UNABATED VIOLATIONS IN AGARA BELLANDUR WETLAND

Mismanagement of Landscape: Abuse of Bellandur-Agara wetlands, Narrowing and Concretising Rajakaluve and encroachment of storm water drains, Dumping of solid waste & building debris, buildings in the buffer zone, Apathy of Civic Agencies

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Unabated Violations in Agara - Bellandur Wetland

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Content

Unabated Violations in Agara - Bellandur Wetland

HIGHLIGHTS

Persisting Violations in Agara-Bellandur wetlands:

(i) The abuse of wetlands with the Construction activities in the valley zone (SEZ by Karnataka Industrial Areas Development Board (KIADB)) **of Agara-Bellandur Lake. Wetland was earlier aiding in retaining the rain water, ground water recharge and bioremediation**

(ii) **dumping of construction and demolition wastes in the wetland region, (iv) alteration of topography in the region and**

(iii) **removal of storm water drains (connecting Agara- Bellandur lakes),**

(iv) construction work in the buffer zones (lake, primary and secondary drains, Rajakaluve);

(v) Illegal occupation of Karab lands (public utility lands);

(vi) **narrowing and concretising rajakaluves (connecting Bellandur lake from Agara as well as S T Bed sides)**

(vii) **Non-implementation of constructed wetlands (in the region between Agara – Bellandur lakes)**

During the field work on 12 December 2017 (violations are presented with the pictorial evidences in the next section – pages 10 to 15) and 1 May 2017 along with CEO and DCF KLCDA it was observed

i) Continued illegal occupation of wetlands (Valley zone: protected zone as per BDA norms and also wetlands rule 2010, 2016 and KLCDA norm 2015);

ii) Dumping of plastics in the storm water drains;

iii) Buildings in the wetlands and buffer zones (lakes, raja kaluve, storm water drains);

iv) Rajakaluve (storm water drain) connecting Bellandur Lake from city market side is narrowed to 28.5 m against the original width of 60 m (Figure 1) and also violating recent NGT guidelines (of maintaining storm water drains physical integrity as well as maintaining the buffer). This is mainly to help the encroachers of storm water drains while bypassing NGT's guidelines of storm water drain buffer regions

v) Concretisation of storm water drains – this would affect the hydrological functional ability of storm water drains – ground water recharge, remediation and flood mitigation

vi) Concretization and narrowing the drains has only enhanced the flooding in the city, observed recently (15th August 2017, 24th August 2017).

vii) implications of concretization: Impaired Ecosystem Functions - bioremediation and groundwater recharge (but maximization of benefits to consultants with frequent floods)

viii) Para state agencies (BDA and BBMP) while wasting the public money has made Bangalore landscape vulnerable with frequent floods.

ix) Continued inflow of untreated sewage (due to inefficient BWSSB and nearby localities) and industrial effluents.

x) Continued encroachments and illegal occupation of lake bed and flood plains.

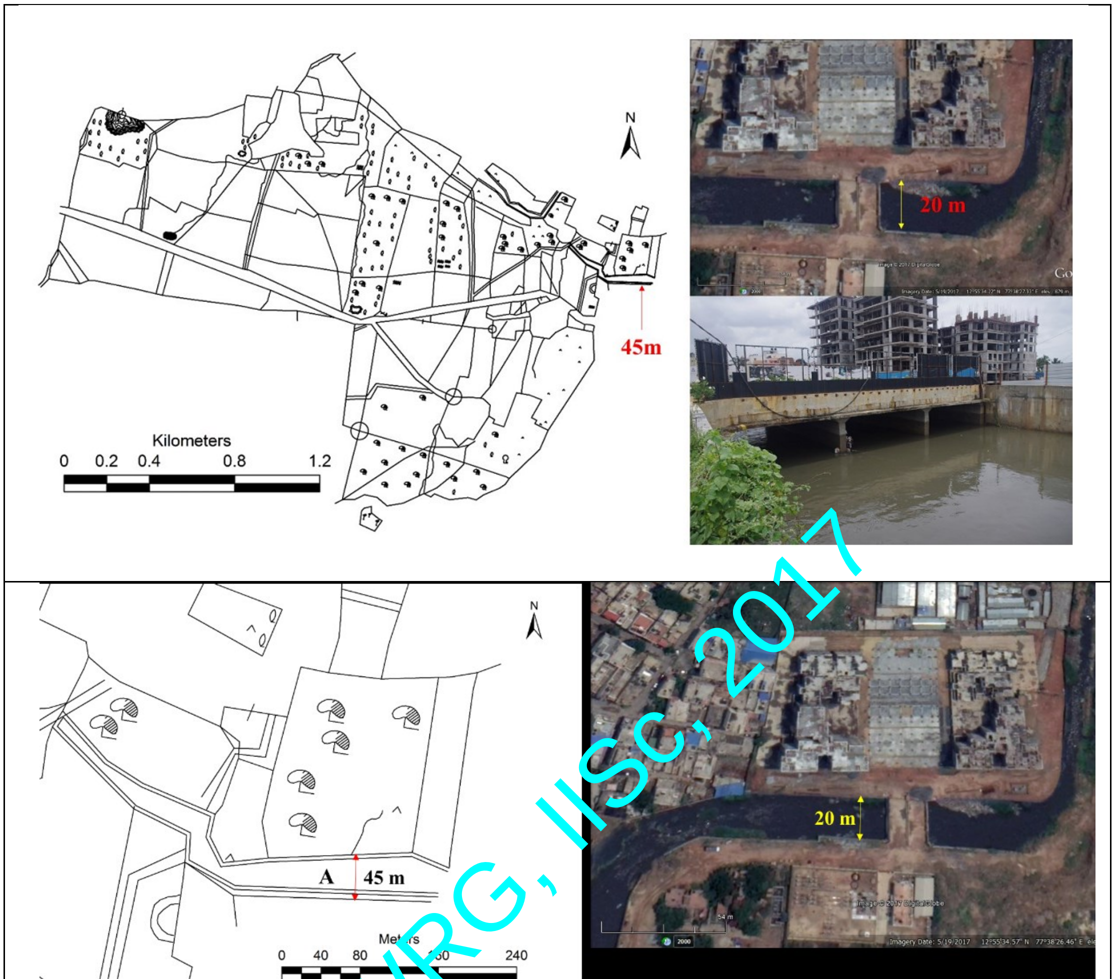


Figure 1: Rajakaluve A: from Agara Lake to Bellandur Lake

Reduced Channel size (Senseless narrowing drains violating NGT guidelines to maintain integrity of storm water drain with buffer) – drain itself is reduced by 50% (Cadastral map – 45 m, current width as per Google Earth: 20m)

Frequent flooding in the region is a consequence of mismanagement of wetlands, narrowing Rajakaluves (storm water drain) and the removal of first and second order drains. Irrational decision of SEZ in wetlands has enhanced the flooding episodes in the region and citizens are now vulnerable to recurring flooding hazards (with increased precipitation and associated factors). CITIZEN ARE PAYING (WITH THE DAMAGES TO PROPERTIES AND LOSS OF LIFE) FOR IRRATIONAL DECISIONS OF DECISION MAKERS.

