flooding and soil erosion, is the direct consequence of damaging the water harvesting structures. Therefore, it is necessary to inculcate the traditional knowledge on sustainable water harvesting and management practices in the educational curricula. At a village/ward level it’s necessary to identify the appropriate investment strategies and make the local Panchayats/ward member responsible for the operation and maintenance of the tanks. This will help in adopting the decentralized water harvest and management practices in the arid and semi-arid regions that are economical and technically feasible alternative to meet the regional water demand.

A well-known and success model of lake ecosystem is at Jakkur in Bangalore with integrated wetlands ecosystem (Secondary treatment plant integrated with constructed wetlands and algae pond). Complete removal of nutrients and chemical contaminants happens when treated sewage (secondary treated) passes through constructed wetlands and algae pond, undergoes of bio-physical and chemical processes. The water in the lake is almost potable with minimal nutrients and microbial counts. This model has been functional successfully for the last 5 years after interventions to rejuvenate the lake. This system is one of the self-sustainable ways of lake management while benefitting all stakeholders - washing, fishing, irrigation and local people. Wells in the buffer zone of 500 m now have higher water levels and without any nutrients (nitrate). Groundwater quality assessment in the same region, before rejuvenation of Jakkur Lake had higher nitrate values. Adoption of this model also ensures nutrient free and clean groundwater, which helps in achieving the goals of providing clean water to the local community.

Another very good example of constructed water body is of the centenary pond at IISc, created solely to harvest rainwater. Taking advantage of undulating terrain in the campus, storm water drain is routed to a low lying area. The spatial extent of the water body is about one hectare and stores on an average 0.1 million liters. This water body is now an abode of a variety of aquatic animals and has been an attractive to several resident and migratory birds. The creation of these water bodies has helped in a good ambience and maintaining a good biodiversity in the region besides providing a very good aesthetics and is a now a means of stress relief for the students learners of higher education. These successful experiments highlight that water quality can be maintained to meet the local requirements by optimal management of bio-physical dynamics in a water body.

Deterioration of traditional water harvesting practices in other parts of burgeoning Bangalore has resulted in the inequity in water distribution and growing water scarcity, which has escalated water conflicts during the 20th century. Irresponsible management of natural resources is evident from

- sustained inflow of untreated sewage and industrial effluents;
- dumping of solid waste (with 70% being organic); and
- transport of untreated wastewater in storm water drains (water drains are essentially arteries of a landscape carrying water).

Due to these unauthorized practices, vital constituents of the landscape (wetlands and drains,) have become breeding ground of disease vectors, stinking cesspool and emitters of GHG's (Greenhouse gases: methane, carbon di-oxide, etc.), etc. These practices are posing serious threat to public health and hygiene with an irrecoverable loss in aquatic biodiversity. Unplanned and un-coordinated rapid urbanization has further stressed the natural resources in the region. The water demand of the urban conglomerates is met with piped water supply or from water transported from distant areas. Coupled with this, substantial degeneration of the traditional knowledge has resulted in deterioration of tank management practices. Sustainable water management of water resources through revival of traditional water harvesting strategies and comprehensive watershed restoration and management by involving local stakeholders is essential for adequate groundwater recharge and for maintaining water balance in the region.

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

Source: Ramachandra T V, Vinay S, Durga Madhab Mahapatra, Sincy Varghese, Bharath H. Aithal, 2016. Water situation in Bengaluru, ENVIS Technical Report 114, Environmental Information System, CES, Indian Institute of Science, Bangalore 560012

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Dr. T.V. Ramachandra
Co-ordinator
Energy & Wetlands Research Group

CES/TVR/MFC/10477/2017
29- May - 2017

To
Sri. Ananth Kumar
Member of Parliament, Bangalore (South),
15th Cross, South End Circle, 2nd Block,
Jayanagar, Bangalore- 560011

Dear Sir

Subject: Foaming or algal blooms in water bodies of India: Remedial measures – Restrict phosphate (P) based detergents, ENVIS Technical Report 108
Ref: Letter FEE/53/SECY(E&E)/2017, 10 May 2017 (copy from GoK enclosed)

We are enclosing herewith a copy of our recent scientific report investigating causal factors of foaming or frothing in water bodies in Bangalore and elsewhere in India. The study confirms, major causal factors are detergents (with phosphates and surface active compounds). You may kindly note that, this report we have sent to (i) Department of Ecology and Environment, GoK and (ii) the Ministry of Environment, Forests and Climate Change, GoI. I understand policy actions towards **restricting Phosphates in detergents** has to be taken by the Ministry of Chemicals and Fertilisers, GoI. We seek your interventions with appropriate norms to prevent eutrophication (nutrient enrichment) of water bodies in India. I would like to place on record that countries such as Canada, US, etc. has restricted phosphate in detergents after large scale problems of frothing during nineties and have witnessed significant progress in the effective conservation and management of water bodies with effective policy measures. I attach a copy of our report and a letter from DEE, GoK for your information and immediate action.

