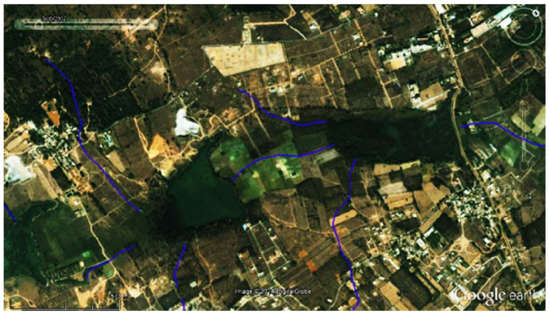
Vanishing Lakes Interconnectivity & Violations in Valley Zone: Lack of Co-ordination among Para-State Agencies



March 2002

May 2014

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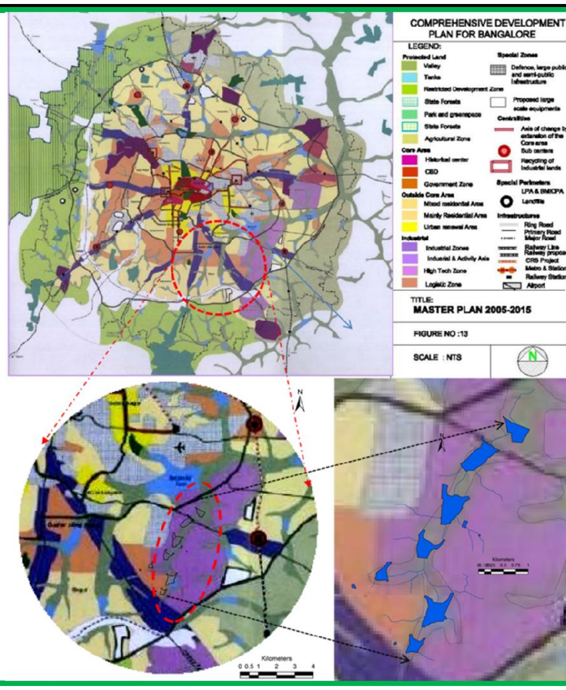

Valley Zone as per 2015 CDP

Builtup | Vegetation | Water | Others

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Vanishing Lakes Interconnectivity & Violations in Valley Zone: Lack of Co-ordination among Para-State Agencies

Executive Summary:

Kaikondrahalli and Kasavanahalli lakes are in the series of Varthur Lake and falls in Koramangala and Challaghatta valley of Urban Bangalore. Kaikondrahalli Lake is situated under the survey number 8 with an area of 27.09 Ha and was restored in 2009 with financial spending of Rs. 2.70 crores. Kasavanahalli comprises an area of 8.91 Ha under survey number 70 and restoration started in 2013 with 3.75 crores set aside. The major works included fencing, de-silting, embankment, pitching, cobble, toilets, immersion tank, grill and plantation. The fencing was done by Karnataka Forest department (KFD) under two phases. These lakes were restored by the initiation of citizens including original inhabitants of villages around the lake and resident welfare associations have worked with the BBMP. These lakes support 37 species of birds and good population of fishes. The lakes has good green cover which are acting as a nesting grounds for migratory birds such as Painted storks (*Mycteria leucocephala)* etc., and in the year 2009-10 more than 1000 trees were planted in association with MAPSAS (Mahadevapura Parisara Samrakshane Mattu Abhivrudhi Samiti). The fresh sewage is entering in the south side of the Kasavanahalli lake and a drainage channel is being destroyed due to construction activities that are taking place on the lake bed. Rampant urbanisation in the catchment area has disturbing the life forms in the lakes. Earlier these lakes were acted as a water source for drinking, ritual place, agriculture, fishing, washing cattle and cloths for villagers of Kasavanahalli and Kaikondrahalli.

Unplanned rapid urbanisation during post 2000 in Bangalore witnessed large scale conversion of watershed area of the lake to residential and commercial layouts. This has altered the hydrological regime and enhanced the silt movement in the catchment. Declining vegetation cover has lowered water yield in the catchment, affecting the groundwater recharge. Alterations in ecological integrity is evident from reduced water yield, flash floods, contaminated water, obnoxious odour, copious growth of invasive floating macrophytes, disappearance of native fish species, breeding ground for mosquito and other disease vectors, etc. A major portion of untreated city sewage (500+ million liters per day) is let into the lake, beyond the neutralizing ability of the lake, which has hampered the ecological functioning of the lake.

Significance of wetlands: Wetlands are lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, microclimate regulation, enhance the aesthetics of the landscape, and support many significant recreational, social and cultural activities, aside from being a part of our cultural heritage. **Wetlands function as kidneys of landscape due to remediation of contaminants (which include nutrients, heavy metals, etc.). These fragile ecosystems are vulnerable to even small changes in their biotic and abiotic factors. In recent years, there has been concern over the continuous degradation of wetlands due to unplanned developmental activities** (Ramachandra, 2002)**.** Most urban wetlands are seriously threatened by conversion to non-wetland purposes, encroachment of drainage through landfilling, pollution (discharge of domestic and industrial effluents, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes), and over-exploitation of their natural resources. This results in loss of biodiversity and disruption in goods and services provided by wetlands (Ramachandra, 2009).

Policy and legislative measures for Wetlands conservation in India are:

- The Indian Forest Act - 1927
- Forest (Conservation Act) - 1980
- Wildlife (Protection) Act - 1972
- Water (Prevention and Control of Pol1ution)Act - 1974
- Water (Prevention and Control of Pollution) Act - 1977
- Environmental (Protection) Act - 1986
- Wildlife (Protection) Amendment Act - 1991
- National Conservation Strategy and Policy Statement on Environment and I Development - 1992
- National Policy And Macro level Action Strategy on Biodiversity-1999
- Biological Diversity Act, 2002, areas rich in biodiversity, cultural importance, etc.
- Wetlands (Conservation and Management) rules 2010, Government of India

Construction activities in the valley zone of Kaikondanahalli- Kasavanahalli lake series need to be stopped immediately and all wetlands are to be restored considering

Activities	Norms
Construction activities in the valley zone	This is contrary to sustainable development as the natural resources (lake, wetlands) get affected due to this decision. Eventually this kills the lake. This reflects the ignorance of the administrative machinery on the importance of ecosystems and the need to protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
Location of high rise buildings in flood prone zone of the lake and in wetland - 30 m buffer zone of the water body is to be no development zone	In case of water bodies a 30.0 m buffer of 'no development zone' is to be maintained around the lake (as per revenue records) ✓ As per BDA, RMP 2015 ✓ section 17 of KTCP Act, 1961 and sec 32 of BDA Act, 1976 ✓ Wetlands (Conservation and Management) rules 2010, Government of India
Alterations in topography	Adjacent localities would be vulnerable to floods. This would lead to loss of property and human life with frequent flood in the region.
Loss of interconnectivity among lakes: Removal of rajakaluve (storm water drain) and gradual encroachment of rajakaluve as well as lake bed	Removal of lake connectivity enhances the episodes of flooding and associated disasters The Hon'ble Supreme Court in Civil appeal number 1132/2011 at SLP (C) 3109/2011 on January 28,2011 has ex-pressed concern regarding encroachment of common property resources, more particularly lakes and it has directed the state governments for removal of encroachments on all community lands. Eviction of encroachment: Need to be evicted as per Karnataka Public Premises (eviction of unauthorised occupants) 1974 and the Karnataka Land Revenue Act, 1964.
Encroachment/ Narrowing storm water drains	Removal of *raja kaluve* would affect inter connectivity and leads to flooding in the region.
Loss of Inter connectivity	Would affect ground water in the region,

	evident from ground water table depletion from 100 m to 300-400 m already with the construction activities and exploitation of ground water in the region. Would affect the lakes in the downstream, as there would be cascaded lake water overflows from one lake to other and recharges the ground water. Would result in the loss of wetlands, decreases in catchment yield, loss of water storage capacity and shrinkage in the wetland area.
Increase in deforestation in catchment area	Removing vegetation in the catchment area increases soil erosion and which in turn increases siltation and decreases transpiration.
Ongoing construction activities violates Hon'ble High Court of Karnataka's verdict to protect, conserve, rehabilitate and wisely use lakes and their watersheds in Bangalore all lakes in Karnataka and their canal networks (about 38,000)	High Court of Karnataka (WP No. 817/2008) • Protects lakes across Karnataka, • Prohibits dumping of Garbage and Sewage in Lakes • Lake area to be surveyed and fenced and declare a no development zone around lakes • Encroachments to be removed. • Forest department to plant trees in consultation with experts in lake surroundings and in the watershed region • Member Secretary of state legal services authority to monitor implementation of the above in coordination with Revenue and Forest Departments. • Also set up district lake protection committees
Dumping of debris and filling of wetlands	This is done mainly to encroach lakes gradually, which would affect sustainability of ecosystem.
Construction of basement with 2-3 floors	Would affect the inter connectivity among aquifers. This will aggravate the ground water crisis in the region.
Increased vehicle density	Increases traffic bottleneck in the region and air

	pollution (with the increase in density of vehicles)
Increase in vehicular traffic and enhanced pollutants	Traffic congestion (due to additional vehicle movement). The density of traffic would increase, the road's current level of service (LOS) is under category **C**. The equivalent ratio of V/C (with construction) to the LOS is D and F respectively for the connecting road and the Sarjapur road, indicating very poor traffic conditions, creating bottle necks. The increase in vehicles would worsen the traffic condition**.** enhanced levels of vehicular pollutants; likely increase in respiratory diseases;
Loss of buffer zone	The loss of shoreline along the lakebed results in the habitat destruction for most of the shoreline birds that wade in this region. Some of the shoreline wading birds like the Stilts, Sandpipers; etc will be devoid of their habitat forcing them to move out such disturbed habitats. As per Wetland regulatory act of GOI (Wetland conservation and Management rules 2010, Government of India) 200 m from wetland area is prohibited for any construction activities. Since wetlands (the region where inflow to the lake happens through plank beds) acts as a kidney, which helps in treating water. Construction, filling activities will affect the functional abilities of lake (treatment of water). Violation of the rules specified, mismanagement of lakes by individuals, community are liable for punishment. As per BDA (Bangalore Development Authority) and CDP (City Development Plan) norm 30m from the lake boundary is a buffer zone. Creating buffer zones limiting anthropogenic activities around the demarcated corridor of the wetland could revive its natural functioning. Removal of riparian vegetation and allowing construction activity will affect sustainability of lake.

Direct sustained inflow of untreated sewage to lakes	Violation of Water (Prevention and Control of Pol1ution)Act – 1974 & 1977 • Need to penalise para-state agency BWSSB for contaminating lake (and subsequent contamination of groundwater due to the sustained inflow of untreated sewage to these lakes. Need to implement "Polluter pays" principle.
Lack of clean air, water and environment to our children	Violates the norms of 'Right to water' and right to 'healthy environment' guaranteed under Article 21of the Indian constitution. This has been protected as a fundamental human right by the Indian Supreme Court as part of the Right to Life The right to life has been expanded significantly over the last three decades to include the right to health and the right to a clean environment which can include the right to clean drinking water.
Slum colony on the lake bed and in the buffer zone	Unauthorized occupation by illegal immigrants (some occupants appeared to be non-Indians. Associated social crimes in the locality. • Unauthorsied occupation in the buffer zone contrary to norms of BDA • Illegal immigrants pose serious security threat to the region as well as to our country. Government need to act immediately, otherwise Bangalore will face similar situation as other parts of the country.
Water shortage	Bangalore is already experiencing severe water shortages as water yield in rivers (Cauvery, etc.) has come down due to large scale land cover changes. Neither Cauvery, T G Halli nor groundwater can sustain Bangalore's growing water demand.

	BWSSB has not given NOC and has indicated inability to supply such huge quantity of water on regular basis.
Pathetic water scenario and insufficient drinking water in Bangalore	At the 4% population growth rate of Bangalore over the past 50 years, the current population of Bangalore is 8.5 million (2011). Water supply from Hessarghatta has dried, Tippegondahanally is drying up, the only reliable water supply to Bangalore is from Cauvery with a gross of 1,410 million liters a day (MLD). There is no way of increasing the drawal from Cauvery as the allocation by the Cauvery Water Disputes Tribunal for the entire urban and rural population in Cauvery Basin in Karnataka is only 8.75 TMC ft (one thousand million cubic – TMC ft equals 78 MLD), Bangalore city is already drawing more water—1,400 MLD equals 18 TMC—than the allocation for the entire rural and urban population in Cauvery basin.

Ecological and Environmental Implications:

- *Land use changes:* Conversion of green cover / vegetation cover removal in the watershed especially in the valley regions of the lake to paved surfaces would alter the hydrological regime leading to flash floods, lowered groundwater table, less water in the lake during lean seasons.
- *Loss of Drainage Network: Removal of drain (Rajakaluve) and reducing the width of the drain would flood the surrounding residential as* the interconnectivities among lakes are lost and there are no mechanisms for the excessive storm water to drain and thus the water stagnates flooding in the surroundings.

- *Alteration in landscape topography:* This activity alters the integrity of the region affecting the lake catchment. This would also have serious implications on the storm water flow in the catchment. The dumping of construction waste along the lakebed and lake has altered the natural topography thus rendering the storm water runoff to take a new course that might get into the existing residential areas. Such alteration of topography would not be geologically stable apart from causing soil erosion and lead to siltation in the lake.

- *Loss of Shoreline:* The loss of shoreline along the lakebed results in the habitat destruction for most of the shoreline birds that wade in this region. Some of the shoreline wading birds like the Stilts, Sandpipers; etc will be devoid of their habitat forcing them to move out such disturbed habitats. It was also apparent from the field investigations that with the illogical land filling and dumping taking place in the Kasavanahalli lakebed, the shoreline are gobbled up by these activities.

- *Loss of livelihood:* Local people are dependent on the wetlands for fodder, fish etc. estimate shows that wetlands provide goods and services worth Rs 10500 per hectare per day (Ramachandra et al., 2005).

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

It is the responsibility of all Bangalore citizens (to ensure intergenerational equity, sustenance of natural resources and to prevent human-made disasters such as floods, etc.) to stall the irrational conversion of land in the name of development and restrict the land encroachers with decision makers taking the system (ecosystem including humans) for granted as in the case of these wetlands large scale buliders.

Vanishing Lakes Interconnectivity & Violations in Valley Zone: Lack of Co-ordination among Para-State Agencies

Introduction:

Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, microclimate regulation, enhance the aesthetics of the landscape, and support many significant recreational, social and cultural activities, aside from being a part of our cultural heritage. It was acknowledged that most urban wetlands are seriously threatened by conversion to non-wetland purposes, encroachment of drainage through landfilling, pollution (discharge of domestic and industrial effluents, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes), and over-exploitation of their natural resources. This results in loss of biodiversity and disruption in goods and services provided by wetlands (Ramachandra, 2008. 2009a,b). Last section of this communication addresses the strategies considering the current trends in aquatic ecosystem conservation, restoration, and management including the hydrological and the biophysical aspects, peoples' participation and the role of non-governmental, educational, and governmental organisations and future research needs for the restoration, conservation, and management.