RECOMMENDATION:

1. **RECOVER WETLANDS** (BELLANDUR-AGARA) AND **RESTORE WETLANDS** PHYSICAL AND CHEMICAL INTEGRITY ON PRIORITY -Shift the proposed SEZ (in the ecologically fragile Bellandur-Agara wetlands) to other location in Karnataka immediately,
2. **Reestablish interconnectivity** among lakes by removing all blockades (encroachments, solid waste dumping)
3. **Restore removed drains** - Maintain the integrity of drains (as per cadastral maps) and reestablish connectivity through drains
4. **Protect Valley zones** and Buffer regions of wetlands: protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
5. Restore wetlands (between Agara and Bellandur lakes) and set up STP (Sewage Treatment Plant) with constructed wetlands (similar to Jakkur Lake) in this region.
6. Stop narrowing and concretising natural drains
7. Remove the compound wall altering the hydrologic regime leading to escalation of flooding impact
8. Penalise decision makers for violation of norms – acquiring wetlands (valley zone) for industrial activities, narrowing and concretising natural drains, allowing constructions in lake (wetlands) bed and in drains, deliberating violating NGT guidelines of buffer zone for lakes and Rajakaluves (narrowing drains to help encroachers).
9. **Single Agency to manage lakes (preferably KLCDA as per 5 June 2015 Gazette Notification and Wetlands Rule 2016, GoI)** – currently fragmented and deliberate un-coordinated governance with too many para-state agencies (inefficient, incompetent and deliberately mismanaged – mechanism to maximize pilferages)

Frequent flooding (since 2000, even during normal rainfall) in Bangalore is a **consequence of the increase in impervious area with the high-density urban development in the catchment and loss of wetlands and vegetation**. This is coupled with narrowing and concretising storm water drains, encroachment of drains, removal of drains, lack of appropriate drainage maintenance works with the changes in enhanced run-offs, the encroachment and filling in the floodplain on the waterways, obstruction by the sewer pipes and manholes and relevant structures, deposits of building materials and solid wastes with subsequent blockage of the system and also flow restrictions from under capacity road crossings (bridge and culverts). The lack of planning and enforcement has resulted in significant narrowing of the waterways and filling in of the floodplain by illegal developments. Causal factors and remedial measures to mitigate impacts of flooding are:

Reasons

1. Loss of interconnectivity among lakes due to encroachment of drains, removal of drains or dumping of solid wastes or construction and demolition (C & D) wastes
2. Encroachment of flood plains and wetlands (construction in valley zones, flood plains and lake bed) and de-notifying wetlands)
3. Narrowing and concretising storm water drains impairing hydrological functions of the natural drains
4. Loss of pervious areas - reduction of open spaces, wetlands and vegetation cover
5. Bangalore: Increased paved surfaces in the city (78% paved surface and likely to be 94% by 2020) due to unplanned irresponsible urbanisation by senseless decision makers.

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

1. Reestablish interconnectivity among lakes by removing all blockades (encroachments, solid waste dumping)
2. Maintain the integrity of drains (as per cadastral maps) and reestablish connectivity through drains
3. Protect Valley zones and Buffer regions of wetlands: protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
4. Stop narrowing and concretising natural drains
   - Vegetation in the drain takes the load during peak monsoon, there is no need to concretise the channel.
   - Vegetation allows groundwater recharge while treating the water (bioremediation);
   - Drains with vegetation without any bottlenecks (hindrances) would be the best option to mitigate floods.
   - Narrowing channel and concretizing would only increase the quantum of water and velocity, which would be disastrous.
   - Objective should be towards mitigation of floods and not to generate high overland flows (with increased quantum and flow velocity)
   - Experts should think sensibly with holistic knowledge (considering all subject knowledge) than fragmented narrow sectorial knowledge. Advice by pseudo experts would be detrimental as the society would be deprived of ground water, frequent floods and unnecessary livelihood threats.

<table>
<tr><td colspan="2">

5. Stop further choking of Koramangala

- Shift the proposed SEZ (in Bellandur-Agara wetlands) to other location in Karnataka,
- Stop further industriaisation and commercial establishments in the region.
- Protect open spaces – lakes, parks, etc.
- Stop further growth of dying city – with water and oxygen scarcity
- BWSSB should stop issuing senselessly NOC (no objection certificate) to major building projects as there is not sufficient water in the city.
- Environment clearance as per the norms of Environment Protection Act (2016), Wetlands (Conservation and Management) Rules, 2016, SWM 2016, C & D Wastes, 2016, Air act 1981, Water (prevention of Pollution) Act, 1974.

</td></tr>
<tr><td>Activities around lakes</td><td>Norms to protect and conserve Wetlands</td></tr>
<tr><td>Encroachment of lake bed and loss of interconnectivity among lakes</td><td>The Hon'ble Supreme Court in Civil appeal number 1132/2011 at SLP (C) 3109/2011 on January 28,2011 has expressed concern regarding encroachment of common property resources, more particularly lakes (and raja kaluves) and it has directed the state governments for removal of encroachments on all community lands.

Eviction of encroachment: Need to be evicted as per Karnataka Public Premises (eviction of unauthorised occupants) 1974 and the Karnataka Land Revenue Act, 1964</td></tr>
<tr><td>Buildings in the buffer zone of lakes</td><td>In case of water bodies, 75.0 m buffer of 'no development zone' (as per recent National Green Tribunal direction) is to be maintained around the lake (buffer region to be as per revenue records)

• As per BDA, RMP 2015 (Regional Master Plan, 2015)
• Section 17 of KTCP (Karnataka Town and Country Planning) Act, 1961 and sec 32 of BDA Act, 1976
• Wetlands (Conservation and Management) Rules 2010, Government of India; Wetlands Regulatory Framework, 2008.</td></tr>
<tr><td>Construction activities in the valley zone (SEZ by Karnataka Industrial Areas Development Board (KIADB)) in the valley zone</td><td>This is contrary to sustainable development as the natural resources (lake, wetlands) get affected, eventually leading to the degradation/extinction of lakes. This reflects the ignorance of the administrative machinery on the importance of ecosystems and the need to protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015</td></tr>
<tr><td>Alterations in topography</td><td>Flooding of regions would lead to loss of property and human life and, spread of diseases.</td></tr>
</table>

Increase in deforestation in catchment area	Removing vegetation in the catchment area increases soil erosion and which in turn increases siltation and decreases transpiration
Documentation of biodiversity	• The biodiversity of every water body should form part of the School, College, People's Biodiversity Registers (SBR, CBR, PBR). • The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity. • The presence of endemic, rare, endangered or threatened species and economically important ones should be highlighted • A locally implementable conservation plan has to be prepared for such species
Implementation of sanitation facilities	• The lakes are polluted with sewage, coliform bacteria and various other pathogens • Preserving the purity of waters and safeguarding the biodiversity and productivity, dumping of waste has to be prohibited • All the settlements alongside the water body should be provided with sanitation facilities so as not to impinge in anyway the pristine quality of water
Violation of regulatory and prohibitory activities as per Wetlands (Conservation and Management) Rules, 2016 and 2010; Regulatory wetland framework, 2008	Environment Impact Assessment (EIA) Notification, 2009. **Wetlands (Conservation and Management) rules 2010, Government of India; Regulatory wetland framework, 2008** **Regulated activity** • Withdrawal of water/impoundment/diversion/interruption of sources • Harvesting (including grazing) of living/non-living resources (may be permitted to the level that the basic nature and character of the biotic community is not adversely affected) • Treated effluent discharges – industrial/ domestic/agro-chemical. • Plying of motorized boats • Dredging (need for dredging may be considered, on merit on case to case basis, only in cases of wetlands impacted by siltation) • Constructions of permanent nature within 50 m of periphery except boat jetties • Activity that interferes with the normal run-off and related ecological processes – up to 200 m **Prohibited activity** i. Conversion of wetland to non-wetland use ii. Reclamation of wetlands iii. Solid waste dumping and discharge of untreated effluents

Damage of fencing, solid waste dumping and encroachment problems in Varthur lake series	High Court of Karnataka (WP No. 817/2008) had passed an order which include: • Protecting lakes across Karnataka, • Prohibits dumping of garbage and sewage in Lakes • Lake area to be surveyed and fenced and declare a no development zone around lakes • Encroachments to be removed • Forest department to plant trees in consultation with experts in lake surroundings and in the watershed region • Member Secretary of state legal services authority to monitor implementation of the above in coordination with Revenue and Forest Departments • Also setting up district lake protection committees
Polluter Pays principle	**National Environment Policy, 2006** The principal objectives of NEP includes : • Protection and conservation of critical ecological systems and resources, and invaluable natural and man-made heritage • Ensuring judicious use of environmental resources to meet the needs and aspirations of the present and future generations • It emphasizes the "Polluter Pays" principle, which states the polluter should, in principle, bear the cost of pollution, with due regard to the public interest
Prevention of pollution of lake	**National Water Policy, 2002** Water is a scarce and precious national resource and requires conservation and management. Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted. The water resources should be conserved by retention practices such as rain water harvesting and prevention of pollution.
Discharge of untreated sewage into lakes	**The Environment (Protection) Act, 1986** • Lays down standards for the quality of environment in its various aspects • Laying down standards for discharge of environmental pollutants from various sources and no persons shall discharge any pollutant in excess of such standards • Restriction of areas in which industries, operations or processes shall not be carried out or carried out subject to certain safeguards