Thank you

With best regards and wishes

T.V. Ramachandra

Dr. T. V. RAMACHANDRA
Co-ordinator
Energy & Wetlands Research Group (CES)
Centre for Ecological Sciences
Indian Institute of Science

URGENT

No.13012/01/2017-Chem-II
Government of India
Ministry of Chemicals & Fertilizers
Department of Chemicals and Petrochemicals

Shastri Bhawan, New Delhi
Dated the 28th June, 2017

OFFICE MEMORANDUM

Subject: Foaming or Algal Bloom in Water Bodies of India – Remedial measures – Restrict Phosphate(P) based detergents- ENVIS Technical Report – reg.

The undersigned is directed to enclose herewith letter dated 29.05.2017 from Dr. T. V. Ramachandra, Co-ordinator, Energy & Wetlands Research Group (CES), Indian Institute of Science, Bangalore along with a copy of Report on " Foaming or algal blooms in water bodies of India: Remedial measures- Restrict Phosphate(P) based detergents" .

2. It is indicated in the report that Algal bloom or foaming is a consequence of nutrient enrichment (N and P) due to untreated sewage (mostly from human and household waste and detergents) and industrial effluents. The phosphorus from several sources reaching water bodies causes pollution leading to algal blooms, frothing, etc. The main sources of phosphate in aquatic environment, is through household sewage water containing detergents and cleaning preparations, agricultural run-off containing fertilizers, as well as, industrial effluents from fertilizers, detergent and soap industries.

3. The cause of foam formation at the Varthur North (Kodi) outfalls and southfalls, collection of water and foam from Varthur South (VI) and North (V2) outlets. The Physico-chemical parameters of water (collected from V1 and V2 and foam samples (from V2) of Varthur lake revealed that the foam had higher concentrations of all the parameters compared to that of water. Thus, foams are enriched with particulate organic and inorganic compounds such as nutrients (Nitrogen, Phosphorus and Carbon), cations (Sodium, Potassium, Calcium and Magnesium). Foam generated is normally sticky and white in color. Most surfactants originate from the detergents, oil and grease that are used in households or industry. The report suggests various measures along with the use of non –phosphate based detergents etc.

cotnd..

4. The study highlights the need for immediate intervention towards the reduction in the amount of sodium tri polyphosphate (STPP) used in detergent builders and switch to 'alternative' non-phosphate based builders, such as Zeolite A and improving wastewater treatment taking advantage of constructed wetlands in urban wastewater treatment.

5. The subject "Soaps and Detergents" is under the domain of D/o Industrial Policy & Promotion, Ministry of Commerce and Industry, Government of India as per the Allocation of Business Rule.

6. In view of above, it is kindly requested to look into the matter and to furnish the comments to Dr. T. V. Ramachandra, Co-ordinator, Energy & Wetlands Research Group (CES), Indian Institute of Science, Bangalore under intimation to this Department.

(Dinesh Kumar)
Director
011-23386047

To,

Shri Ramesh Abhishek
Secretary,
D/o Industrial Policy & Promotion,
M/o Commerce and Industry,
Udyog Bhawan, New Delhi

Copy to: Dr. T. V. Ramachandra, Co-ordinator, Energy & Wetlands Research Group (CES), Centre for Ecological Sciences, Indian Institute of Science, Bangalore-560012

डॉ. हर्ष वर्धन
Dr. Harsh Vardhan

सत्यमेव जयते

भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्री
GOVERNMENT OF INDIA
MINISTER OF ENVIRONMENT, FOREST & CLIMATE CHANGE

D.O.No.A-11014/11/2017-CPW

Date: 01 September, 2017

Dear Shri P.C. Mohan ji,

Kindly refer to your letter dated 15th June, 2017 requesting banning of phosphorous in detergents to prevent pollution of water bodies.

2. The Ministry of Environment, Forest & Climate Change is looking into the matter and has requested for inputs in the matter from Central Pollution Control Board (CPCB) and the other stakeholders. We also have requested the Bureau of Indian Standards (BIS) and Central Drugs Standard Control Organization (CDSCO) to look into the matter of phosphate content in detergents and appropriate labeling of detergent packages.

With regards,

Yours sincerely,

Harsh

(Dr Harsh Vardhan)

Shri P.C. Mohan,
Member of Parliament (Lok Sabha),
3rd Floor, Podium Block,
Ambedkar Veedhi, Vishveshwaraiah Centre,
Bangalore -01.

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Bangalore - 560 001

D.O. No. : FEE/53/Secy(E&E)/2017

Dated : 10-05-2017

Dear Dr. Ramachandra.