Urbanisation is a form of metropolitan growth that is a response to often-bewildering sets of economic, social, and political forces and to the physical geography of an area. It is the increase in the population of cities in proportion to the region's rural population. The 20th century is witnessing "the rapid urbanisation of the world's population", as the global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005 and is projected to rise to 60% (4.9 billion) by 2030 (UN, 2005). Urban ecosystems are the consequence of the intrinsic nature of humans as social beings to live together (Sudhira *et al*., 2003; Ramachandra and Kumar, 2008). The process of urbanisation contributed by infrastructure initiatives, consequent population growth and migration results in the growth of villages into towns, towns into cities and cities into metros. Urbanisation and urban sprawl have posed serious challenges to the decision makers in the city planning and management process involving plethora of issues like infrastructure development, traffic congestion, and basic amenities (electricity, water, and sanitation), etc. (Kulkarni and Ramachandra, 2009). Apart from this, major implications of urbanisation are:

- **Loss of wetlands and green spaces:** Urbanisation has telling influences on the natural resources such as decline in green spaces (vegetation) including wetlands and / or depleting groundwater table (Ramachandra and Kumar, 2008).
- **Floods:** Common consequences of urban development are increased peak discharge and an increased frequency of floods as land that was converted from fields or woodlands to roads and parking lots loses its ability to absorb rainfall. Conversion of water bodies to residential 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 (Ramachandra and Mujumdar, 2009).
- **Decline in groundwater table:** Studies reveal the removal of water bodies has led to the decline in water table. Water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of lake with its catchment for commercial activities. In addition, groundwater table in intensely urbanized area such as Whitefield, etc. has now dropped to 400 to 500m (Ramachandra, 2009).
- **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 (Ramachandra and Kumar, 2009).
- **Increased carbon footprint**: Due to the adoption of inappropriate building architecture, the consumption of electricity has increased in certain corporation wards drastically. The building design conducive to tropical climate would have reduced the dependence on electricity. Higher energy consumption, enhanced pollution levels due to the increase of private vehicles, traffic bottlenecks have contributed to carbon emissions significantly. Apart from these, mismanagement of solid and liquid wastes has aggravated the situation (Ramachandra and Shwetmala, 2009).

Threats faced by Wetlands in Bangalore

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

Water bodies – Lentic (Lakes, wetlands) or lotic (rivers and streams) have been the cradles of biodiversity and key constituent of our human wellbeing and environment. The region surrounding the water body that acts as container to drain water to the water body is a wetland which houses all requirement that offer several substantive benefits such as life support systems, winter resorts for a variety of birds, suitable habitats for fish and other flora, fauna, effective in flood control, waste water treatment, reducing sediment loads and recharging of aquifers. Thus these water bodies, though relatively small in size whether natural, or manmade play a significant vital role in environmental, social economic functions, maintaining environmental sustainability particularly in urban environments in today's context of rapid and unplanned urbanisation. Today, these water bodies are being encroached, fed with sewage, garbage and much of the landscape around them has been covered by impervious surfaces. Table 1 lists the threat faced by Kaikondanahalli-Kasbanahalli lake series in Bangalore.

S.no	Impact	Implication
1.	Construction activities in valley zone of wetlands and removal of Inter connectivity	Would affect ground water in the region, evident from already depletion of ground water table from 100 m to 300-400 m in the region. Would affect the lakes in the downstream, as these lakes are cascaded, water overflows from one lake to other apart from recharging the ground water. This action, if unabated would result in the loss of wetlands, decreases in catchment yield, loss of water storage capacity and shrinkage in the wetland area.
2.	Encroachment/ Narrowing storm water drains	Removal of *raja kaluve* would affect inter connectivity and leads to flooding in the region.
3.	Alteration in topography	Topography alteration would lead to frequent flood in the region with the loss of property and human life.
4.	Construction of basement with 2-3 floors	Would affect the inter connectivity among aquifers. This will aggravate the ground water crisis in the region.
5.	Dumping of debris and filling of wetlands	This is done mainly to encroaching lakes gradually, which would affect sustainability of ecosystem.
6.	Loss of buffer zone	The loss of shoreline along the lakebed results in the habitat destruction for most of the shoreline birds that wade in this region. Some of the shoreline wading birds like the Stilts, Sandpipers; etc will be devoid of their habitat forcing them to move out such disturbed habitats.

		As per Wetland regulatory act of GOI (Wetland conservation and Management rules 2010, Government of India) 200 m from wetland area is prohibited for any construction activities. Since wetlands (the region where inflow to the lake happens through plank beds) acts as a kidney, which helps in treating water. Construction, filling activities will affect the functional abilities of lake (treatment of water). Violation of the rules specified, mismanagement of lakes by individuals, community are liable for punishment. As per BDA (Bangalore Development Authority) and CDP (City Development Plan) norm 30m from the lake boundary is a buffer zone. Creating buffer zones limiting anthropogenic activities around the demarcated corridor of the wetland could revive its natural functioning. Removal of riparian vegetation and allowing construction activity will affect sustainability of lake.
7.	Increase in deforestation in catchment area	Removing vegetation in the catchment area increases soil erosion and which in turn increases siltation and decreases transpiration.
8.	Water (lake and groundwater) contamination - Direct sustained inflow of untreated sewage to lakes	Violation of Water (Prevention and Control of Pol1ution)Act – 1974 & 1977 • Need to penalise para-state agency BWSSB for contaminating lake (and subsequent contamination of groundwater due to the sustained inflow of untreated sewage to these lakes. Need to implement "Polluter pays" principle.
9.	Lack of clean air, water and environment to our children	Violates the norms of 'Right to water' and right to 'healthy environment' guaranteed under Article 21of the Indian constitution. This has been protected as a fundamental human right by the Indian Supreme Court as part of the Right to Life The right to life has been expanded significantly over the last three decades to include the right to health and the right to a clean environment which

		can include the right to clean drinking water.
10.	Illegal occupation of lake bed / buffer zone -Slum colony on the lake bed and in the buffer zone	Unauthorized occupation by illegal immigrants (some occupants appeared to be non-Indians. Associated social crimes in the locality. • Unauthorsied occupation in the buffer zone contrary to norms of BDA • Illegal immigrants pose serious security threat to the region as well as to our country. Government need to act immediately, otherwise Bangalore will face similar situation as other parts of the country.

Table 1: Impact of mismanagement of water bodies and its implications

Status of water bodies and wetlands in India: Aquatic ecosystem in India is classified under marshes, swamps, open water bodies, mangroves, tidal flats and salt marshes etc. apart from coast. Wetlands in India (excluding rivers), account for 18.4% of the country's geographic area, of which 70% is under paddy cultivation. The India has 5306314 ha inland wetland cover (excluding rivers) and the total wetland area of Karnataka is 542515 ha only. Table 2 explains the total area of inland wetlands of India under different categories (Anon, 2011). Inland aquatic biodiversity of rivers, lakes, reservoirs and wetlands is very rich, harbors 15% of India's floral and 20% faunal diversities. India has lost more than 38% of its wetlands in just the last decade, in some regions rate has been as high as 88% (Vijayan, 2004). Contaminated runoff from expanding urban and agricultural areas, floating pollutants and hydrologic modifications such as drainage of wetlands are just few of the many factors that continue to degrade surface waters in recent times. Wetlands in India supports around 2400 species and subspecies of birds. But losses in habitat have threatened the diversity of these ecosystems. Introduced exotic species like water hyacinth *(Eichhornia crassipes)* and salvinia *(Salvinia molesta)* have threatened the wetlands and clogged the waterways, competing with the native vegetation (Prasad et al., 2002).

The urban population in India is growing at about 2.3% per annum with the global urban population increasing from 13% (220 million in 1900) to 49% (3.2 billion, in 2005) and is projected to escalate to 60% (4.9 billion) by 2030 (Ramachandra et al., 2012). The quantum jump and instantaneous growth of urban population by expanding existing urban areas in the last century without corresponding expansion of civic facilities resulting in depletion of lakes, wetlands and becoming sinks for contaminants. The water bodies are facing degradation due to encroachments eutrophication (from domestic and industrial effluents) and silt without exception in varying degrees of environmental degradation. A survey conducted by WWF-IUCN covering some of the important wetlands in India identified wildlife poaching (38%), pollution (37%), grazing pressure, alteration to other land uses, over-fishing and siltation as some of the major threats. The lakes and wetlands jurisdiction are diffused and falls under various departments like municipal corporations, forest, agriculture, fisheries, irrigation, revenue, tourism, water resources and local bodies. The lack of a comprehensive policy frame work and coordination with each department resulting depriving these precious water resources. The developmental policies and priorities of the local governing bodies further aggravating the situation of losing water bodies by encouraging large scale aquaculture, filling with waste water and solid waste dump sites etc.

	Wetland type	Area (ha)
1	Lakes, ponds, ox-bow lakes, high altitude wetlands	957909
2	Swamp/marsh, waterlogged (natural, manmade)	542477
3	Reservoirs, tanks, abandoned quarries ash or cooling ponds, salt pans	3805928
4	River/streams	5258385
Total inland wetlands		1,05,64,699

Table 2: Wetland types in India and their extent

Legal Framework for protection of Wetlands

The conservation and management of water bodies has initiated in India after the independence under the regulatory frame work by incorporating as a primary right of citizens in constitution. **Article 48 A** of constitution state has endeavor to protect environment, forest and wild life of the region. It shall be the duty of every citizen of the country to protect and improve environment, which includes forests, lakes, rivers, wetlands and wild life under **Article 51 A clause (g)**. **Article 253** of constitution empowers parliament under the schedule VII to legislate the suggestions and initiations to be adopted to protect environment and natural resources. Several legal and legislations have been enacted by initiation of Ministry of Environment and forestry (MoEF). These include Forest act 1972, Wildlife protection act 1980, Pollution prevention and control act 1974 (Air), the Water cess act, 1977. These all together brought under the umbrella provision of Environment (Protection) Act, 1986. Ramsar convention (1971) on wetlands, the first intergovernmental convention for conservation and 'wise use' of any ecosystem, entered into force in 1975 and has 168 contracting parties from all over the world. So far the convention has 2169 wetland sites under its aegis covering 206.64 million ha area (Ramsar Convention, 2013).

The Biodiversity Act, 2002, was legislated to preserve the floral and faunal biodiversity, and securing equitable share in benefits arising out of the use of biological resources, protecting associated knowledge of local communities relating to biological resources (clause (1) of article 243B and clause (1) of Article 243Q of the Constitution). It also aimed to conserve and sustainably use biological diversity, taking necessary actions on uncontrolled commercial exploitation of natural resources (as determined by the National Biodiversity Authority under section 2.1). This act also provided guidelines for sustainable development and management of water resources, aquaculture at the local level.

National Environment Policy (NEP), 2006 is another initiative to safeguard water sources and management. This policy has initiated some action plans to be taken by regulatory authorities for efficient protection. It includes, setting up of legally enforceable regulatory mechanism to prevent their degradation and enhance their conservation. Develop a national inventory, formulate conservation and prudent use strategies with participation of local communities, and other relevant stakeholders. The National Wetland Conservation Program was launched in 1987 and initially restricted itself to the notified Ramsar Wetlands. In 2009, the MoEF issued Guidelines for Conservation and Management of Wetlands and has identified some 122 wetlands for protection by issuing a Draft Regulatory Framework for Wetlands Conservation, under the provisions of the Environment (Protection) Act (EPA), 1986. In the year 2010, Wetlands Conservation and Management rules were framed to provide further direction in protection and efficient management.
The highlights are:

- Restrictions on activities within the wetlands include reclamation, setting up industries in vicinity, solid waste dumping, manufacture or storage of hazardous substances, discharge of untreated effluents, any permanent construction, etc.
- Regulated Activities (which will not be permitted without the consent of the state government) include hydraulic alterations, unsustainable grazing, harvesting of resources, releasing treated effluents, aquaculture, agriculture, dreading, etc.
- The major functions of the authority include identification of new wetlands for conservation, ensuring that the Rules are followed by the local bodies, issue clearances, etc.

In recent time, Indian judiciary were instrumental in protecting wetlands throughout the country. The court and law have been extremely proactive on the issue of environmental and by considering Public Interest Litigations (PIL) in courts across the country. The groups of affected people and citizens have been filing PIL in courts across the country seeking remedial actions, specifically in respect of highly polluted urban lakes and water bodies. The Supreme Court of India has provided judgment in 2006 as the government is duty-bound to preserve these natural water bodies, to ensure its citizens the right to water and protection of natural lakes and ponds honors the most basic fundamental right under Article 21 of the Constitution (Infochange, 2006). The Supreme Court bench has clarified that, protection of water bodies, envisioned in view of the fact that the right to water, as also quality of life, is guaranteed under Article 21 of the Constitution. The court also noted that the government was duty-bound under Articles 47 and

48A of the Constitution to protect the environment as well as to improve the living standards of its citizens of the country.

Bangalore Scenario

Bangalore is the capital of Karnataka state, India lies between the latitudes 12°39'00'' to 13°13'00''N and longitude 77°22'00'' to 77°52'00''E. Also known as the Garden City of India and it is 3,113 feet (949 m) above sea level. Bangalore has grown spatially more than ten times since 1949 (~69 square kilometers to 741) and is the fifth largest metropolis in India. The rapid urbanization process in Bangalore has led to the drastic changes in land use leading to imbalance in biological and social environment. There has been a 584% growth in built-up area during the last four decades with the decline of vegetation by 66% and water bodies by 74% (Ramachandra et al., 2012). The population has increased from 5.8 Million (2001) to 8.6 Million (2011), accounting for 45.68% growth in a decade. Population density has increased from as 10732 (in 2001) to 13392 (in 2011) persons per sq. km.

Bangalore is located on a ridge with natural water courses along the three directions of the Vrishabhavaty, Koramangala-Challaghatta (K&C) and Hebbal-Nagavara valley systems, these water courses are today being used for the transport and disposal of the city's sewage. 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. Lakes of Bangalore are all built and interconnected by an intricate network of canals. These inter connected series of lakes help capture monsoon overflow, and store it for use in the post monsoon season, that help recharge ground water aquifers. Large scale unplanned developmental activities in recent times due to uncontrolled urbanisation in the lake catchment, has resulted in reduced catchment yield and higher evaporation losses. Inefficient primary feeder channels, encroachment of raja kaluves resulting the lake water shortage and drying. However, this shortage has been supplemented by an increased quantum of sewage inflow by local regulatory boards such as BWSSB (Bangalore Water Supply and Sewerage Board), BDA (Bangalore Development Authority) and LDA (Lake Development Authority). Due to the sustained influx of fresh sewage over a decade, nutrients in the lake are now well over safe resulting in eutrophication. There are substantial algal blooms, dissolved oxygen depletion and malodor generation, and an extensive growth of water hyacinth that covers about 70 % of the lakes in the dry season (Durga et al., 2011). The lack of awareness in appreciating the full economic benefits of water bodies led to loss of them at a greater extent.

Greater Bangalore had 207 water bodies in 1973, by 2011 left with only 93 water bodies (Figure 1) and many lakes (54%) were encroached for illegal buildings. Field investigation of all lakes shows that nearly 66% of lakes are sewage fed, 14% surrounded by slums and 72% showed loss of catchment area. About 30% of the lakes were drained either for residential sectors in their ornamental borders and nearly 22% of the lakes were encroached land filling and walling of the lake margin has been observed. The major lake's catchment area were used as dumping yards for either municipal solid waste or building debris (Ramachandra, 2009; Ramachandra, et al., 2012). Bruhat Bangalore Mahanagara Palike (BBMP) claims the city had lost the major lakes due to developmental activities such as residential layouts, playgrounds, stadiums, industries, government buildings and bus stands. Lake beds now are dominated by private projects, apartments and independent houses commercial complexes etc. The land swindlers have not left the storm water drains and lake catchment areas from encroaching and converting to commercial activities. The over exploitation of lakes and wetlands in Bangalore in recent times have resulted in rendering the ecosystem in peril by receptacles of untreated sewage, runoff from developed urban and agricultural areas, changing land use within the watershed etc. These series of unethical actions are deteriorating water quality by pollution, led to spawning of mosquitoes and became cores for dissemination of deceases. The BDA has informed the Principal Secretary to Government, Revenue Department in Apex committee meeting held on 10/05/2013 that 2311 families have illegally encroached the lake bed areas in 64 lakes in Bangalore.