The water pollution, prevention and its control measures were not looked upon	**Water (Prevention and Control of Pollution) Act, 1974** • It is based on the "Polluter pays" principle. The Pollution Control Boards performs the following functions : • Advice the government on any matter concerning the prevention and control of water pollution. • Encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution. • Inspects sewage and effluents as well as the efficiency of the sewage treatment plants. • Lay down or modifiy existing effluent standards for the sewage. • Lay down standards of treatment of effluent and sewage to be discharged into any particular stream. • Notify certain industries to stop, restrict or modify their procedures if the present procedure is deteriorating the water quality of streams.
Pathetic water scenario and insufficient drinking water in Bangalore	The depletion of ground water and drying up of lakes has affected the water availability to meet the current population. At the 4% population growth rate of Bangalore over the past 50 years, the current population of Bangalore is 8.5 million (2011). Water supply from Hesaraghatta has dried, Thippagondanahalli is drying up, the only reliable water supply to Bangalore is from Cauvery with a gross of 1,410 million liters a day (MLD). There is no way of increasing the drawal from Cauvery as the allocation by the Cauvery Water Disputes Tribunal for the entire urban and rural population in Cauvery Basin in Karnataka is only 8.75 TMC ft (one thousand million cubic – TMC ft equals 78 MLD), Bangalore city is already drawing more water-1,400 MLD equals 18 TMC—than the allocation for the entire rural and urban population in Cauvery basin

UNABATED VIOLATIONS IN AGARA BELLANDUR WETLAND

Belladur Agara wetland is the pristine wetland in the valley zone of south-east Bangalore. Agara Bellandur wetland is being abused with the numerous unplanned senseless developmental activities violating the environmental norms. Figure 1 illustrates the persisting violations in the buffer zones of lakes, stream as on 2017 December despite sensible NGT order. Large number of structures still exist in the buffer zones violating norms of NGT.

Figure 1: Lakes, Streams, Buffer zones, Violations and Sections (1, 2, 3,…9)

Note: Yellow lines (75 m buffer zone of Lakes), Blue lines (50 m buffer zone of Rajakaulves), Red line (25 m buffer zone from streams)

Table 1: Section wise Violations in Agara Bellandur Zone

Section	Geographic Features	Location	Violation
1		12.927669^0N 77.644392^0E	Existing Structures and Buildings in the buffer zone of Bellandur lake (75m)

			
2	 	12.927567^{0}N 77.647227^{0}E	Existing Structure in the buffer zone of Bellandur lake (75m)
3		12.923796^{0}N 77.641443^{0}E	Numerous Buildings Existing in the buffer zone of Agara Lake

4		12.924938^{0}N 77.646224^{0}E	Buildings Existing in the buffer zone of Agara Lake
5		12.924945^{0}N 77.648460^{0}E	Buildings Existing in the buffer zone of Agara Lake
6		12.927567^{0}N 77.647227^{0}E	Buildings Existing in the buffer zone of Stream connecting Agara and Bellandur Lake
7		12.927016^{0}N 77.644686^{0}E	Structure Existing in the buffer zone of Stream connecting Agara and Bellandur Lake

8	 	12.927266^{0}N 77.647219^{0}E	Structure Existing in the buffer zone of Stream connecting Agara and Bellandur Lake
9	 	12.926025^{0}N 77.649508^{0}E	Buildings and Structures Existing in the buffer zone of Stream connecting Agara and Bellandur Lake

GPS data (Waypoints and Tracks) overlay on Google earth is as depicted in Figure 2, based on field visit carried out on 12 December 2017.

Figure 2: GPS overlay on Google earth

Figure 3: Field visit (GE + Photographs)

Field work photographs (12 December 2017) – Violations Galore (where are law abiding citizens?)

Flooding*:* Floods in an urbanised landscape refer to the partial or complete inundation from the rapid accumulation or run-off resulting in the damage to property and loss of biotic elements (including humans). Urban flooding is a consequence of increased impermeable catchments resulting in higher catchment yield in a shorter duration and flood peaks sometimes reach up to three times. Thus, flooding occurs quickly due to faster flow times (in a matter of minutes). Causal factors include combinations of loss of pervious area in urbanising landscapes, inadequate drainage systems, blockade due to indiscriminate disposal of solid waste and building debris, encroachment of storm water drains, loss of inter connectivity among lakes, housing in floodplains and natural drainage and loss of natural flood-storages sites. Flood mitigation in urban landscape entails integrated ecological approaches combining the watershed land-use planning with the regional development planning. This includes engineering measures and flood preparedness with the understanding of ecological and hydrological functions of the landscape.

Bangalore is experiencing unprecedented urbanisation and sprawl in recent times due to concentrated developmental activities with impetus on industrialisation for the economic development of the region. This concentrated growth has resulted in the increase in population and consequent pressure on infrastructure, natural resources and ultimately giving rise to a plethora of serious challenges such as climate change, enhanced green-house gases emissions, lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc. This study shows that there has been a growth of 1028% in urban areas of Greater Bangalore across 45 years (1973 to 2017). Urban heat island phenomenon is evident from large number of localities with higher local temperatures. The study unravels the pattern of growth in Greater Bangalore and its implication on local climate (an increase of ~2 to 2.5 ºC during the last decade) and also on the natural resources (88% decline in vegetation cover and 79% decline in water bodies), necessitating appropriate strategies for the sustainable management.

CAUSAL FACTORS OF RECURRING FLOODS

CAUSAL FACTOR 1: ABUSE OF WETLANDS (AGARAM – BELLANDUR) - VIOLATIONS LEADING TO THE ALTERATIONS IN THE ECOSYSTEM INTEGRITY

Violation that persist in Bellandur – Agara wetland (Figure 1) are:

i. Abuse of wetlands (with dumps, building materials, etc.) -Non-removal of building debris (used for filling the drains – highlighted in Figure 2)
ii. Narrowing Rajakaluves;
iii. Concretised storm water drains;
iv. Construction of compound wall altering the hydrologic regime – leading to escalation of flooding impact;
v. Buildings in the buffer zone of Bellandur lake (and valley zone of Agara-Bellandur);
vi. Existence of labour sheds and pollution due to open defecation (lack of appropriate sanitation for labourers);
vii. Dumping of solid waste – plastic bottles, polythene covers, etc.;
viii. Unauthorised occupation of wetlands in the valley zone;
ix. Not clearing encroached lake area (dumped debris continue to exist);
x. Inefficient custodians of wetlands (BDA and revenue department);
xi. Unplanned activities – proposing SEZ in the city (that would enhance traffic density, leading to further traffic chaos; decline in groundwater table; pollution of wetlands) by KIADB, which only highlight the inefficient and incompetent planning system in the city.
xii. Lack of accountability – decision makers and hence inefficient and incompetent management of natural resources.

Belladur Agara wetland is the pristine ecosystem supporting dependent biota and was aiding as a zone for the inundation of floodwater, percolation of precipitation, sustained recharge of ground water resources, while reducing overland flow. The wetlands are part of flood plains that follows the terrain. Consequences of continued abuse of wetlands are (i) increased instances of flooding, (ii) enhanced velocities of the discharge (iii) reduced recharge of ground water, (iv) loss of life and damages to the property.

Bellandur-Agara wetland's integrity is altered due to (i) filling of low lying area with construction debris, (ii) removal of interconnecting drains (visible in remote sensing data of 2000, Figure 2) , (iii) narrowing and concretizing drains to aid the encroachment. Figure 1 indicates the Revenue map of Agara village indicating Wetland under study. Cyan line in the revenue map indicates channels connecting Agara and Bellandur lakes along the wetland