Sub: Ban of Phosphate based detergents in Indian Market.

Ref: Your letter dated: 05-05-2017

***

With reference to above subject, I thank you for sending the following reports, which are quite informative and useful for rejuvenation of lakes in Bangalore.

(1) Bellandur and Vartur Lakes Rejuvenation Blueprint – Envis Technical Report 116 April 2017

(2) Foaming or Algal Bloom in Water Bodies of India – Remedial measures-Restrict-Phoshate (P) based detergents-Evnis Technical Report 108. March, 2017.

As suggested in your letter cited at referred(1) above, the matter has been already takeup with the Ministry of Environment, Forest and Climate Change, New Delhi vide letter dated:06-03-2017 (copy enclosed). This is for your kind information.

Warm regards,

Yours Sincerely

(RAMACHANDRA) 10/5/17

Dr. T.V. Ramachandra,
Co-ordinator,
Energy and Wetlands Research Group (CES)
Centre for Ecological Sciences,
Indian Institute of Science,

ಪಿ. ರವಿಕುಮಾರ್, ಭಾ.ಆ.ಸೇ.,
ಸರ್ಕಾರದ ಅಪರ ಮುಖ್ಯ ಕಾರ್ಯದರ್ಶಿ
ಅರಣ್ಯ, ಜೀವಿ ಪರಿಸ್ಥಿತಿ ಮತ್ತು ಪರಿಸರ ಇಲಾಖೆ

GOVERNMENT OF KARNATAKA

P. RAVIKUMAR, I.A.S.,
Additional Chief Secretary to Govt.
Forest, Ecology and Environment Department

(431)

Dear Ajay,

06.03.2017.

FEE 1 EAA 2017

Sub: Ban/Regulate the use of Phosphate in manufacture of detergents—reg

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With reference to above, during the past two decades due to rapid development of Bengaluru city there is an increase in the generation of sewage and as a result of under capacity UGD system, the sewage finds it's way into lakes causing pollution. Recent incident of fire in Bellandur lake is the result of such lake pollution of higher order.

In order to address the issue of Bellandur and Varthur lake pollution the Government constituted an expert committee under the chairmanship of Additional Chief Secretary to Government, Urban Development Department, Bangalore to take up a study to address the problems of lake contamination as well as the feasible technical solutions, for restoration of Bellandur and Varthur lakes to their positive state.

The committee has submitted it's report to the Government with recommendations consisting of short term and long term remedial measures. Among the short term remedial measures, ban of phosphate in detergents and soaps for froth reduction in the lake is one of the suggestions. It is reported that the foams are formed in lakes due to surfactants like synthetic detergents, fats, oils, greases and bio surfactants which are abundant in sewage. These surfactant agents rise to the surface of lake water and interact with water molecules and air, thus, reducing surface tension of water molecules resulting in bubble formation and thereby formation of foam in the lake.

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ದೂರವಾಣಿ: 080-2225 6722 / 2203 2509, ಫ್ಯಾಕ್ಸ್: 080-22258393, ಮಿಂಚಂಚೆ: prs-fee@karnataka.gov.in / prsfee@gmail.com

It is also mentioned that white color of the lake foam indicates that is caused by synthetically produced surfactants released along with sewage through surface waters. Synthetic surfactants are widely used in household cleaning products such as detergents, soaps, cosmetic and personal care products like shampoo, tooth paste etc. Detergents/soaps mostly contains phosphate as softeners to help enhance the effectiveness of surfactants by reduction of water hardness. As per the result of analysis of Bellandur lake water monitored by the KSPCB between 6.12.2016 - 16.12.2016, the Phosphate level is 2.0 mg/lt.

Hence, it is opined that avoiding phosphate in the manufacture of detergents would help in control of pollution related foam/froth formation in the lakes and as such it would be very necessary to ban or to regulate the use of phosphate in the detergents, soaps, cosmetic and personal care products including shampoo etc.

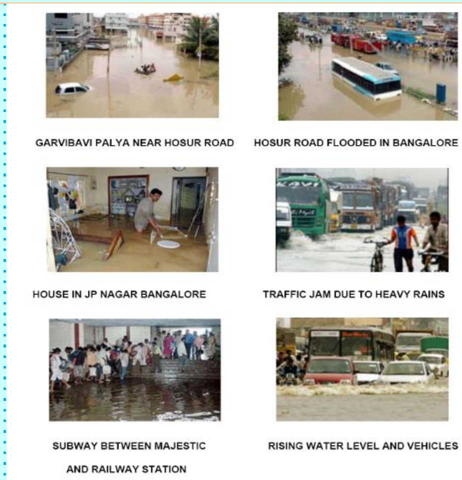
Keeping in view of the above, it is requested to examine and initiate suitable action on the matter and issue necessary orders with regard to ban or to regulate phosphate in manufacture of detergents, soaps, cosmetic and personal care products including shampoo etc.