There were about 43 lakes in Bangalore were utilized for various public purposes/converted into house sites or encroached by 1985. The Government of Karnataka constituted an expert committee headed by Sri N. Lakshman Rau in 1985 to examine all the aspects of the preservation restoration of lake in Bangalore. The report was accepted by the GO No.PWD 82 IMB 85 dated 11th February 1988, but implementation of the recommendations have not been implemented due to the involvement of many agencies. Ramaswamy committee, a joint Legislature committee (2007) reported an area of 747.86 ha of lake areas (2488 cases) of Government lands encroachments in Bangalore Urban district. Presently the Bangalore city is facing pathetic water supply scenario and BWSSB is not in a position to supply the required 150 litres per person water requirement to the existing population of 89 lakh people in BBMP area. Bangalore has around 1.5 lakh bore-wells to meet the water requirements. Further, well maintained lakes can augment the water supply to the Bangalore city, as there is already acute shortage of water supply. There is no way of increasing the drawl from Cauvery as the allocation by the Cauvery Water Disputes Tribunal for the entire urban and rural population in Cauvery Basin in Karnataka is only 8.75 TMC ft (one thousand million cubic – TMC ft equals 78 MLD). No more water can be drawn from Cauvery, after Stage IV, Phase II is completed by 2011.

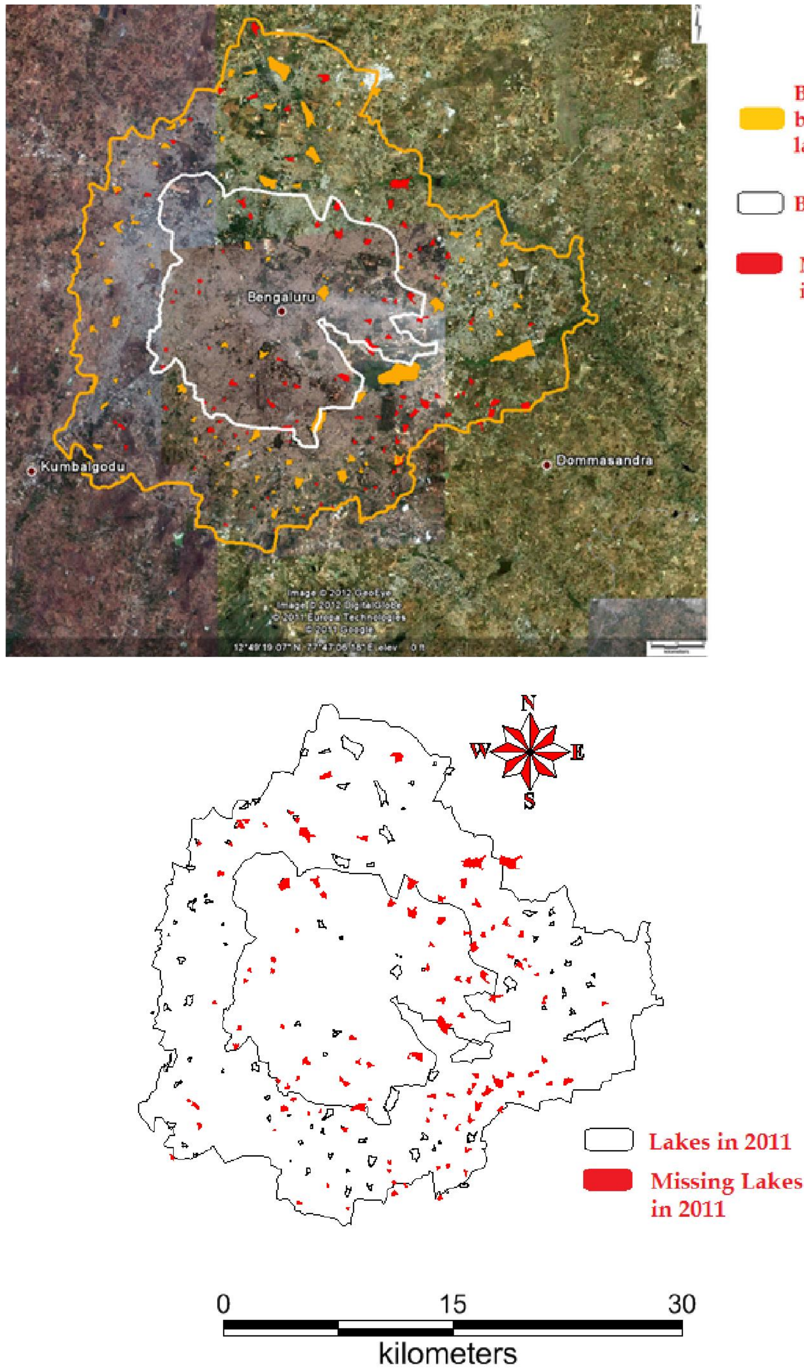


Figure 1: Greater Bangalore with 207 water bodies (1973), 93 water bodies (2011) Erstwhile Bangalore city 58 water bodies (1973), 10 water bodies (2011).

Court verdicts pertaining to lakes in Bangalore

The Hon'ble Supreme Court in Civil appeal number 1132/2011 at SLP (C) 3109/2011 on January 28,2011 has ex-pressed concern regarding encroachment of common property resources, more particularly lakes and it has directed the state governments for removal of encroachments on all community lands. The high court of Karnataka under Justice N. K. Patil Committee has provided judgment dated 3/3/2011 on plan of action for Bangalore Lakes in response to PIL of (WP No. 817/2008) and involved the Chiefs of of Dept. of Revenue, Karnataka State Pollution Control Board, Bangalore Water Supply and Sewerage Board, Karnataka Forest Department, Bangalore Development Authority, Bruhat Bengaluru Mahanagara Palike, Minor Irrigation Department, Lake Development Authority and Dept of Town Planning. The judgment emphasis on immediate action to remove encroachments from lake area and also the Raja Kaluves (canals interconnecting lakes). The committee has advised the regulatory agencies to conduct a thorough survey of legal limits of all lake and canal areas, and thus protecting the entire watershed (the drains that bring rainwater into the lake). The plan of action is proposed as surveying, removal of encroachments, fencing, clearing of blocked and encroached Raja kaluves and drains and de-silting to the extent absolutely required. The judgment also provided directions on lake restoration, which is to be taken up based on lake series/ sub-series and not in isolation. Respective departments were directed to strictly penalize individuals or companies who are responsible for diverting raw sewage into lakes nearby. The lakes which has very high biodiversity, especially of migratory birds and waterfowl, is to be notified for conservation under the Wetland (Conservation and Management Rules), 2010, per the Environment Protection Act and wildlife conservation act. The Court also guided LDA to maintain effective lake area which should not be reduced by converting lake area into parks, children play grounds, widened bunds etc.

The Karnataka High Court division Bench comprising Chief Justice D.H. Waghela and Justice Ashok B. Hinchigeri on 05/08/2014 has passed the order to evacuate 135 encroachments under Section 104 of the Karnataka Land Revenue Act in response to PIL for protecting Sarakki lake at J.P. Nagar based on the survey conducted by the tahsildar of Bangalore South taluk. The Karnataka High Court has ordered the complete removal of encroachments of lakes in the State. Karnataka High Court judge Justice L Narayanaswamy in Lok Adalat 16/08/2014 has asked all district commissioners (DCs) to submit an affidavit details of evacuated encroachments within two months. The court also ordered to take stringent action against owners on illegal digging of bore wells and asked the government to seize those bore wells.

Study area - Kaikondrahalli and Kasavanahalli lakes

Kaikondrahalli and Kasavanahalli lakes are in the series of Varthur Lake and falls in Koramangala and Challaghatta valley of Urban Bangalore (Figure 2). Kaikondrahalli Lake is situated under the survey number 8 with an area of 27.09 Ha and was restored in 2009 with financial spending of Rs. 2.70 crores. Kasavanahalli comprises an area of 8.91 Ha under survey number 70 and restoration started in 2013 with 3.75 crores set aside. The major works included fencing, de-silting, embankment, pitching, cobble, toilets, immersion tank, grill and plantation.

The fencing was done by Karnataka Forest department (KFD) under two phases. These lakes were restored by the initiation of citizens including original inhabitants of villages around the lake and resident welfare associations have worked with the BBMP. These lakes support 37 species of birds and good population of fishes. The lakes has good green cover which are acting as a nesting grounds for migratory birds such as Painted storks (*Mycteria leucocephala)* etc., and in the year 2009-10 more than 1000 trees were planted in association with MAPSAS (Mahadevapura Parisara Samrakshane Mattu Abhivrudhi Samiti). Fresh sewage is entering in the south side of the Kasavanahalli lake and a drainage channel is being destroyed due to construction activities in the lake bed. Rampant urbanisation in the catchment area has disturbing the life forms in the lakes. Earlier these lakes were acted as a water source for drinking, ritual place, agriculture, fishing, washing cattle and cloths for villagers of Kasavanahalli and Kaikondrahalli.

Materials and Methods

Data: Survey of India (SOI) toposheets of 1:50000 and 1:250000 scales were used to generate base layers. Field data was collected with a handheld GPS. The time series remote sensing data acquired from Landsat Series Multispectral sensor (57.5m) and Thematic mapper (28.5m) sensors were downloaded from public domain (http://glcf.umiacs.umd.edu/data). Google Earth data (http://earth.google.com) served in pre and post classification process and validation of the results. Latest data for 2014 (IRS – Indian remote Sensing) was procured from the National remote Sensing Centre (http://www.nrsc.gov.in), Hyderabad. The methods adopted in the analysis involved:

Pre-processing of data: The remote sensing data were geo-referenced, rectified, and cropped pertaining to the study area. Geo-registration of remote sensing data (Landsat data) was done using ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also from known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India. Geo-referencing of acquired remote sensing data to latitude-longitude coordinate system with Evrst 56 datum: Landsat bands, IRS MSS bands, were geo-corrected with the known ground control points (GCP's) and projected to Polyconic with Evrst 1956 as the datum, followed by masking and cropping of the study area.

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

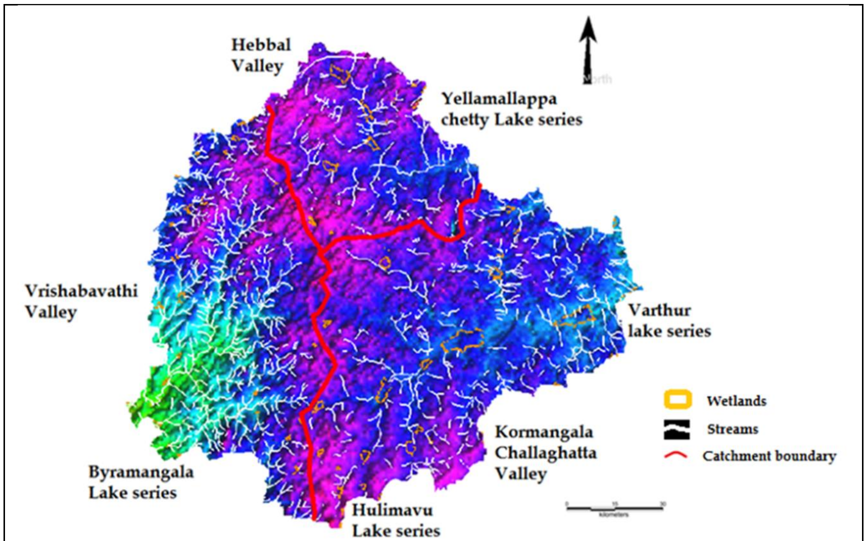
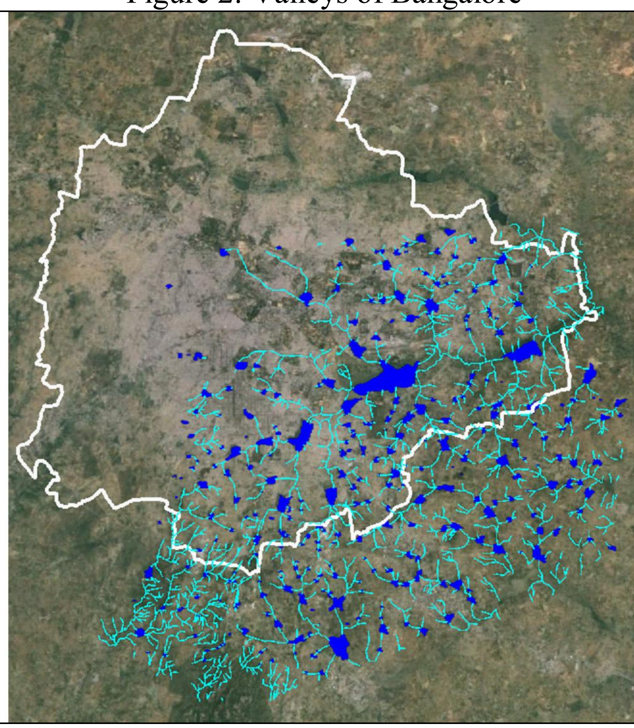


Figure 2: Valleys of Bangalore



Koramangala and Challaghatta valley

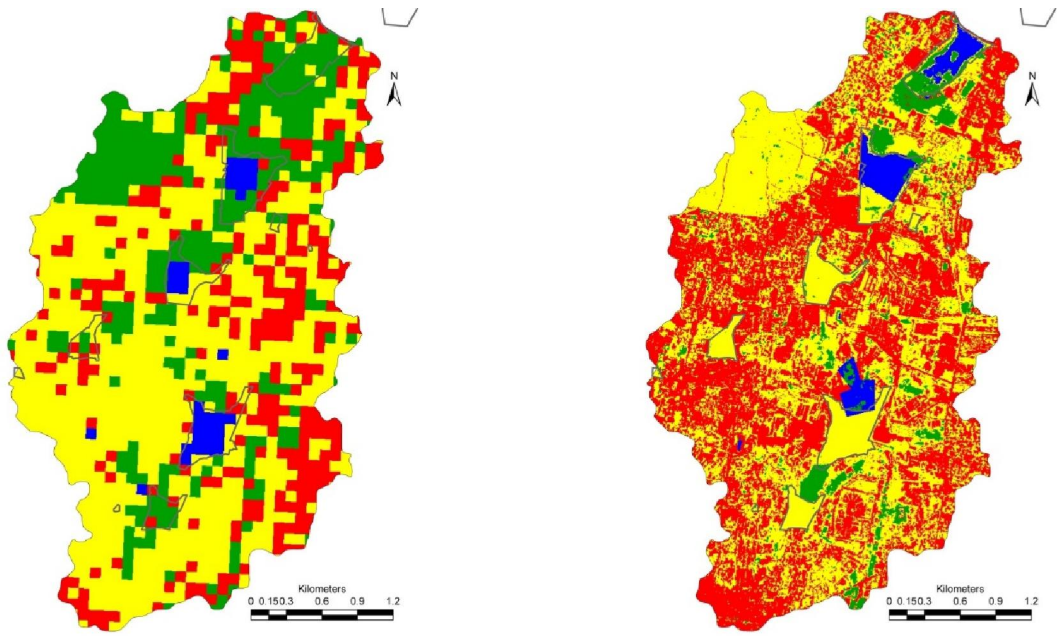
Results and Discussion

Land use: Land use Dynamics: Gaussian MLC classifier was used, the land use (figure 3, Table 3) results shows that Built up area in the catchment has increased from 22.14% in 2003 to over 46.2% compromising the laws of the city developmental authorities, CDP, MoEF.