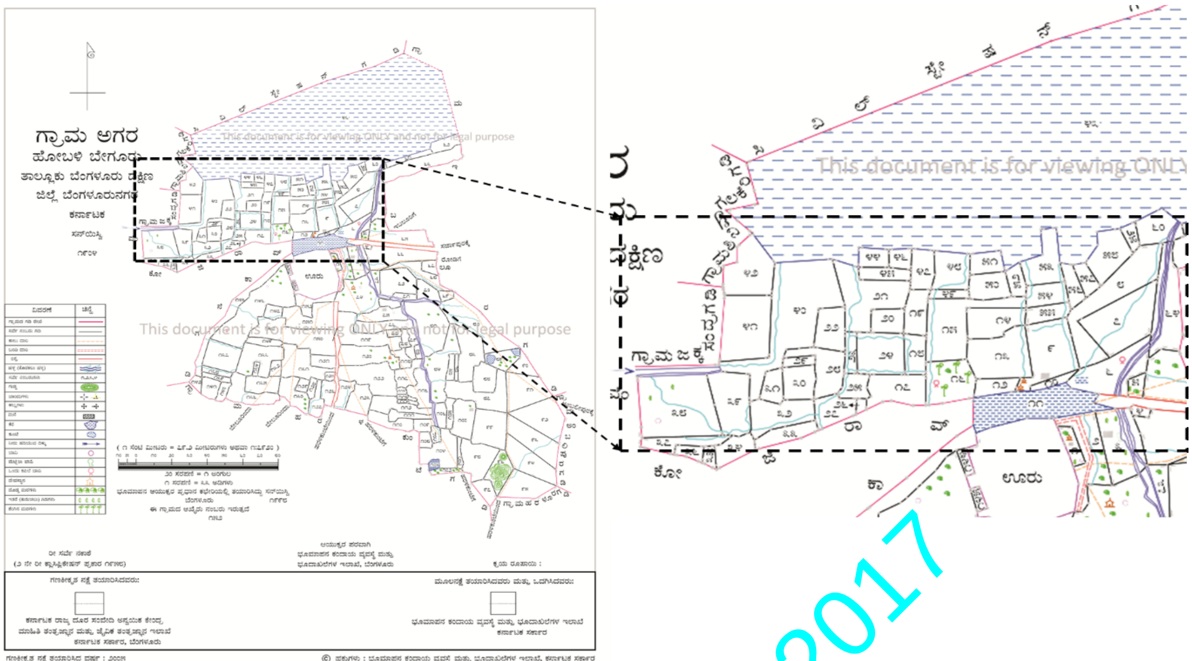
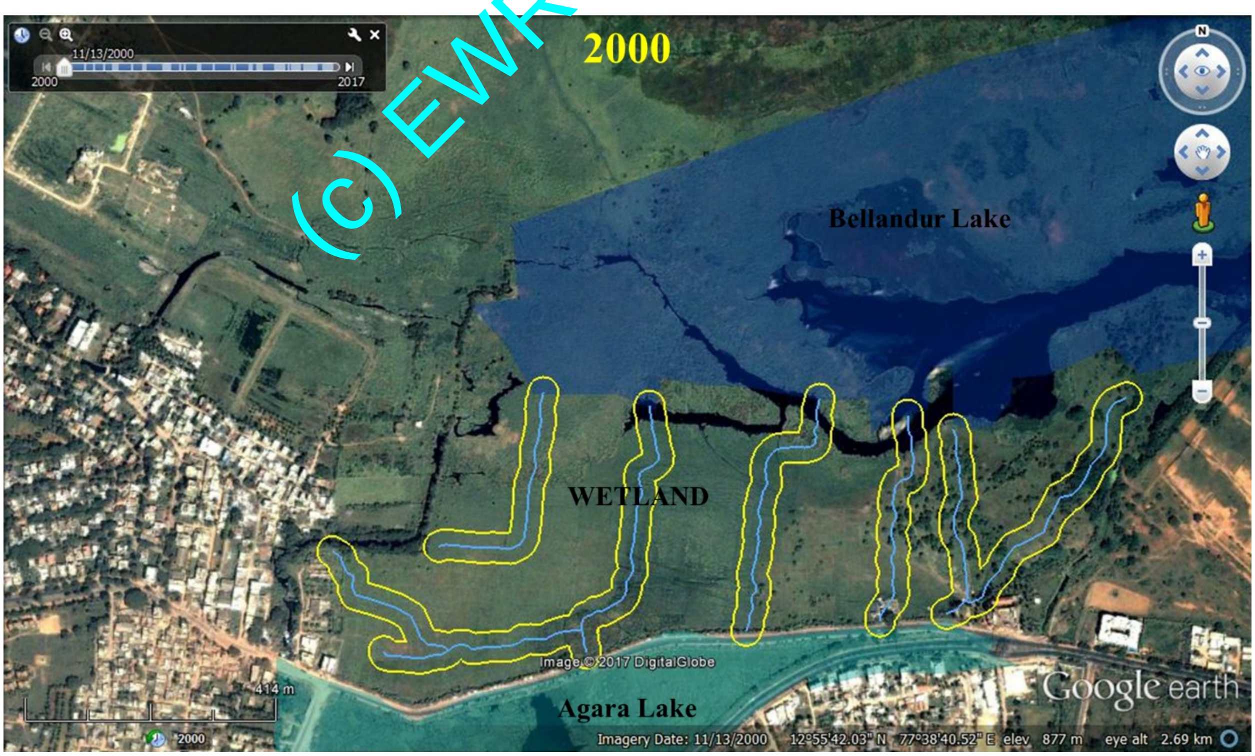
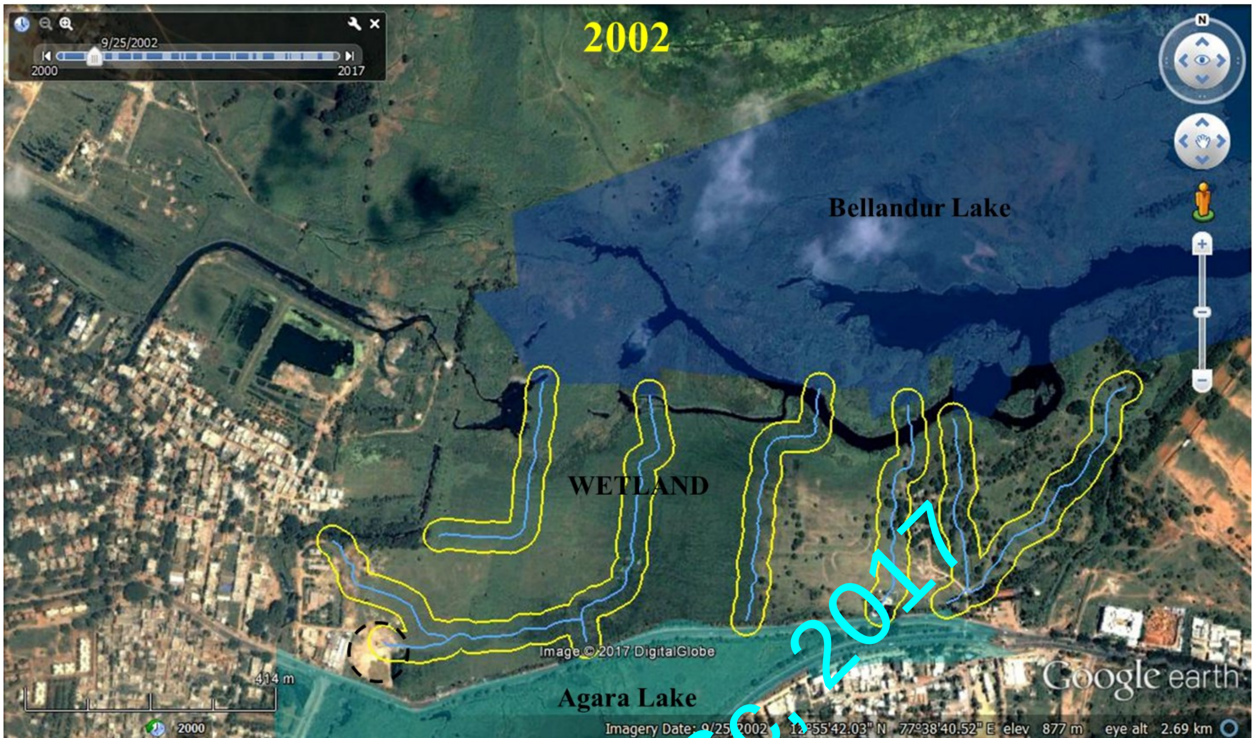


Figure 1: Agara Bellandur Wetland

Land cover dynamics in the wetland of Agara Bellandur lake is as presented in Figure 2. It is observed that since 2002, construction debris, soil were constantly dumped in the wetland, altering the topography (undulating terrains are levelled). The wetland was completely altered in 2012 with the disappearance of connecting drains due to large scale filling, excavations for construction activity. Now, only drains in the army campus exists.