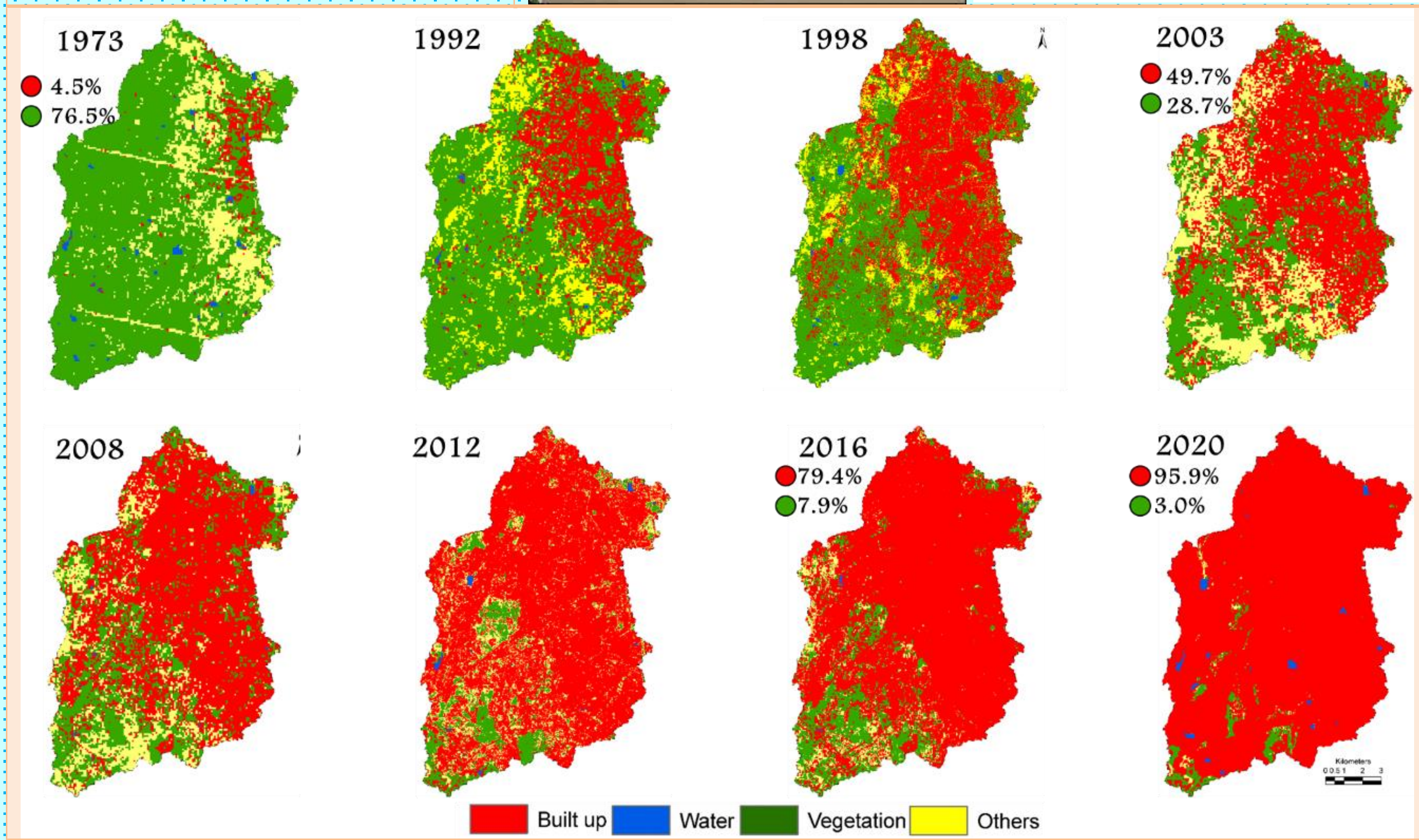
With

Your's

(P. RAVI KUMAR)

Mr. Ajay Narayan Jha, IAS,
The Secretary,
Ministry of Environment, Forest and Climate Change,
Indira Paryavaran Bhawan,
Jor Bagh Road,
New Delhi- 110 003.





VALLEY CONCRETISATION: UNPLANNED, UNREALISTIC URBANISATION

Rejuvenate all Lakes in the valley; Re-establish interconnectivity among lakes;
Protect origin of **streams with appropriate catchment treatment (ecological);**
Stop Pollution – Decentralised treatment options - Sewage treatment through integrated constructed wetlands (similar to Jakkur Model – Secondary Treatment Plant (STP) + Constructed Wetlands + Algae ponds)**.**

ENERGY AND WETLANDS RESEARCH GROUP

SAHYADRI: ENVIRONMENTAL INFORMATION SYSTEM (ENVIS)

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