Land use	2003	2014
Built up	22.14%	46.62%
Vegetation	23.23%	5.51%
Water	2.61%	2.89%
Others	52.01%	44.98%

Table 3: Land use in the catchment

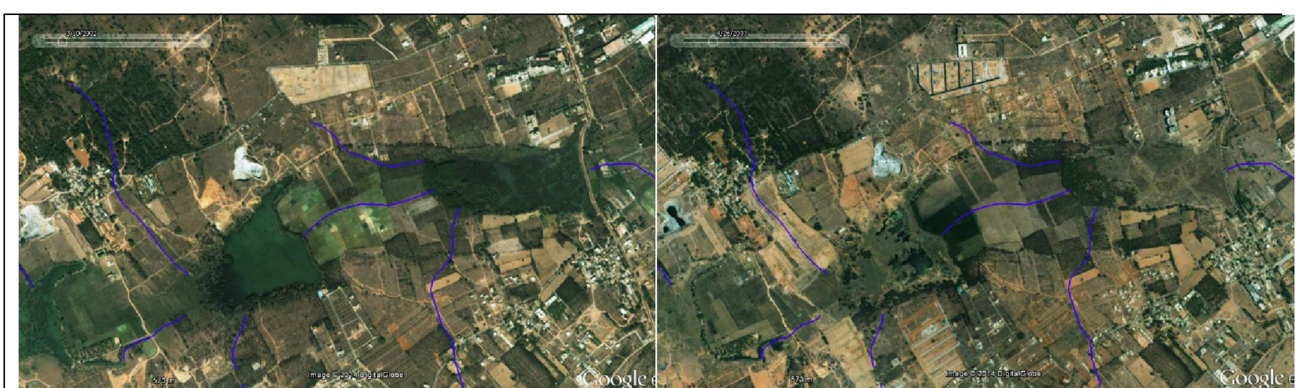
Temporal remote sensing data (Google earth data) were compared in order to visualize, understand the land use dynamics in the catchment with respect to the acquired satellite data (Figure 4).



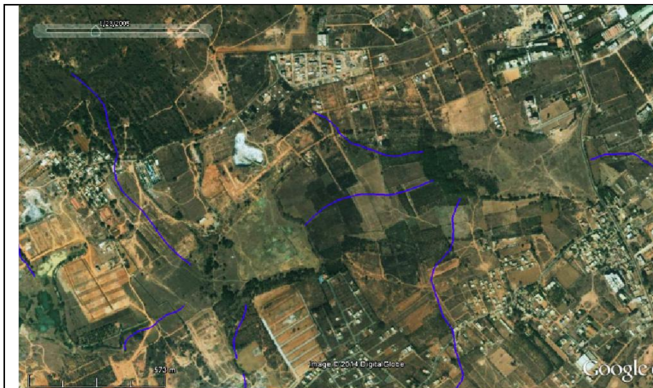
2003 (Landsat 5, 30 m) 2014 (IRS LISS4 P6, 5.8 m)

Builtup Vegetation Water Others

Figure 3: Land use changes in the catchment

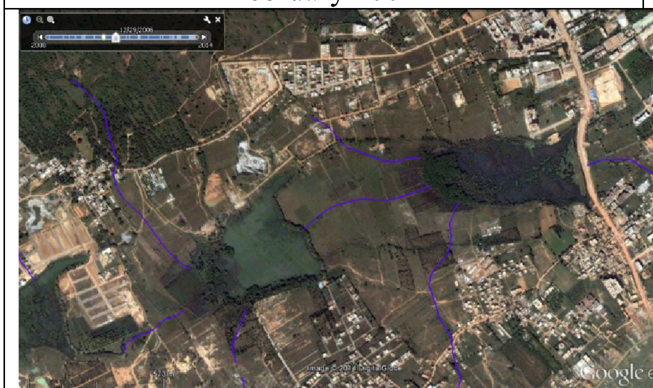


March 2002	April 2003

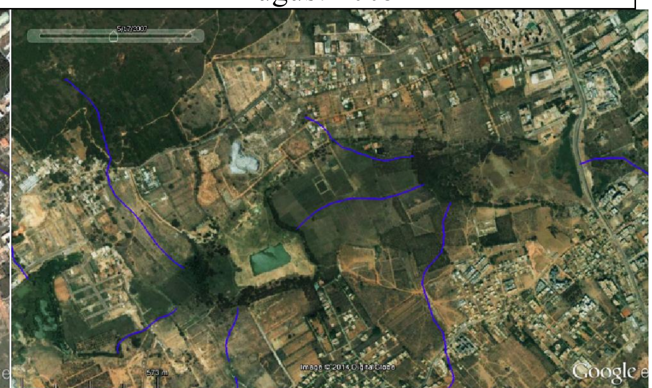


February 2004

August 2005

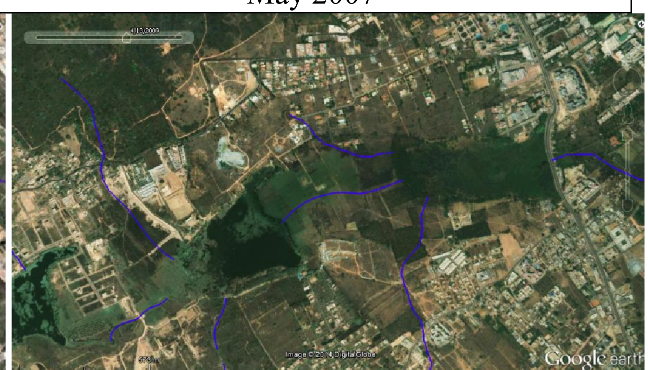


December 2006



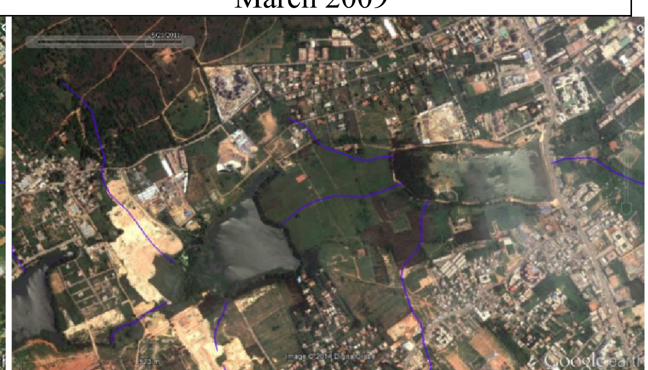
May 2007

April 2008

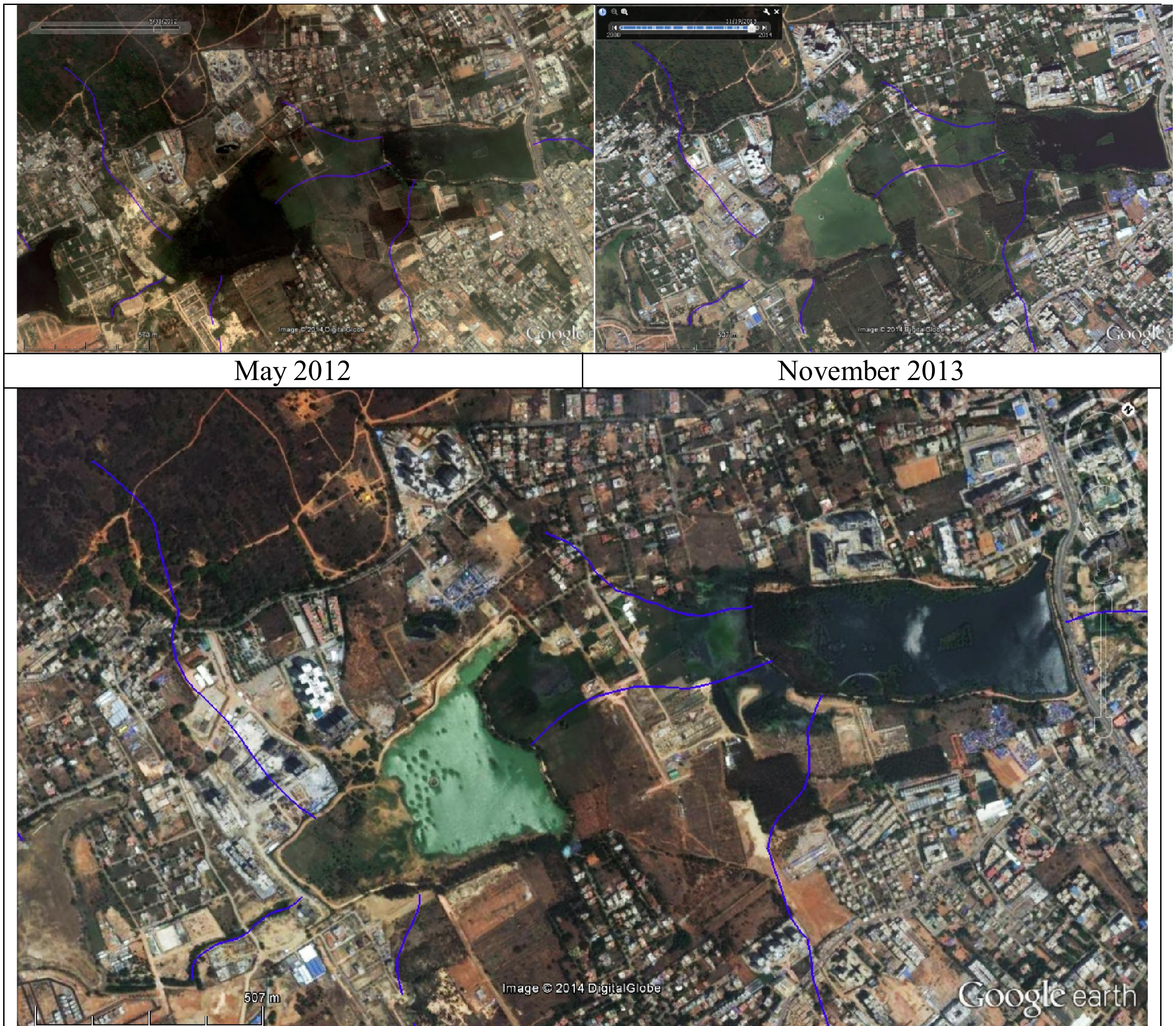


March 2009

January 2010



May 2011



May 2012 | November 2013

May 2014

Figure 4: Land use dynamics Google earth

Illegalities: Unabated construction activities in ecologically fragile valley zone of the interconnected lake systems highlight prevailing negligent, incompetent and corrupt executive mechanism, which is evident with the

1) Violations in valley zone (restricted land uses as per the CDP 2015).
2) Violations in 30m buffer (regulated activities as per BDA norms -lakes, natural drains, flood plains).
3) Construction of high rise buildings and letting untreated sewage t lakes (highlights weak regulatory mechanism in the region).
4) Water contamination (water act 1974, 1977)
5) Unauthorized occupation of lake bed
6) Article 21, constitution of India – right to clean drinking water and clean environment.
7) Grant of environmental clearance (?) by the state level committee further confirms incompetency and lacuna in the decision making process.

Encroachment of Valley Zone: The valley zone along with the lakes in par with the City Development Plan is as depicted in **figure 5**, the land use along the valley zone is as in **figure 6 and table 4**, it can be clearly observed that the laws made by the policy makes have been outrun by the developers by encroaching the valley zone (as shown in figure 7).