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Bellandur Lake
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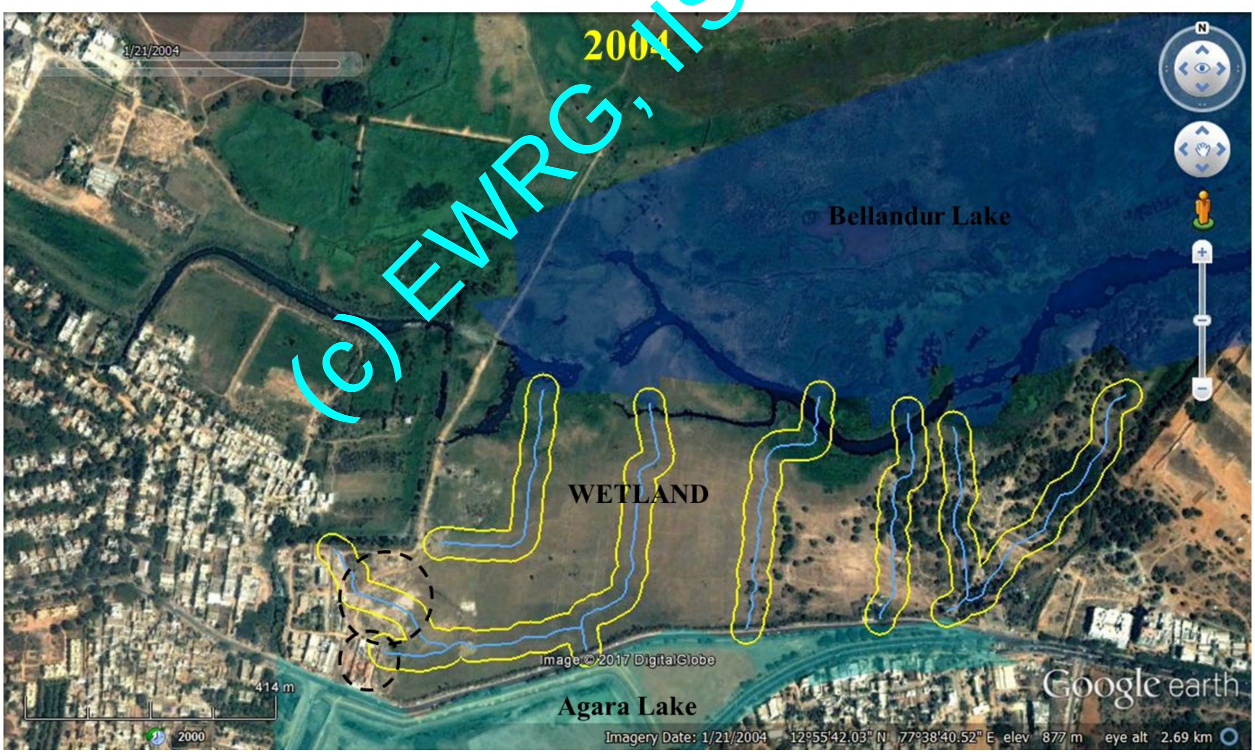
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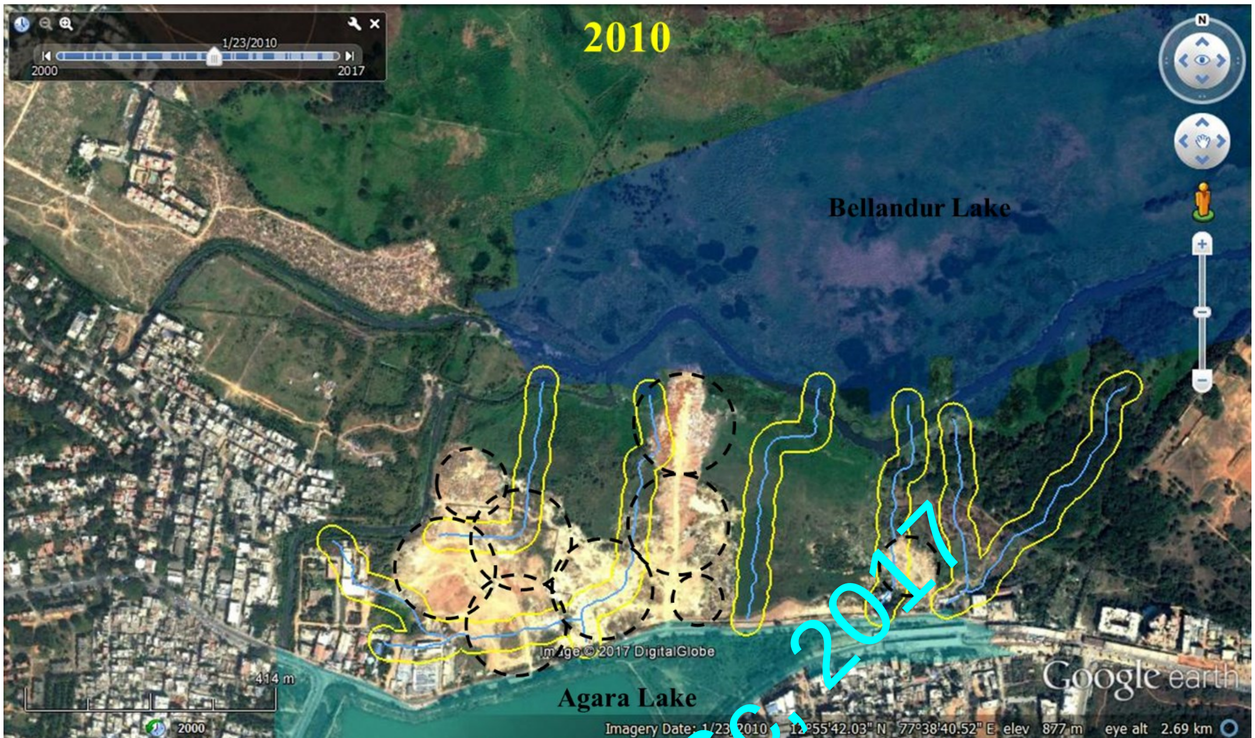
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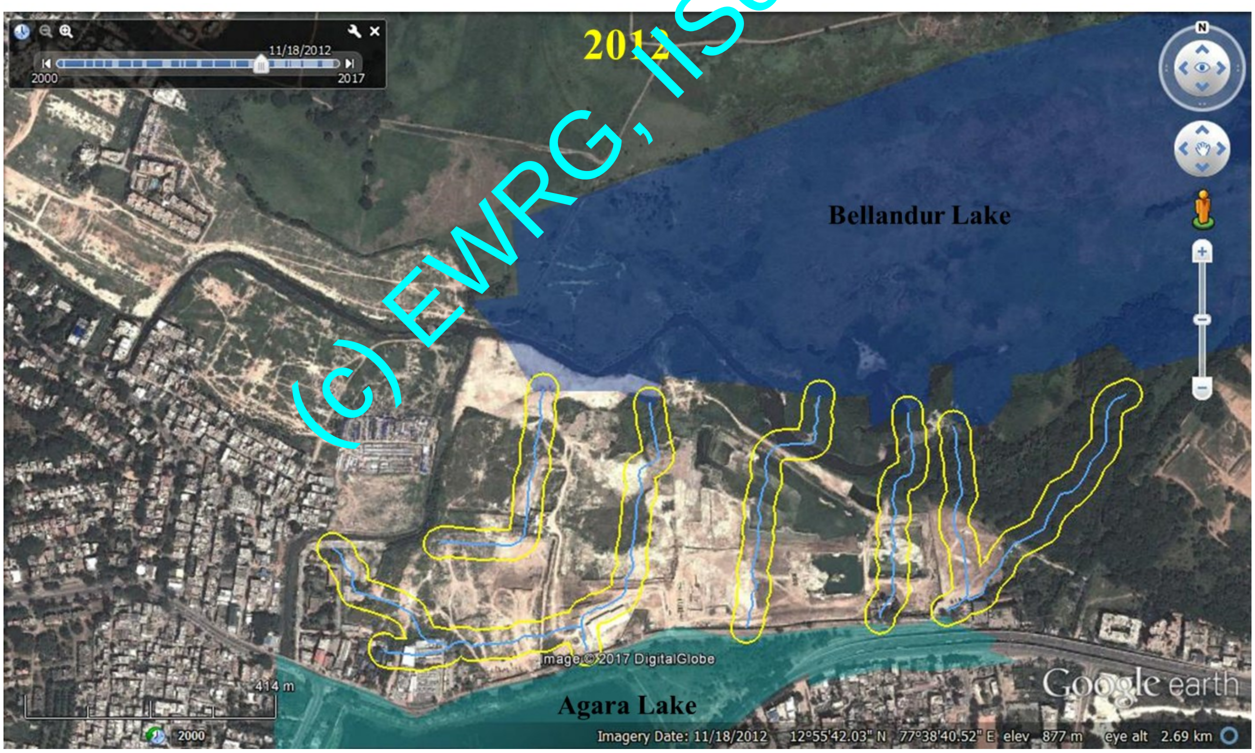
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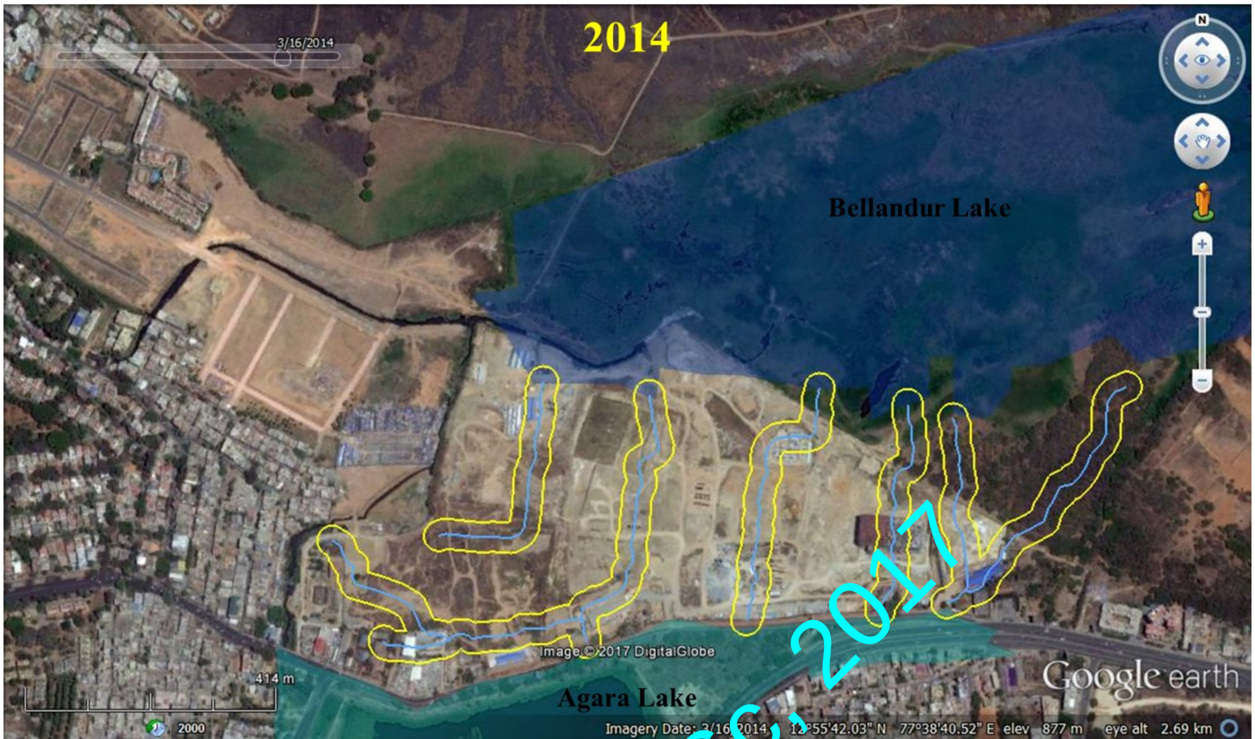
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Figure 2: Landscape changes in the Wetland region and along buffer zone (25 m) of channels

Figure 3 and Figure 4 demonstrates the alterations in the wetlands region observed at the site at sites in 2014 and 2017 field visits. Large scale construction debris, Soil and Solid waste filled, over which construction activity was under progress. Figure 4 also depicts the concretized channel and violation of norms. The channel has been reduced in width from 45 m to nearly 20 m (Figure 5).

Figure 3: Land status in 2014

Figure 4: Landscape status as on September 2nd 2017

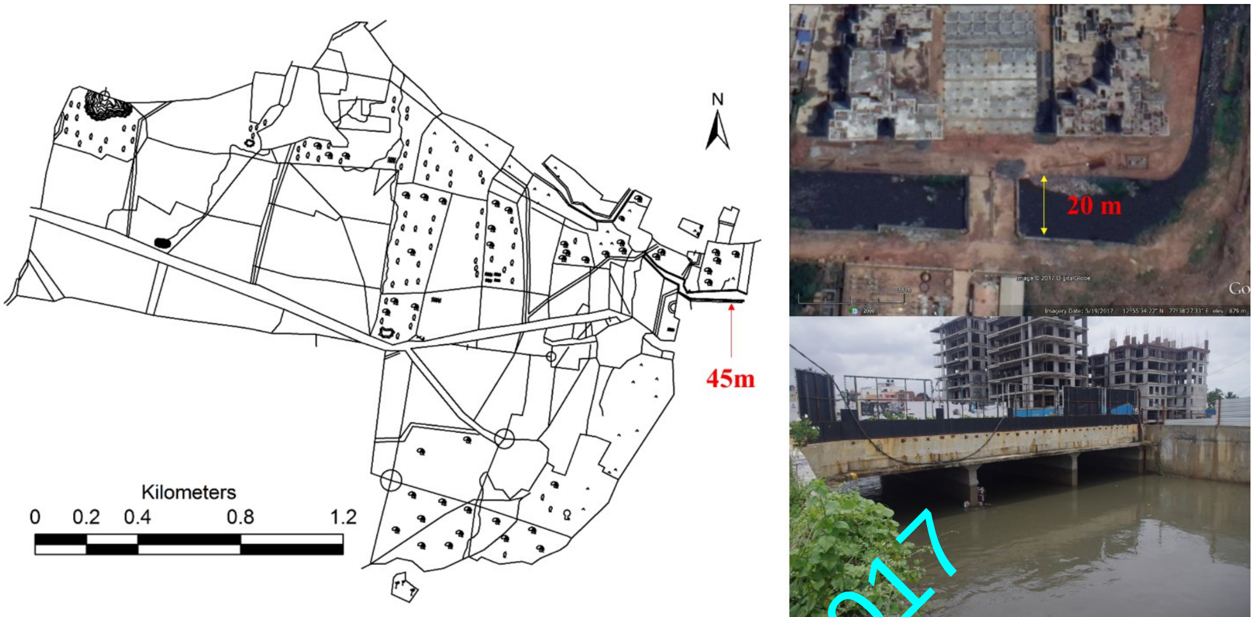
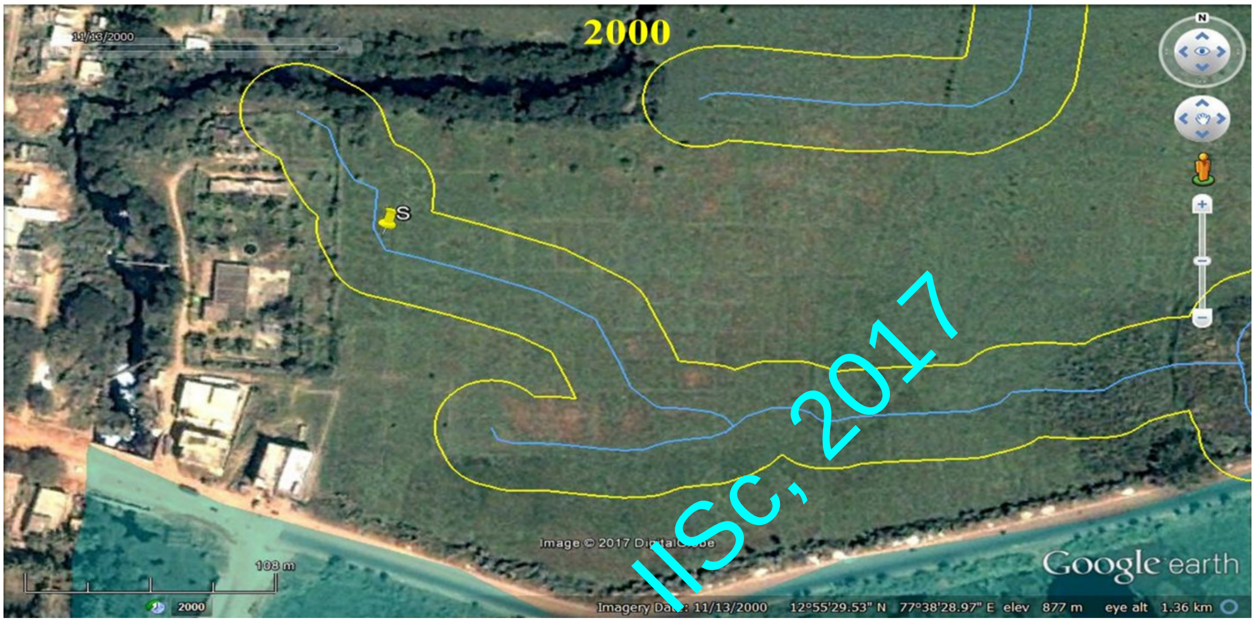
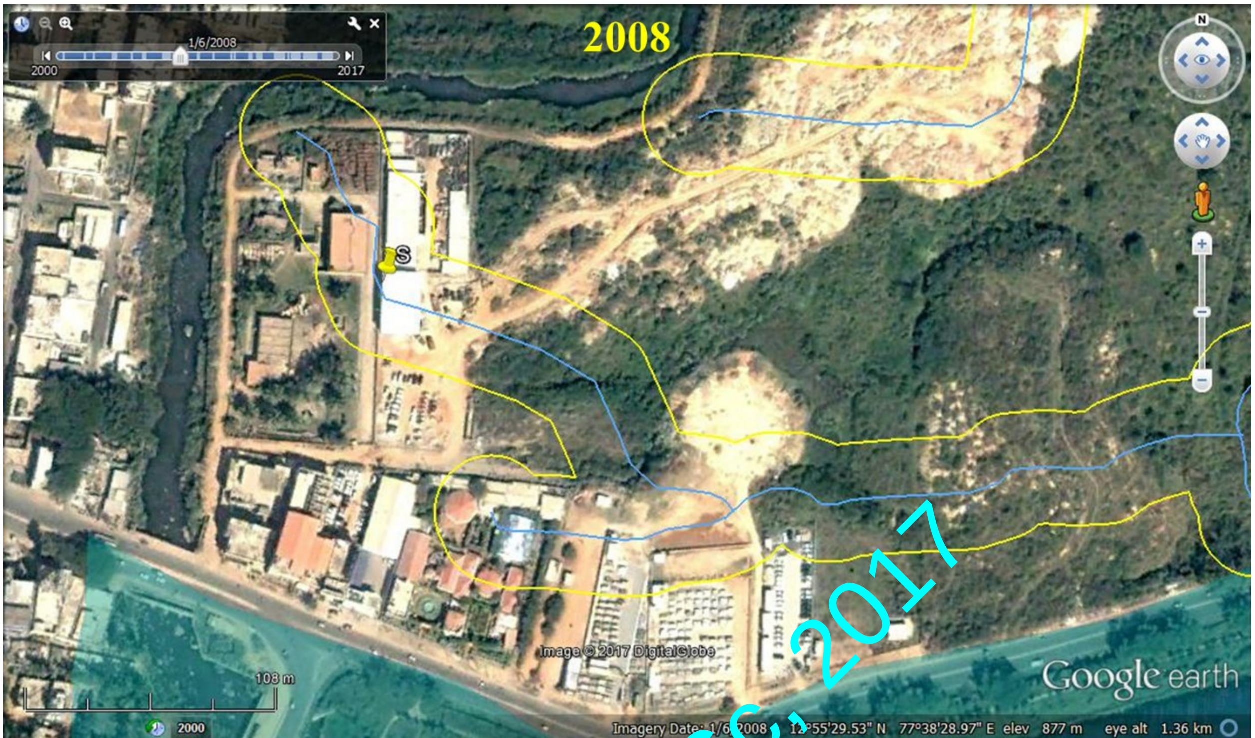