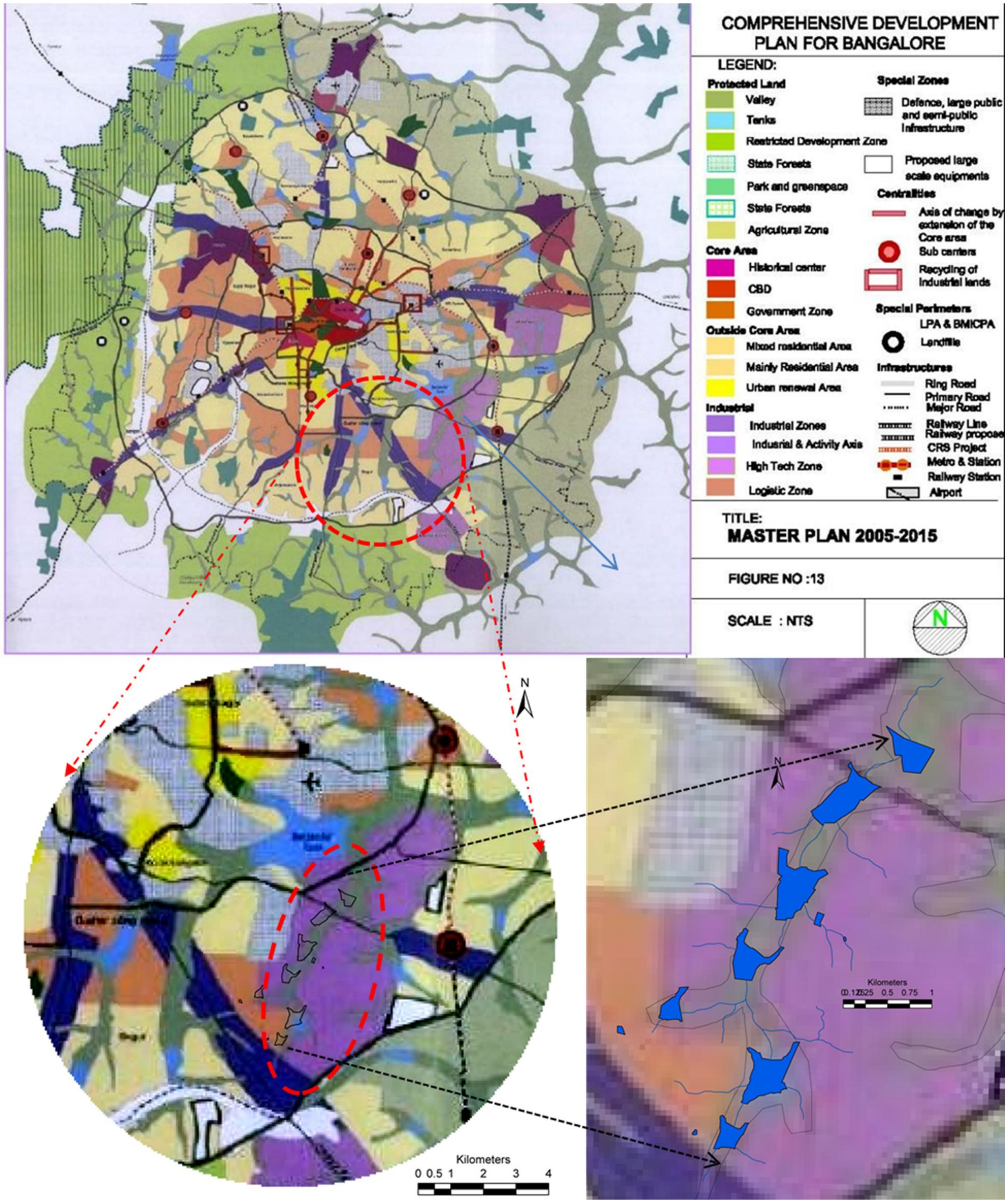


Figure **5**: Valley Zone as per 2015 CDP

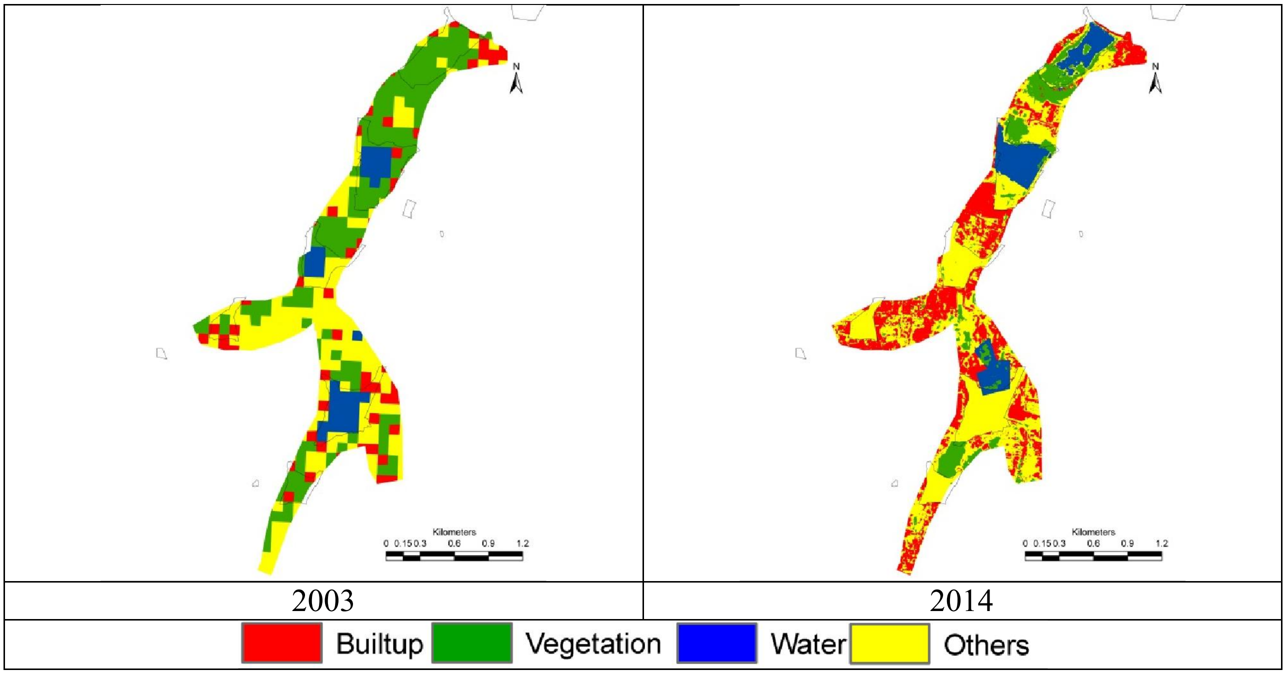


Figure 6: Land use in the Valley zone

Land use	2003	2014
Built up	11.92 %	30.37 %
Vegetation	40.85 %	12.18 %
Water	9.92 %	11.60 %
Others	37.31 %	45.84 %

Table 4: Land use in the valley zone

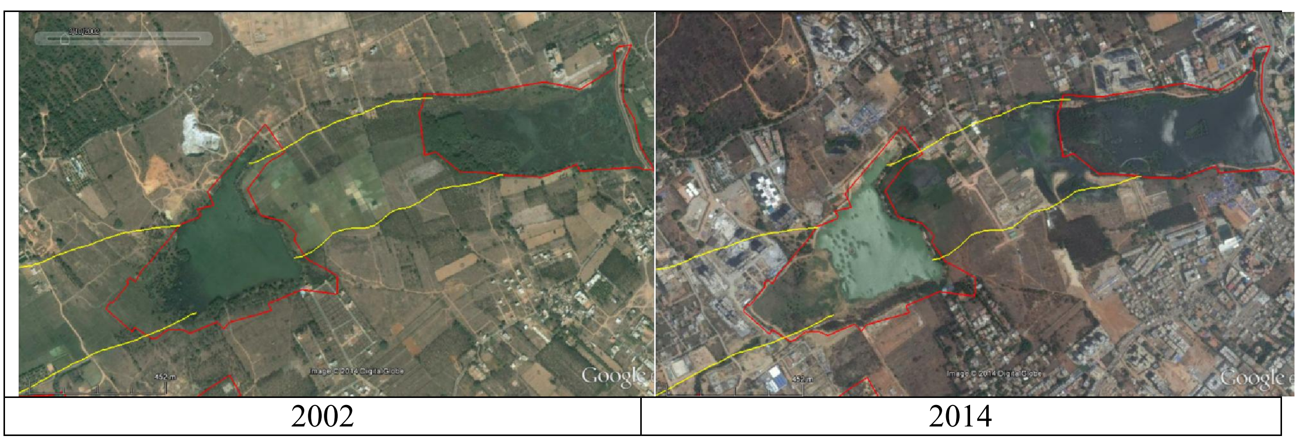


Figure 7: Valley Zone upstream of Kaikondrahalli lake.

Violation of BDA, BBMP and MoEF norms of protecting wetlands and regulated activities in the buffer zone.

The BDA norms specify that the distance between the wetlands (lakes, natural drainages) and any developmental activity should be atleast 30m, whereas the MoEF specifies the distance as 200 m. Figure 8, figure 9 and table 5 depicts the land use in the buffer regions.

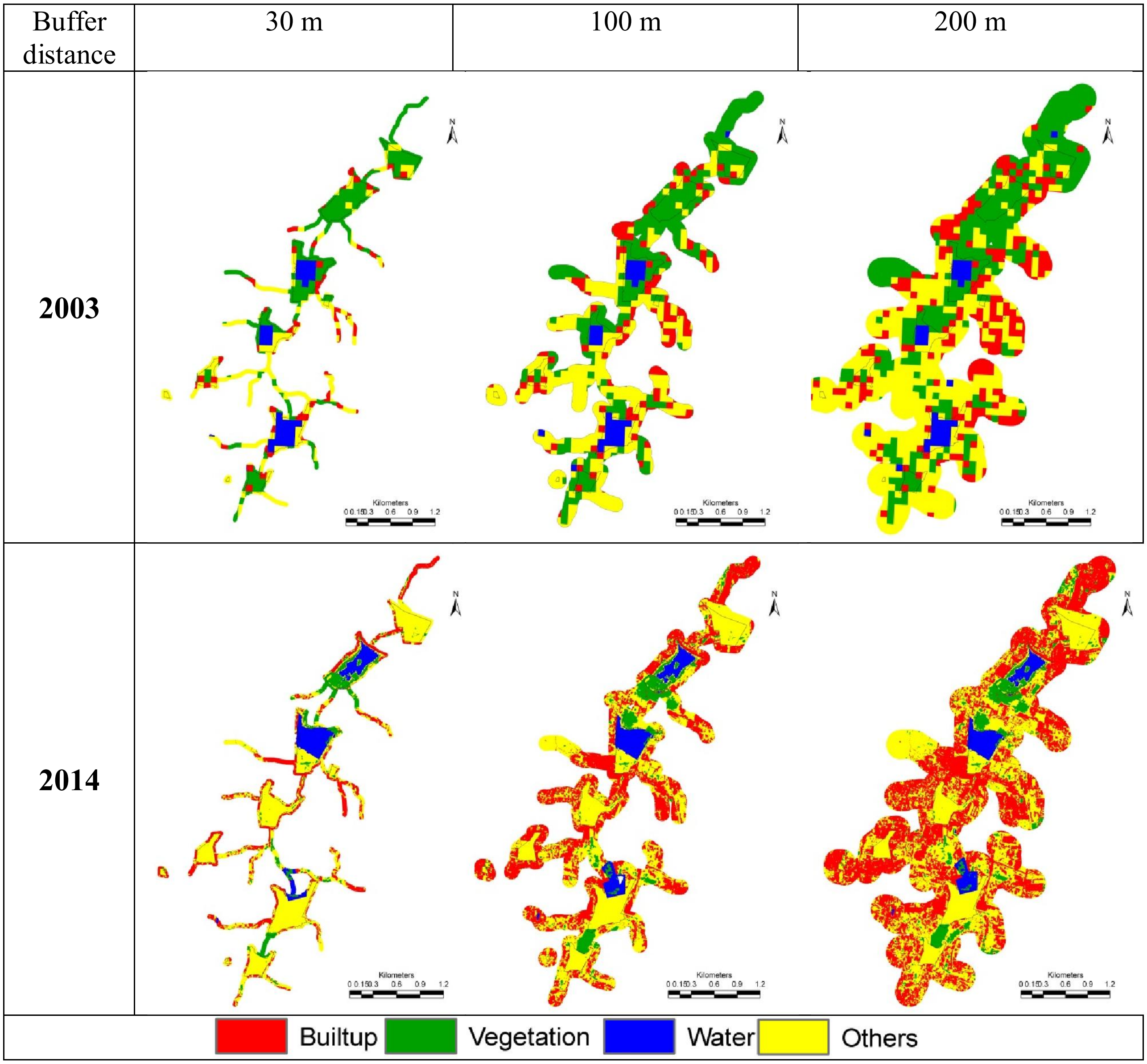
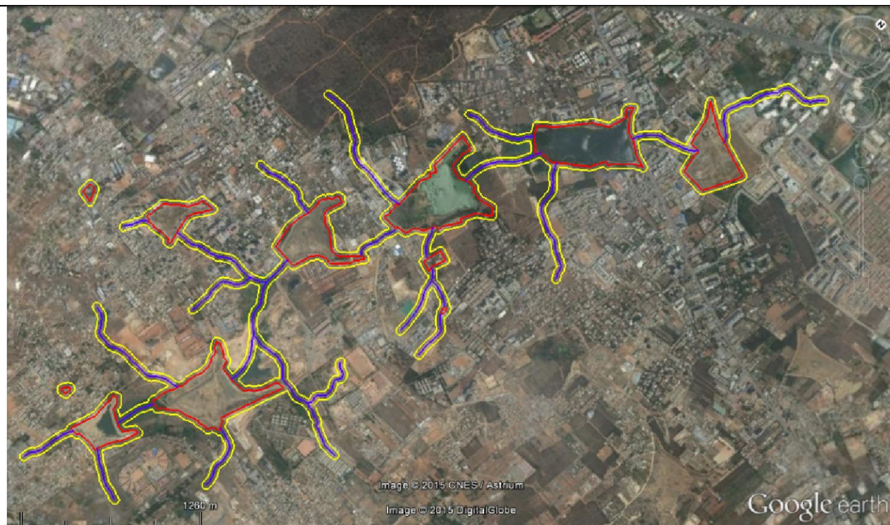
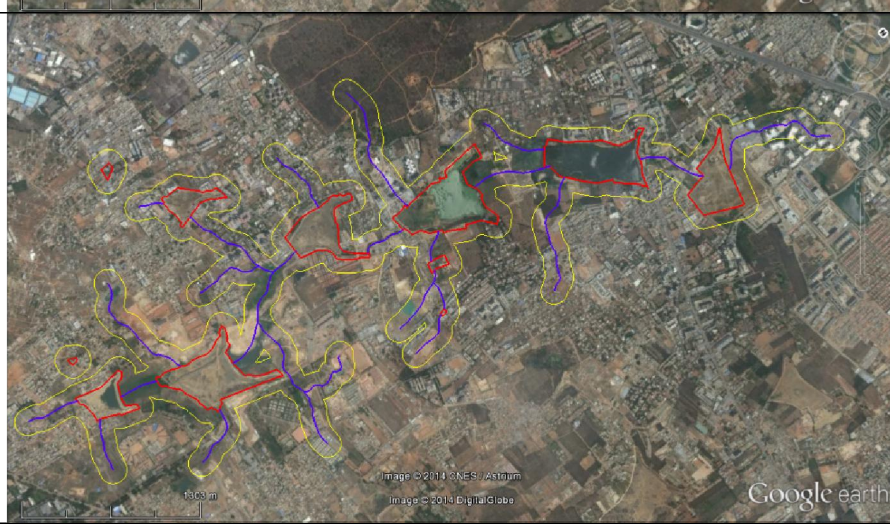


Figure 8: Land use in the buffer zones

Buffer	30 m		100 m		200 m	
Land use	**2003**	**2014**	**2003**	**2014**	**2003**	**2014**
Built up	12.89	23.55	16.12	38.40	19.16	45.31
Vegetation	41.40	10.99	37.36	8.42	33.09	6.69
Water	11.75	11.91	5.70	6.27	3.56	3.83
Others	33.95	53.55	40.83	46.91	44.19	44.17

Table 5: Land use in buffer zone (as percentage)

Buffer distance	**2014**
30 m	
100 m	

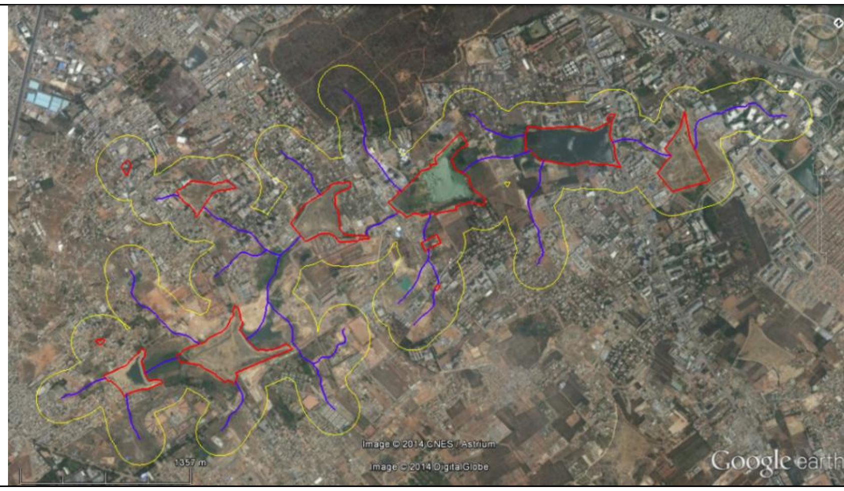
200 m	

Figure 9: Land use in the buffer zones as per Google earth

Hydrology: The Catchment of Kaikondrahalli, Bangalore on an average receives rainfall of 760mm, figure10 and 11 describe the rainfall in the catchment. With average rainfall of 760mm, the runoff in the catchment based on the various land use, the runoff in the catchment is about 5.5 Million cubic meters.