Figure 5: Reduced Channel size

CAUSAL FACTOR 2: DEBRIS IN STORM WATER DRAINS:

Figure 6 indicates the status of one of the connecting channel during the field visit on 1st September 2017. The channel continued to be filled with construction debris (since 2004). Figure 7 depicts the current status of one of the connecting channel.

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108 m
Google earth
Imagery Date: 1/6/2008 12°55'29.53" N 77°38'28.97" E elev 877 m eye alt 1.36 km


2014
1/4/2014
Image © 2017 DigitalGlobe
108 m
Google earth
Imagery Date: 1/4/2014 12°55'29.53" N 77°38'28.97" E elev 877 m eye alt 1.36 km

Figure 6: Status of Channel across time

Figure 7: Channel at the site (Dated 2 September 2017, Location: 12°55'30.84"N, 77°38'25.38"E)

CAUSAL FACTOR 3 – ERECTION OF COMPOUND WALL:

The compound walls were erected in the wetlands region, hindering flow of water. These structures violating the hydrologic regime as (i) the compound walls inside wetlands restrict the movement of water from upstream to downstream, (ii) compound wall is being built (after filling and altering the topography) altering the wetlands physical integrity. Figure 8 depicts the Compound walls on Google earth. Figure 9 depicts the status of compound walls in 2014 and 2017. IT can be observed that a new boundary has been erected in 2017, but the land is seeming not be rejuvenated to the original status.

Figure 8: Compound Wall on Google Earth

Figure 9: Compound Wall and Building in the buffer zone

CAUSAL FACTOR 4: NARROWING AND CONCRETISATION OF STORM WATER DRAINS

Storm water drains – implications of concretization: Impaired Ecosystem Functions - bioremediation and groundwater recharge (but maximization of benefits to consultants with frequent floods)

During the field work on 1 May 2017 along with CEO, KLCDA it was observed

xi) Rajakaluve (storm water drain) connecting Bellandur lake from city market side is narrowed to 28.5 m against the original width of 60 m and also violating recent NGT guidelines. This is mainly to help the encraochers of storm water drains while bypassing NGT's guidleines of storm water drain buffer regions

xii) Concretisation of storm water – this would affect the hydrological functional ability of storm water drains – ground water recharge, remediation and flood mitigation

xiii) Concretization and narrowing the drains has only enhanced the flooding in the city, observed recently (15th August 2017, 24th August 2017).

xiv) BBMP while wasting the public money has made Bangalore landscape vulnerable with frequent floods.

Figure 10 shows revenue map of Jakkasandra village which is in the upstream of Bellanduru lake. Figure 11 illustrates narrowed width of rajakaulve between 1908 and 2017. It can be noted that nearly 50% of the channel width is reduced and has been concretized.

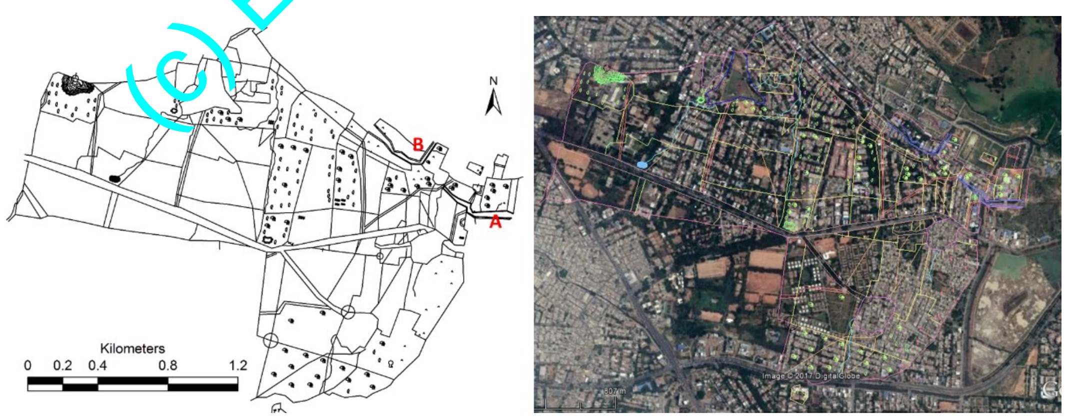

Figure 10: Jakkasandra Village map
(Note : A indicates the Rajakaluveys measured for change in width)

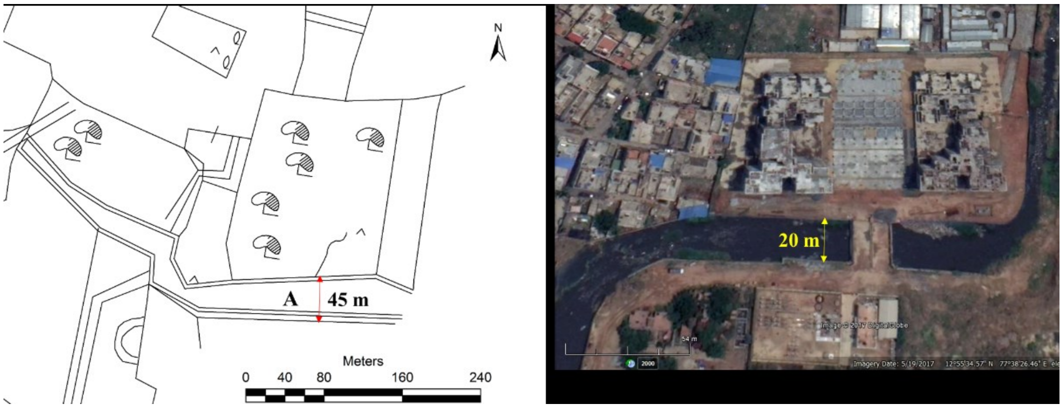

Figure 11: Rajakaluve A: from Agara Lake to Bellandur Lake

The need for sensible interventions.