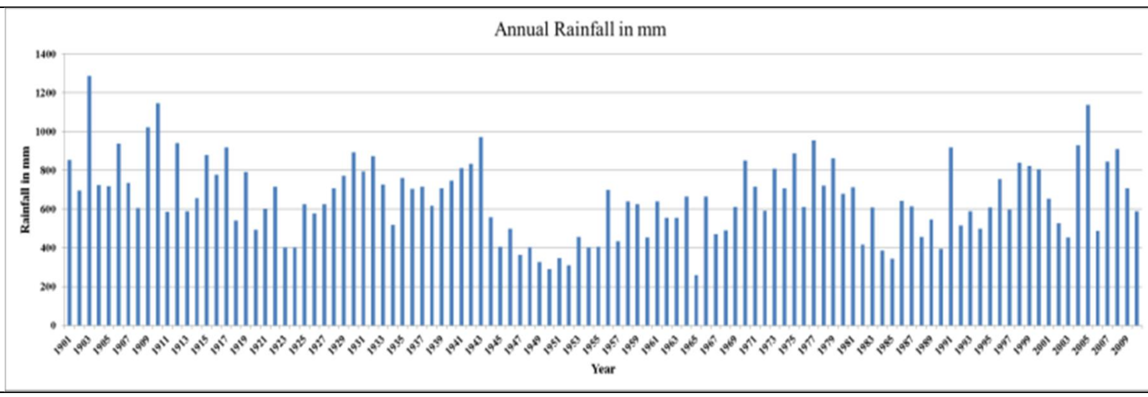


Figure 10: Annual rainfall variations

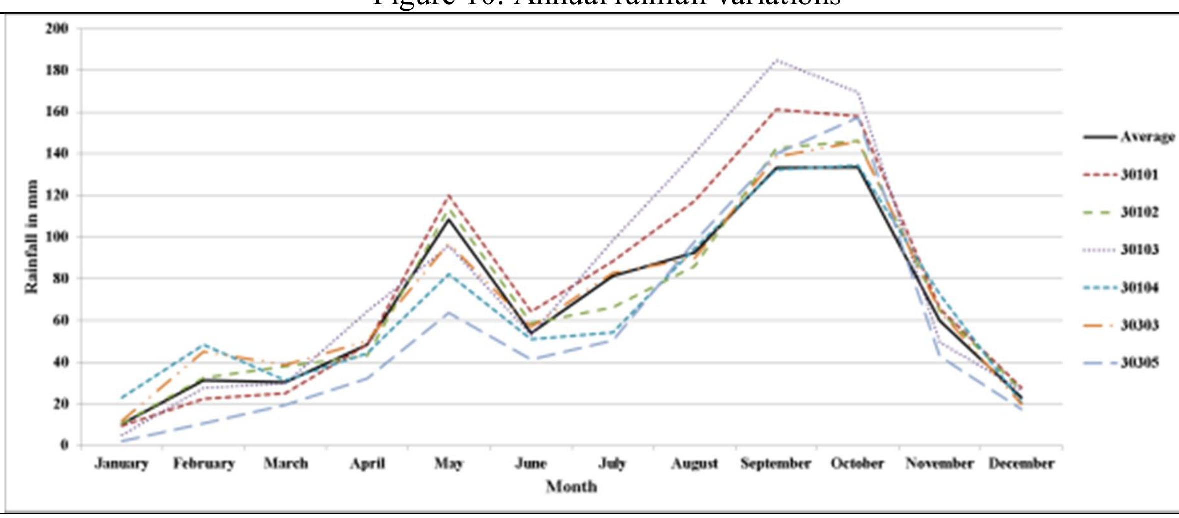


Figure 11: Monthly Rainfall

Effect of Vehicular traffic: The road network is as depicted in figure 12, the nearest main road (Sarjapur road) from the existing construction site behind Kaikondrahalli lake is 1.5 km, with road width of 7.0 m, 2 lanes and 2 way

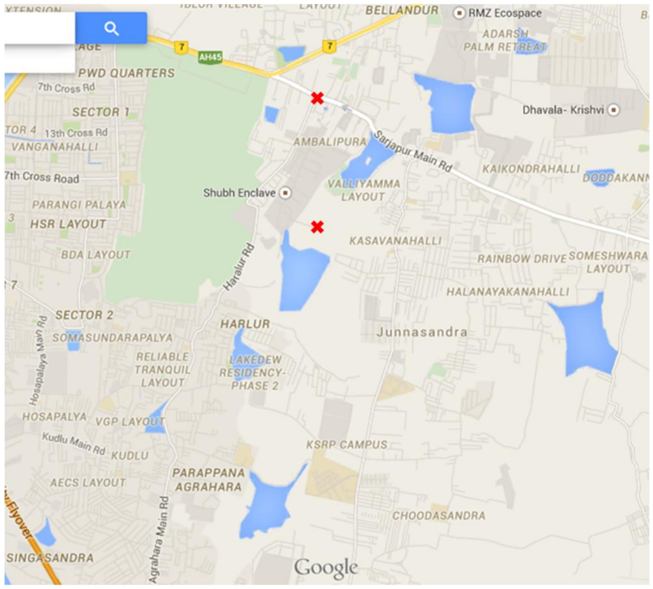


Figure 12: Existing road network(Source: Google Maps).

Road maximum capacity: As per IRC (Indian Road Congress) for a 2 lane road with traffic flow on both sides, for roads with no frontage access, no standing vehicles, very little cross traffic (intersection) capacity is 1200 PCU/hour (PCU- Passenger Car Unit) (Table 6).

No. of Traffic Lanes and width	Traffic Flow	Capacity in PCU per hour for traffic condition		
		Roads with no frontage access, no standing vehicles, very little cross traffic	Roads with frontage access, but no standing vehicle and high capacity intersections	Roads with free frontage access, parked vehicles and heavy cross traffic
Two lane 7.0-7.5 m	One way	2400	1500	1200
Two lane 7.0-7.5 m	Two way	1500	1200	750
Three lane 10.5 m	One way	3600	2500	2000
Four lane 14.0 – 15.5 m	One way	4800	3000	2400
Four lane 14.0 – 15.5 m	Two way	4000	2500	2000
6 lane 21 m	Two way	6000	4200	3600

Table 6: Capacity of Urban Roads as per IRC

Source: Highway Engineering. S.K.Khanna & C.E.G.Justo,8th Edition, Table 5.8,pp 191

V/C ratio	LOS	Performance
0.0 – 0.2	A	Excellent
0.2 – 0.4	B	Very Good
0.4 – 0.6	**C**	**Average / Fair**
0.6 – 0.8	D	Poor
0.8 – 1.0	**E**	**Very Poor**
1.0 – 1.2	F	Very Very Poor

Table 7: Category of Roads based on traffic and service, Source: IRC

For Connecting road between Sarjapur Road and the , with average length of a PCU as 4.5m at an average speed of 35kmph and driver reaction time of 0.7 seconds, the capacity was estimated to be **3094 PCU/hour**, on either side of the road, where as for Sarjapur Road, with average length of a PCU as 4.5m at an average speed of 45kmph and driver reaction time of 0.7 seconds, the capacity was estimated to be **3372 PCU/hour**, on either side of the road. Table **8** explains the effectiveness of the road based on the traffic. Due to the dwelling apartments additional 3000 vehicles as PCU is likely to be added

Description of Road	Connecting road	Sarjapura Road
Vehicle speed in kmph	35	45
Average length of vehicle PCU in m	4.5	4.5
Number of lanes	2	4
Driver reaction time in seconds	0.7	0.7
average spacing between vehicles = (0.278*velocity* reaction time)+ Vehicle Length	11.3	13.3
Theoretical Maximum Capacity of Lane as PCU per lane per hour = 1000*(Velocity)/(Spacing b/w vehicles)	3094	3394
PCU Density vehicle/km/lane = Number of Vehicles per hour/Vehicle speed	88	75
Maximum capacity flow occurs when speed is Velocity/2 and Density is PCU Density/2 (or Jam Density) Maximum flow of traffic as number of PCU per lane per hour per km = Velocity/2 * PCU Density/2	770	843
Length of the road	1.8	0.8
Maximum flow as vehicles per km per hour	2310	2697
Peak Hour Traffic	800	2000
Current Vehicular Traffic to Maximum Capacity Ratio (ratio of peak hour traffic to maximum flow)	0.34	0.74

Current Level of Service	**Good**	**Average**
Additional Vehicles as PCU due to the apartments	2000	
Additional Vehicles added to traffic per hour	800	800
Number of Vehicles due to addition	1600	2800
Vehicular Traffic to Maximum Capacity Ratio due to addition of new vehicles	0.69	1.04
Level of Service due to the additional vehicles	**Average**	**Very Very Poor**

Reference: Highway Engineering. S.K.Khanna & C.E.G.Justo

[*Assumption: 800 PCU/hour addition during peak hours for 3 hours (example : 8 AM to 11 AM)*]

Table 8: Vehicular Traffic

The equivalent ratio of V/C (Table 7) to the LOS is D and F respectively for the connecting road and the Sarjapur road, indicating very poor traffic conditions, creating bottle necks. The probable bottle necks are as depicted in figure 13.

Figure 13: Bottlenecks

Conservation and Management of Wetlands: The loss of ecologically sensitive wetlands is due to the uncoordinated pattern of urban growth happening in Greater Bangalore. This could be attributed to a lack of good governance and decentralized administration evident from lack of coordination among many Para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for (Ramachandra, 2009a,b):

- **Restoring and conserving the actual source of water -** the water cycle and the natural ecosystems that support it - are the basis for sustainable water management
- **Reducing the environmental degradation that is preventing us from reaching goals** of good public health, food security, and better livelihoods world-wide
- **Improving the human quality of life** that can be achieved in ways while maintaining and enhancing environmental quality
- **Reducing greenhouse gases to avoid the 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 non-point and point sources as well as from catchment degradation. Watershed-based planning and resource management is a strategy for more effective protection and restoration of aquatic ecosystems and for protection of human health. The watershed approach emphasizes all aspects of water quality, including chemical water quality (e.g., toxins and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., stream channel morphology, substrate composition, riparian zone characteristics, catchment land cover), and biological health and biodiversity (e.g., species abundance, diversity, and range). Policy interventions required in order to conserve fragile ecosystems – wetlands are:

1. **Carrying capacity studies for all macro cities:** to adopt holistic approaches in regional planning considering all components (ecology, economic, social aspects) in rapidly urbanizing macro cities such as Greater Bangalore, etc.
2. **Demarcation of the boundary of water bodies:** The existing regulations pertaining to boundary demarcations within different states need to be reviewed according to updated norms and based on geomorphology and other scientific aspects pertaining to individual water bodies. Maximum Water Level mark should form the boundary line of the water body. The buffer zone should be treated as inviolable in the long-term interests of the water body and its biodiversity. This requires
    - Digitisation of all land parcels (especially common lands) with clear title of ownership and availability of this information through well managed portal (with regular updating of details). This would help in curtailing unauthorised occupation of common lands.
    - Declare and maintain floodplains and valley zones of lakes as no activity regions
    - Remove all encroachments – free flood plains, valley zones, storm water drains, etc. of encroachments of any kind.
    - Ban conversion of lake, lakebed for any other purposes.
    - Urban wetlands, mostly lakes, have to be regulated from any type of encroachments.

- Regulate the activity which interferes with the normal run-off and related ecological processes – in the buffer zone (200 m from lake boundary / flood plains is to be considered as buffer zone)

3. **Mapping of water-bodies:** The mapping of water bodies should also include smaller wetlands, springs etc. The neglect of these hydrological systems could cause considerable impoverishment of water flow in the river systems as well as turn out to be threats to rare kinds of biodiversity.
4. **Holistic and Integrated Approaches – Conservation and Management:** Integration of the activities with the common jurisdiction boundaries of Government Para-state Agencies for effective implementation of activities related to management, restoration, sustainable utilization, and conservation. This necessitates common jurisdictional boundary for all Para-state agencies. To minimise the confusion of ownership – assign the ownership of all natural resources (lakes, forests, etc.) to a single agency – **Lake Protection and Management Authority** (or Karnataka Forest Department). This agency shall be responsible for protection, development, and sustainable management of water bodies). There is a need to maintain catchment integrity to ensure lakes are perennial and maintain at least 33% land cover should be under natural Vegetation.
5. **Documentation of biodiversity:** The biodiversity of every water body should form part of the School, College, People's Biodiversity Registers (SBR, CBR, and PBR). The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity. The presence of endemic, rare, endangered, or threatened species and economically important ones should be highlighted. A locally implementable conservation plan has to be prepared for such species.
6. **Mitigation of Floods**: This entails maintenance of open spaces (vegetation, water bodies). Mitigation necessitates restoration of wetlands, removal of blockages in the drainage network, removal of encroachments (storm water drains, wetlands), prevention of indiscriminate disposal of solid waste (including building debris) in storm water drains, lake beds, catchment of wetlands and restoration of the connectivity of lakes
7. **Preparation of management plans for individual water bodies:** Most large water bodies have unique individual characteristics. Therefore, it is necessary to prepare separate management plans for individual water bodies.
8. **Implementation of sanitation facilities:** It was noted with concern that the water bodies in most of India are badly polluted with sewage, coliform bacteria, and various other pathogens.
9. **Restoration of lakes:** The goals for restoration of aquatic ecosystems need to be realistic, and should be based on the concept of expected conditions for individual eco-regions. Further development of project selection and evaluation technology based on eco-region definitions and description should be encouraged and supported by the national and state government agencies.
10. **Protection of riparian and buffer zone vegetation:** Any clearances of riparian vegetation (alongside lakes) and buffer zone vegetation (around lakes) have to be prohibited.
11. **Restoration of linkages between water bodies:** The process of urbanization and neglect caused disruption of linkages between water bodies such as ancient lake systems of many cities. Wherever such disruptions have taken place, alternative arrangements should be provided to establish the lost linkages.
12. **Rainwater harvesting:** Intensive and comprehensive implementation of rainwater harvesting techniques can reduce taxation of water bodies and minimize electricity requirements. The country

needs in principle a holistic rainwater harvesting policy aimed at directing water literally from "roof-tops to lakes" after catering to the domestic needs.

13. **Environment Education**: Lake Associations and citizen monitoring groups have proved helpful in educating the public. Effort should be made to ensure that such groups have accurate information about the causes of lake degradation and various restoration methods.

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Water Quality in Kaikondrahalli and Kasavanahalli Lakes

The water quality assessment of aquatic ecosystems includes the analysis of the physical, chemical and biological parameters. Water samples were collected for physico-chemical and biological analysis from inlets, outlets of the lake (Figures 1 and 2) in disinfected one liter sampling containers.

Figure 1: Google earth image of Kaikondrahalli Lake

The water samples were collected for physico-chemical and biological analysis mainly from 3 different sites: inlet, middle and outlet of the lake (Figure 1).

Figure 2: Google earth image of Kasavanahalli Lake

Water samples from this lake mainly from 6 different sites: 3 inlets and 3 different points (Figure 2) of the lake.

ANALYSIS OF PHYSICO-CHEMICAL PARAMETERS: The water temperature, pH, electrical conductivity, TDS and DO are determined on spot at the time of sampling. Other parameters like nitrate, orthophosphate, turbidity, total alkalinity, calcium and magnesium hardness, total hardness, chlorides, COD, BOD, sodium and potassium are analysed in the laboratory by using standard methods prescribed by Trivedi and Goel (1986) and APHA (1998).

Table 1: Standard methods followed for water quality analysis

Parameters	**Methods (with Reference)**
Onsite Measurements	
Water temperature (^{0}C)	Eutech: PCSTestr 35
pH	Eutech: PCSTestr 35
Total Dissolved Solids (TDS, mg/l)	Eutech: PCSTestr 35
Electrical conductivity (µS/cm)	Eutech: PCSTestr 35
Dissolved Oxygen (DO) (mg/l)	Winkler's Method (APHA, 1998: 4500-O)
Laboratory Measurements	
Hardness (mg/l)	EDTA titrimetric method (APHA, 1998: 2340-C)
Calcium hardness (mg/l)	EDTA titrimetric method (APHA, 1998: 3500-Ca B)
Magnesium hardness (mg/l)	Magnesium by calculation (APHA, 1998:3500-Mg)
Sodium (mg/l)	Flame emission photometric method (APHA, 1998:3500-Na B)
Potassium (mg/l)	Flame emission photometric method (APHA, 1998: 3500-K B)
Alkalinity (mg/l)	Titrimetric method (APHA, 1998: 2320 B)
Chloride (mg/l)	Argentometric method (APHA, 1998:4500-Cl^- B)
Biochemical Oxygen Demand (BOD) (mg/l)	5-Day BOD test (APHA, 5210 B, Trivedi & Goel, 1986, pp.53-55)
Chemical Oxygen Demand (COD) (mg/l)	Closed reflux, titrimetric method (APHA, 5220 C, Trivedi & Goel, 1986, pp.55-57)
Nitrates	Phenol Disulphonic acid method (Trivedy & Goel, 1986: pp61)
Orthophosphates (mg/l)	Stannous chloride method (APHA, 4500-P)
Turbidity(NTU)	Nephlophotometer

PHYTOPLANKTON and ZOOPLANKTON ANALYSIS

Plankton collection and Identification: The plankton samples were collected by filtering 50 litres of lake water through the standard plankton net (No. 25 bolting silk cloth net of mesh size 63 mm and 30 cm diameter). The final volume of the filtered sample was made to 20 ml and then transferred to another 125 ml plastic bottle and labeled, mentioning the time, date and place of sampling. The samples collected were preserved by adding 2ml of 5% formalin. The phytoplanktons and zooplanktons were identified microscopically according to the standard keys.

Physico-chemical parameters:

Temperature: The variation in temperature effects various physical, chemical and biological reactions in the aquatic organisms. An increase in the temperature speeds up the chemical reactions, increases the rate of metabolic activities, reduces the solubility of gases like dissolved oxygen and carbon dioxide in the water. Aquatic organisms have varying tolerance to temperature.

Total Dissolved Solids (TDS) and Electrical Conductivity (EC): Total Dissolved solids are solids that are in the dissolved state in water. TDS constitutes inorganic salts, as well as a small amount of organic matter. Electrical Conductivity is the ability of water to conduct an electric current. It depends on the total concentration, mobility, valence and the temperature of the solution of ions. Most dissolved inorganic substances in the ionised form in water also contribute to conductivity. Higher TDS and EC indicate pollution. The chloride, carbonates, bicarbonates, phosphates, nitrates, sodium, potassium, iron, manganese, sulphates, etc. also contribute towards EC and TDS in lakes.

pH: pH is the measure of acidity or alkalinity of water. pH scale ranges from 0 to 14 (i.e., very acidic to very alkaline) with pH 7 being neutral. A higher pH affects mucous membranes, causes bitter taste, corrosion, and affects aquatic life. In lakes, the diurnal and seasonal variations in pH are governed by the rate of photosynthesis, respiration as well as the equilibrium between carbon dioxide/bicarbonate/carbonate ions. pH of a lake can be affected by inflow of domestic sewage, industrial effluents and atmospheric deposition of acid-forming substances.

Turbidity: Turbidity in water is caused due to the presence of clay, silt, organic and inorganic matter, plankton and other microscopic organisms. It restricts light penetration and thus, reduces photosynthesis in water bodies. It also makes water unfit for domestic purposes as well as other industrial uses.

Dissolved Oxygen: Dissolved oxygen (DO) is the most essential factor in aquatic system as it reflects the various biological activities and changes occurring in lakes, brought about by the aerobic and anaerobic organisms present. The presence of high amount of organic matter, hydrogen sulphide, ferrous ions, ammonia, nitrates and other oxidisable substances in lakes imposes a very high oxygen demand, which may in turn, lead to oxygen depletion thus, affecting other aquatic life. DO more than 5 mg/l favors good aquatic life.

Biochemical oxygen demand (BOD): BOD is the amount of oxygen utilized by microorganisms in stabilizing or oxidation of the organic matter in water bodies. Naturally, BOD is contributed by plankton or plant decay and leaf fall. Other sources of oxygen-consuming waste include domestic wastes and stormwater runoff from farmland or urban areas. BOD test is conducted for 5 days at 20ºC.

Chemical oxygen demand (COD): Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. COD is also determined by the presence of various organic and inorganic materials like calcium, magnesium, potassium, sodium etc.

Alkalinity: Alkalinity is a measure of the buffering capacity of water governed by the equilibrium between carbonic acid, bicarbonates and carbonates in water. Also, he presence of excess of hydroxyl ions, borates, silicates, phosphate etc. causes alkalinity.

Chlorides: It is an indicator of water pollution. The presence of chloride in water can be attributed to the dissolution of salt deposits, discharge of effluents from industries, sewage discharges, irrigation etc. The excreta contains high quantities of chlorides and other nitrogenous compounds.

Total hardness, Calcium hardness and Magnesium hardness: Hardness of water is mainly due to the presence of calcium, magnesium, carbonates, bicarbonates, sulphates, chloride, nitrates etc. Higher values of hardness in lakes are attributed to the regular addition of sewage and detergents. Hard water is unfit for domestic and industrial purposes. Calcium is an important micronutrient in aquatic environment and is especially required in large quantities by molluscs and vertebrates. Magnesium acts as a co-factor in various enzymatic reactions and constitutes the chlorophyll molecule, which is essential for photosynthesis. Sewage and industrial wastes are major contributors of calcium and magnesium in lake water.

Nitrates and Phosphates: Nitrate is the oxidized form of nitrogen and end- product of aerobic decomposition of organic nitrogenous matter. The major sources of nitrate are precipitation, surface run off, sewage, organic matter, leaf litter etc. Phosphates are essential for the growth of phytoplankton (used up as orthophosphates) and acts as a limiting nutrient that limits primary productivity of aquatic ecosystems. The major sources of phosphorus are domestic sewage, detergents, agricultural runoff and industrial wastewater.

Sodium and Potassium: Sodium is highly soluble in water and makes water saltly and unfit for use. Sodium is present is in water treatment chemicals, in domestic water softeners, and in sewage effluents. Potassium is found in lesser concentrations naturally than calcium, magnesium and sodium ions. The natural source of potassium is weathering of rocks, but it also increases due to sewage entry to lakes.

Phytoplankton and Zooplankton: Algae are an important component of biological monitoring programs or water quality assessment because of their rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. They are the primary producers in lakes and thus, are directly affected by physical and chemical factors. Algal assemblages are sensitive to some pollutants and to the variation of environmental and natural disturbances. Zooplanktons are an essential part of aquatic ecosystems and act as indicators of pollution. They serve as a food resource for higher trophic levels and feeds on the algal community.

Physico- chemical characteristics of Kaikondrahalli Lake: The water quality analysis of Kaikondrahalli Lake, collected from 3 different sites like inlet, middle and outlet was performed (Table 1). It was found that the inlet sewage water entering the lake has comparatively higher amount of TDS, EC, Turbidity, BOD, COD, alkalinity, hardness, nutrients, sodium and potassium than the lake water (middle and outlet). The algal growth achieved through nutrient uptake and increased photosynthetic activities has increased the oxygen levels in the lake and there is an evident reduction in the nutrient levels. All the physico-chemical parameters of the lake water are within the permissible limits.

Table 2: Water quality of Kaikondrahalli Lake

Parameters	Kaikondrahalli Inlet	Kaikondrahalli Middle	Kaikondrahalli Outlet	**Water quality Standard IS 10500, 1991-2011**	
				Desirable	Permissible
Water Temperature (^{0}C)	24.8	24.6	23.6	-	-
TDS (mg/l)	1008	671	668	500	2000
EC (µS)	1340	1029	978	-	-
pH	7.69	7.92	7.86	6.5-8.5	No relaxation
Turbidity	27.67	15.5	17	-	-
DO (mg/l)	2.11	5.04	4.88	-	-
BOD (mg/l)	24.39	16.26	8.13	-	-
COD (mg/l)	152	20	24	-	-
Alkalinity (mg/l)	737.33	257.33	273.33	200	600
Chloride (mg/l)	313.35	319.03	313.35	250	1000
Total Hardness (mg/l)	436	200.67	189.33	300	600
Ca Hardness (mg/l)	151.5	38.74	39.55	75	200
Mg Hardness (mg/l)	69.13	39.35	36.4	30	100
Phosphate (mg/l)	1.52	0.052	0.045	-	-
Nitrate (mg/l)	0.267	0.229	0.224	45	100
Sodium (mg/l)	274.4	264.8	260	-	-
Potassium (mg/l)	63.6	51.6	52.4	-	-

Table 3: Algal groups present in Kaikondrahalli Lake

		Middle	Outlet	Near Inlet
i	**Chlorophyceae**			
1	*Chlorella* sp.	+	-	-
2	*Closterium* sp.	+	-	+
3	*Cosmarium* sp.	-	+	-
4	*Desmodesmus* spp.	+	+	-
5	*Dictyosphaerium* sp.	+	+	-
6	*Kirchenerilla* sp.	+	+	+
7	*Monoraphidium* sp.	+	+	+
8	*Oocystis* sp.	+	+	-
9	*Pediastrum* spp.	+	+	-
10	*Scenedesmus* spp.	+	+	-

11	*Spirogyra* sp.	+	-	-
12	*Tetraedron* sp.	+	+	-
13	*Xanthidium* sp.	-	+	-
ii	**Cyanophyceae**			
1	*Aphanotheca* sp.	+	-	-
2	*Aphanocapsa* sp.	+	+	-
3	*Chroococcus* sp.	+	-	-
4	*Gleocapsa* sp.	+	-	-
5	*Merismopedia* sp.	+	+	+
6	*Oscillatoria* sp.	+	-	+
7	*Phormidium sp.*	-	-	+
8	*Radiocystis* sp.	+	+	-
iii	**Bacillariophyceae**			
1	*Amphora* sp.	-	+	-
2	*Cyclotella* sp.	+	+	-
3	*Cymbella* sp.	+		
4	*Fragilaria* sp.	+	-	-
5	*Gomphonema* sp.	+	-	+
6	*Navicula* spp.	+	-	+
7	*Nitzschia* spp.	+	+	+
8	*Pinnularia* sp.	-	-	+
9	*Stauroneis* sp.	+	-	+
10	*Synedra* sp.	+	+	-
iv	**Euglenophyceae**			
1	*Euglena* spp.	-	-	+
2	*Lepocincilis* spp.	-	-	+
3	*Phacus* sp.	+	-	+

In Kaikondrahalli Lake, mainly 4 algal groups were found in the order of their occurrence: Chlorophyceae (13 genera)>Bacillariophyceae (10 genera) > Cyanophyceae (8 genera) > Euglenophyceae (3 genera). The middle sampling point had higher algal groups than inlet and outlet. In Kaikondrahalli Lake, pollution-tolerant genera are present (Table 3) which includes: *Scenedesmus* sp. and *Pediastrum* sp. (Kumar et al., 2012), *Euglena sp.* (Mahapatra et al., 2013; Jafari et al., 2006), *Lepocinclis sp.* (Mahapatra et al., 2013), *Nitzschia sp.* (Karthick et al., 2009; Venkatachalapathy et al., 2013), *Oscillatoria sp.* (Singh et al., 2011; Kumar et al., 2012), and

Phacus sp., Cyclotella sp., *Fragilaria* sp. (Venkatachalapathy et al., 2013), *Gomphonema* sp. (Karthick et al., 2009), *Navicula* sp. (Hosmani, 2012), *Pinnularia* sp. (Hosmani, 2012). The sampling point near inlet to the Lake had higher number of Euglenophyceae members, which indicates sewage pollution. The Chlorophycean growth were favoured by high dissolved contents.The sewage contamination characterized by the low transparency, low dissolved oxygen, higher amounts of carbonates, alkalinity, chlorides, total hardness, calcium and magnesium hardness favoured Euglenophyceae growth in Lakes (Verma et al., 2011).

In Kaikondrahalli Lake, 5 groups of zooplanktons were found: Rotifera, Copepoda, Ostracoda, Cladocera and Protozoa. *Brachionus* sp., *Chydorus* sp. and *Cypris* sp. was found to be more in number. Only in the sampling point near inlet, protozoans were very high which indicates high organic pollution (An et al., 2012). The pollution load in lakes increases the Ostracod population (Padmanabha et al., 2008). *Brachionus* sp. and *Keratella* sp. are indicators of eutrophication of lakes (Ramachandra et al., 2006; Ozcalkap et al., 2011).

Table 4: Zooplankton groups present in Kaikondrahalli Lake

Kaikondrahalli	Middle	Outlet	Near Inlet
Rotifera			
Brachionus spp.	+	+	+
Keratella sp.	+	+	+
Copepoda			
Harpacticoid sp.	+	+	-
Mesocyclops sp.	+	+	-
Nauplius larva	+	+	-
Thermocyclops sp.	-	+	-
Ostracoda			
Cypris sp.	+	+	+
Cladocera			
Chydorus sp.	+	+	-
Diaphanosoma sp.	+	-	-
Protozoa			
Euglena spp.	-	-	+
Phacus sp.	+	-	+

Thus, the sewage entry to Kaikondrahalli lake has degraded the quality of the Lake. The pollution tolerant algae and zooplanktons were present in lake, which indicates pollution. It is suggested to let only the treated sewage to the lake to prevent it from further deterioration.

Kasavanahalli Lake

In Kasavanahalli Lake, sewage water directly enters the lake through two main inlets. The high oxygen demand and less dissolved oxygen in the inlets indicate higher pollution loads and high microbial activity. The pH was found to be alkaline due to the presence of high amounts of carbonates and bicarbonates. The untreated sewage water with high nutrients, organic matter and inorganic ions enters the lake and affects its water quality. The sodium content is very high in Kasavanahalli lake which makes the water unfit for consumption and other purposes (Arafath et al., 2008). The increased amount of nutrients had promoted algal growth.

Table 5: Physico- chemical characteristics of Kasavanahalli Lake

	Kasavanahalli lake Inlet 1	Kasavanahalli lake point 1	Kasavanahalli Inlet 2	Kasavanahalli lake Inlet 2	Kasavanahalli lake point 2	Kasavanahalli lake point 3
Water Temperature (^{0}C)	25.4	24.7	22.9	21.8	24.6	25.6
TDS (mg/l)	897	533	936	756	515	504
EC (µS)	1230	897	1294	1068	890	868
pH	7.71	8.14	7.62	7.6	8.05	8.36
Turbidity	23.07	704	814	33.8	35.43	49.03
DO (mg/l)	0	9.76	0	0.16	11.38	10.57
BOD (mg/l)	30.49	10.16	-	-	20.33	12.2
COD (mg/l)	184	16	288	192	28	16
Alkalinity (mg/l)	642.67	213.33	737.33	605.33	213.33	198.67
Chloride (mg/l)	293.47	242.82	339.85	234.77	236.67	229.09
Total Hardness (mg/l)	349.33	161.33	402.67	347.33	141.33	144.67
Ca Hardness (mg/l)	98.86	35	115.16	101.54	31.53	27.79
Mg Hardness	60.86	30.69	69.86	59.73	26.68	28.4

(mg/l)						
Phosphate (mg/l)	1.285	0.089	1.368	0.786	0.047	0.059
Nitrate (mg/l)	0.877	0.241	0.534	0.345	0.268	0.271
Sodium (mg/l)	273.6	318.4	480	802	305.2	316.4
Potassium (mg/l)	49.6	39.6	80	98	40	34.4

Table 6: Algal groups present in Kasavanahalli Lake

		Inlet	L1	L2	L3
i	**Chlorophyceae**				
1	*Actinastrum* sp.	-	+	-	-
2	*Ankistrodesmus* sp.	-	+	-	-
3	*Chlorella* sp.	-	+	-	-
4	*Chodatella* sp.	-	+	-	-
5	*Closterium* sp.	-	+	-	-
6	*Cosmarium* sp.	-	-	+	-
7	*Crucigenia* sp.	-	+	-	-
8	*Desmodesmus* spp.	+	+	+	+
9	*Dicloster* sp.	-	+	-	-
10	*Dictyosphaerium* sp.	-	+	+	+
11	*Golenkinia* sp.	-	+	+	+
12	*Kirchenerilla* sp.	-	+	-	+
13	*Monoraphidium* sp.	+	+	-	+
14	*Oocystis* sp.	-	+	-	+
15	*Pandorina* sp.	+	-	-	-
16	*Pediastrum* sp.	+	+	+	+
17	*Pyrobotrys* sp.	+	-	-	-
18	*Scenedesmus* spp.	+	+	+	+
19	*Schroederia* sp.	-	+	+	-
20	*Stigeoclonium* sp.	-	+	-	-
21	*Tetraedron* sp.	+	+	-	-
22	*Xanthidium* sp.	-	-	+	-
ii	**Cyanophyceae**				
1	*Aphanocapsa* sp.	-	-	+	+
2	*Chroococcus* sp.	-	-	+	-
3	*Gleocapsa* sp.	-	+	+	+

4	*Merismopedia* sp.	-	+	+	+
5	*Oscillatoria* sp.	+	-	-	-
6	*Phormidium sp.*	+	+	-	-
7	*Tetrabaena* sp.	+	-	-	-
iii	**Bacillariophyceae**				
1	*Amphora* sp.	-	-	+	-
2	*Cyclotella* sp.	+	+	+	+
3	*Diploneis* sp.	+	-	-	-
4	*Gomphonema* sp.	+	+	-	-
5	*Navicula* spp.	-	+	-	+
6	*Nitzschia* spp.	+	+	+	+
7	*Pinnularia* sp.	+	-	-	-
8	*Stauroneis* sp.	-	+	-	-
9	*Surirella* sp.	+	-	-	-
10	*Synedra* sp.	-	+	-	-
iv	**Euglenophyceae**				
1	*Euglena* spp.	+	-	-	-
2	*Lepocincilis* spp.	+	-	-	-
3	*Phacus* sp.	-	-	+	-
4	*Trachelomonas* sp.	-	+	-	+

In Kasavanahalli Lake, pollution-tolerant genera are present which includes: *Euglena sp.* (Mahapatra et al., 2013)*, Nitzschia sp.* (Karthick et al., 2009)*, Phacus sp., Cyclotella* sp. (Singh et al., 2011), *Gomphonema* sp. (Karthick et al., 2009), *Navicula* sp. (Hosmani, 2012), *Pinnularia* sp. (Hosmani, 2012) and *Trachelomonas* sp. (Solorzano et al., 2011). Chlorophyceae were found to be higher in number than Cyanophyceae, Bacillariophyceae and Euglenophyceae.

Table 7: Zooplankton groups present in Kasavanahalli Lake

Kasavanahalli	Inlet	L1	L2	L3
Rotifera				
Brachionus spp.	+	-	-	+
Keratella sp.	+	-	-	+
Philodina sp.	-	+	-	-
Trichocerca sp.	+	-	-	-
Copepoda				
Diaptomus sp.	-	-	+	+

Harpacticoid sp.	-	-	+	+
Mesocyclops sp.	+	-	+	+
Nauplius larva	-	-	+	+
Thermocyclops sp.	-	-	-	+
Ostracoda				
Cypris sp.	+	-	-	+
Cladocera				
Chydorus sp.	-	-	-	+
Daphnia sp.	-	-	+	+
Diaphanosoma sp.	-	-	-	+
Protozoa				
Epistylis sp.	-	+	-	-
Euglena spp.	+	-	-	-
Phacus spp.	-	-	+	-

In Kasavanahalli Lake, 5 groups of zooplanktons were found: Rotifera, Copepoda, Ostracoda, Cladocera and Protozoa. *Cypris* sp., *Mesocyclops* sp. and *Diaphanosoma* sp. were found to be more in number in nutrient rich lakes. Only in the sampling point near inlet, protozoans were very high which indicates high organic pollution (An et al., 2012). The pollution load in lakes increases the Ostracod population (Padmanabha et al., 2008). *Mesocyclops* sp., *Daphnia* sp., *Brachionus* sp. and *Keratella* sp. are indicators of eutrophication of lakes (Ramachandra et al., 2006; Ozcalkap et al., 2011; Wang et al., 2007). The Kasavanahalli is also rich in nutrients and had supported variety of phytoplankton and zooplankton that are tolerant to pollution levels.

Conclusion:

The results reveal that the lake water is polluted due to sewage entry as indicated by high values of COD, BOD, TDS, Sodium and EC. Kasavanahalli Lake is highly disturbed due to anthropogenic activities. The Lake water was mainly used for washing, bathing and construction purposes in the lake vicinity. Due to continuous inflow of sewage, both Kaikondrahalli and Kasavanahalli Lakes seem to be threatened. Thus, proper environment management plan must be adopted to control the sewage entry into these lakes. Otherwise, it may cause contamination of groundwater and also some adverse health effects. Hence, necessary precautionary measures have to be taken before the water is used for domestic and irrigational purposes.

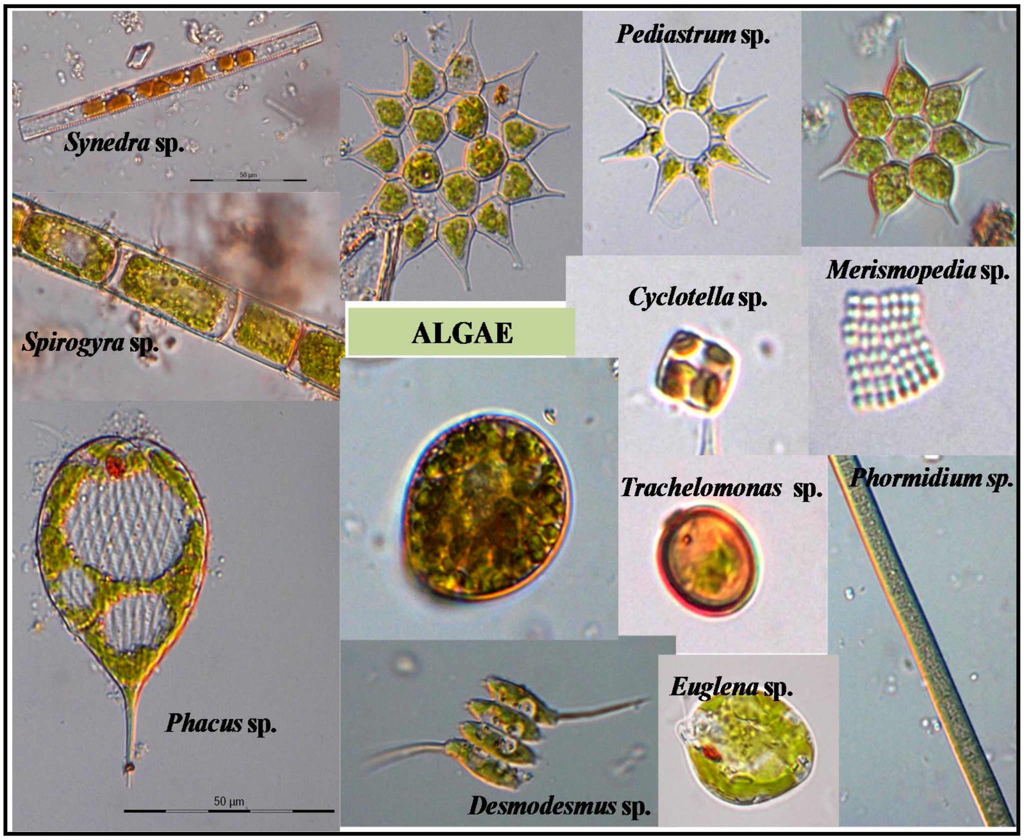


Figure 1: Algae in Lakes

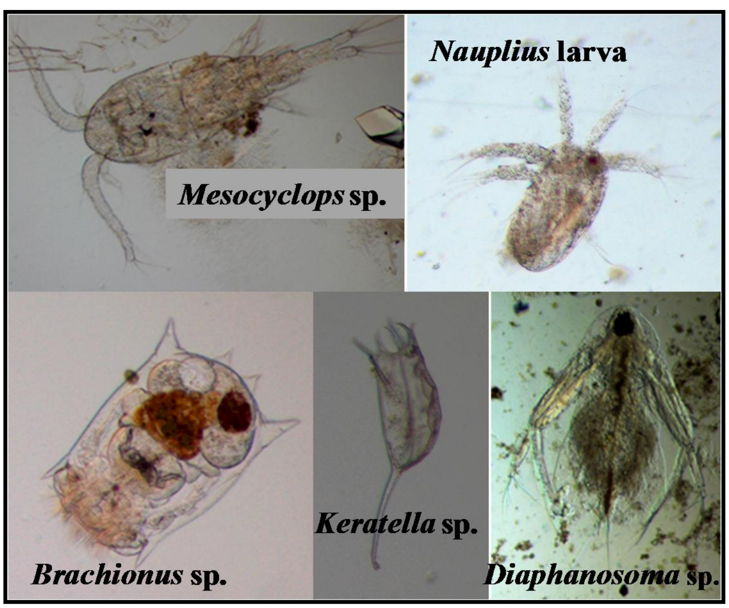


Figure 2: Zooplankton in Lakes

MACROPHYTE DIVERSITY OF KAIKONDRAHALLI AND KASAVANAHALLI LAKES

Macrophyte diversity in the lakes: Macrophytes, the aquatic macroscopic plants confine themselves to the shallow euphotic zone of the water bodies. In the littoral zone, macrophytes are the chief exploiters of plant nutrients from the sediments, which otherwise, are lost temporarily from the water. The nutrients so logged in the body material are released only after death, decay and subsequent mineralization, thus, they play a role in nutrient dynamics and primary productivity of shallow systems. Therefore, seasonal growth rate patterns and population dynamics of macrophytes are very important. When there is enough room for colonization and abundant availability of nutrients, macrophytes show a high growth rate. They assimilate nutrients directly into their tissues.

Macrophyte collection and identification: Macrophyte samples were collected and washed to remove adhering materials. These samples were identified using Cook CDK (1996).

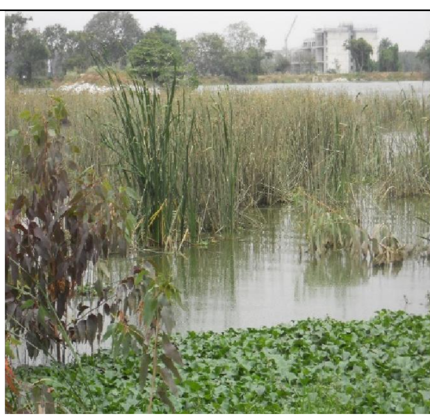
Kaikondrahalli Lake: There were mainly 8 species found in Kaikondrahalli lake. *Alternanthera philoxeroides, Typha angustata, Cyperus* sp1*, Cyperus* sp2, *Lemna gibba, Lemna minor, Eichhornia crassipes, Ipomea aquatica* were the main macrophyte species found in the lake. *Ipomea aquatica* was the dominant macrophytes present in the lake. The inlets were covered by *Lemna minor* and *Lemna gibba, Eichhornia crassipes.* These indicate high amount of nutrient entry into the lake. The middle of the lake was dominated by *Ipomea aquatica.* The outlets were covered by *Typha* and *Cyperus* species.

Kasavanahalli Lake: There were mainly 10 species found in Kasavanahalli Lake. *Alternanthera philoxeroides, Typha angustata, Cyperus* sp1*, Cyperus* sp2, *Lemna gibba, Lemna minor, Eichhornia crassipes, Ipomea aquatica, Potomogetan natans and Nymphaea sp* were the main macrophyte species found in the lake. The sewage inlet points were covered by *Alternanthera philoxeroides, Lemna gibba, Lemna minor* and *Eichhornia crassipes* which indicates high amount of nutrient in the sewage. The middle portion of the lake contained *Alternanthera philoxeroides* and *Cyperus spp.* The outlet was dominated by species like *Potomogetan natans, Ipomea aquatica* and *Nymphaea sp.*

MACROPHYTES OF KAIKONDRAHALLI LAKE

	
Alternanthera philoxeroides	***Ipomea aquatica***
	
Typha angustata and Cyperus sp - inlet	***Lemna gibba***
	
Cyperus spp in the outlet	***Ipomea aquatica*** **and** ***Alternanthera*** **cover in the middle of lake**

MACROPHYTES OF KASAVANAHALLI LAKE

	
Nymphaea sp	***Cyperus sp1***
	
Cyperus sp2	***Lemna gibba***
	
Typha sp	***Eichhornia crassipes***

	
Ipomea aquatica	***Alternanthera philoxeroides***

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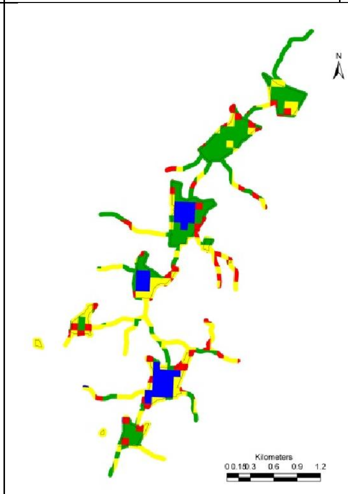
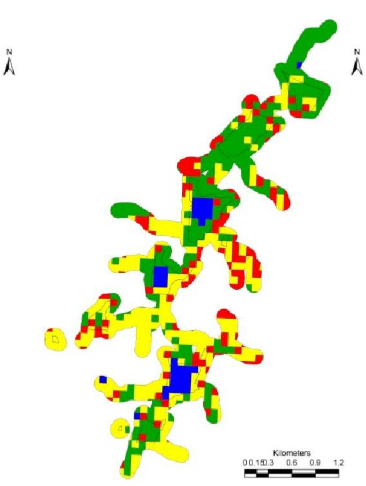
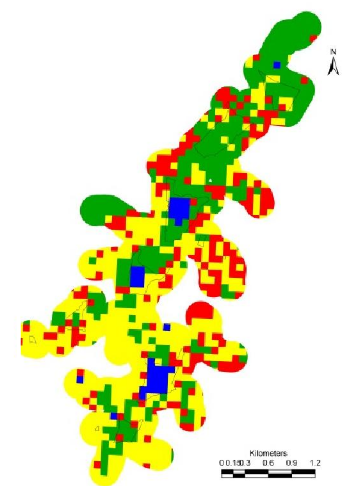
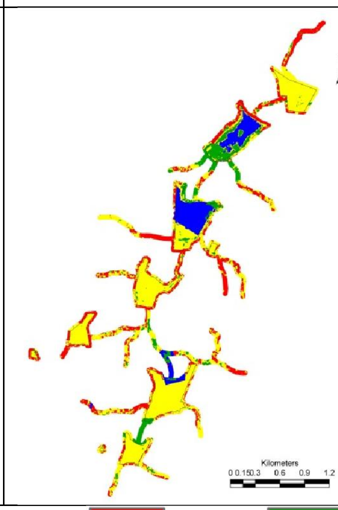
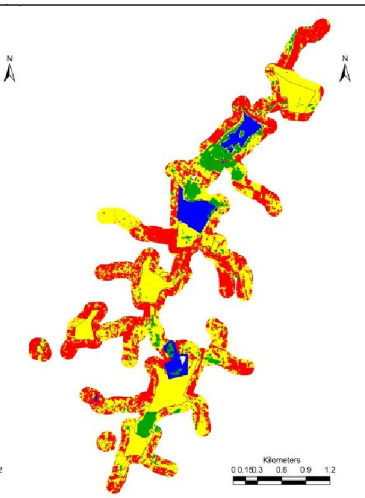
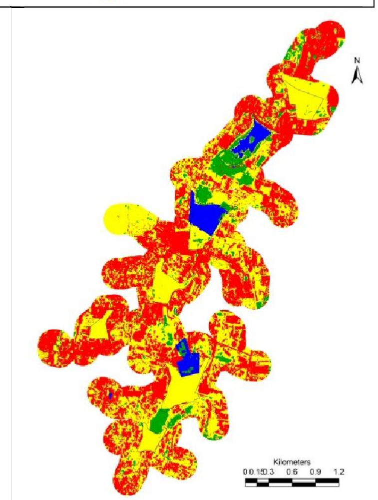
Buffer	30 m	100 m	200 m
2003			
2014			
	Builtup Vegetation Water Others		

	
2002	2014
Valley Zone Kaikondrahalli lake upstream	

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