1. Drains (trapezoidal) are to be designed in the city to optimise natural hydrological principles;
2. No concretization of drain bed – natural bed (soil) would help in (i) retarding velocity, (ii) infiltration – recharge of ground water resources. This would help in mitigating floods. Soil also acts as membrane and aids in remediation preventing the contamination of ground water resources;
3. Concretisation of storm water drain would increase the quantity of water flow (due to absence of infiltration) and enhances water velocity (10-12 times, Refer Table 1.2). This would certainly increases the city's flooding vulnerability with high intense rainfall coupled with the increase in paved surfaces (78% of Bangalore land surface is paved!). Consequent of this would be higher instances of flooding with the damages to the property and human life;
4. Let the drain walls be either stone pitched (for structural stability) or turfed with grasses depending on the location;
5. Chain link fences to prevent un-authorised occupation of drains and also dumping of wastes;
6. Evolve appropriate policy mechanisms to make dumping of solid waste, construction and demolition waste in the drains and lakebed cognizable and non-bailable offence;
7. Make drain and lakebed encroachments as cognizable and non-bailable offence and imprisonment of 12 months;

8. Strengthen legal cell in BBMP to address all illegalities (nexus of mafia - contractors, engineers, etc.) as well as encroachments;

Need to move away from contractor with consultant driven design to maximise individual gains (through cement concretization etc.) -Estimate of Rs 8 crore per kilometer of drain is too exorbitant and waste of public money.

Open Channels Flow: Flow of fluids in natural or manmade channels whose surface is exposed to the atmosphere and flow is due to gravitational force are referred to as open channel flow. In order to understand the channels capabilities or designing the channels, Manning's equation is generally used. Mannings equation is a function of channels physical properties such as wetted perimeter, cross sectional area, bed slope, bed material, depth of flow, *etc.*

Manning's equation for velocity of flow is given by :

$$V = \frac{k}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where

V is the velocity of flow in the channel as m/s
k is constant (1 for SI units and 1.49 for FPS units),
n is Manning's roughness coefficient (Table 1.1).
R is the hydraulic radius which is defined as the ratio of Cross sectional area (A) to Wetted Perimeter (P)

$$R = \frac{A}{P}$$

S is the bed slope of the channel.
Discharge (Q) cum/s is quantified as function of Area (A) sq.m and Velocity (V) m/s

Q = A.V

Table 1.1: Manning's Roughness coefficient (n)

Type of Channel and Description	**Minimum**	**Normal**	**Maximum**
Natural streams - minor streams (top width at flood stage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060

g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040

2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	

j. Vegetal lining	0.030		0.500

Manning's n for Closed Conduits Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	**Minimum**	**Normal**	**Maximum**
1. Brass, smooth:	0.009	0.010	0.013
2. Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.030
6. Cement:			
Neat Surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.020
8. Wood:			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
9. Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.020
Rubble masonry, cemented	0.018	0.025	0.030

Manning's n for Corrugated Metal Pipe (AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	**n**
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	

8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.020
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.030
180" diameter	0.028

Source: www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

DESIGN – ILLUSRATION OF NATURAL DRAINS SUPREMACY

Highest rainfall in a day was observed to be 109 mm in the year 2013 (as recorded between 31st May 2013 8:30 AM and 1st June 2013 8:30 AM), w.r.t which an yield of 1022 kilo.cum of water is generated. Considering that the rainfall has occurred within 6 hours, Discharge would be about 47.31 cum/s. Open channels along the valley zones should be able to carry the discharge of 47.31 cum/s, without clogging or surpassing the flood plain.

In order to quantify the discharge along the channel, various scenarios were observed, i.e., current width of which is about 7 to 8 meters in width, and width as per cadastral maps along with various bed characteristics such as concrete bed, soil bed and bed with vegetation., details are as presented in table 1.2.

The analysis of Channels shows that in the current scenario, where the channel width is about 7 – 8 meters in width, has a capacity to carry discharge of 51.47 cum/s at minimum roughness coefficient of 0.40 for channels with presence of weeds/reeds and stones along the beds indicating that the channels would easily cater to the exiting discharge of 47.31 cum/s.

Table 1.2: Analysis of the Channels

Scenario	As per Revenue map			Current Scenario		
Channel width top (m)	15			8		
Channel width bottom (m)	12			6		
Depth (m)	2.0			2.5		
Side Slope	0.75			0.4		
Area (sq.m)	30.0			20		
Perimeter (m)	17.0			11.4		
Hydraulic Radius (m)	1.8			1.8		
Channel Slope S	0.005			0.005		
Bed Type	**Veg**	**Soil**	**Concrete**	**Veg**	**Soil**	**Concrete**
n (min)	**0.05**	**0.023**	**0.015**	**0.040**	**0.023**	**0.015**
n (normal)	**0.07**	**0.025**	**0.017**	**0.048**	**0.025**	**0.017**
n(max)	**0.08**	**0.03**	**0.02**	**0.055**	**0.030**	**0.020**
V (max) m/s	**2.07**	**4.49**	**6.88**	**2.57**	**4.48**	**6.86**
V (normal) m/s	**1.48**	**4.13**	**6.07**	**2.14**	**4.12**	**6.06**
V (min) m/s	**1.29**	**3.44**	**5.16**	**1.87**	**3.43**	**5.15**
Q (max) cum/s	**61.96**	**134.69**	**206.52**	**51.47**	**89.52**	**137.26**
Q (normal) cum/s	**44.25**	**123.91**	**182.22**	**42.89**	**82.36**	**121.11**
Q (min) cum/s	**38.72**	**103.26**	**154.89**	**37.44**	**68.63**	**102.95**

Velocity estimates indicate that presence of vegetation along with other bed materials (Soil, stones) would help in reducing velocity of flow. In the existing scenario, flow velocity was estimated to be 1.87 to 2.57 m/s, compared to soil bed or concrete bed which has lower friction where the velocity ranges were between 3.43 to 6.86 m/s.

If the drainages were reclaimed as per the cadastral maps, the width of the channel would be around 15 to 18 meters, considering maximum flow depth as 2 meters, channel with natural vegetation (reeds and weeds) would have low flow velocities between 1.29 to 2.07 m/s which is much lower as against the current scenario, and with discharges upto 61.96cum/s, indicating that the valley in its natural condition had a higher sewage carrying potential even with lower depth of flow.

Studies showing relation between Bed material and Surface flows: Studies carried by Nepf in 2012, Miyab et al 2014, Miyab et al 2015, Morri et al 2016, Jarvella, 2002, Green 2005, highlights the role of vegetation on the river channels:

1) Vegetation forms an integral part of the ecosystem providing goods and services (biological, geomorphological, landscape ecology, chemistry), ecological trapping.
2) Vegetation uptakes nutrients (nitrogen and phosphorous), increase oxygen levels and helps in betterment of water quality.
3) Vegetation is known to increase bank stability, reduce erosion and turbidity, provide habitat for aquatic and terrestrial wildlife, attenuate floods, present aesthetic properties, and filter pollutants.
4) Vegetation increases resistance to flow, influence water depth, alters mean velocity.
5) Presence of vegetation alters flow velocities across several scales, ranging from branches to blades of a single plant to cluster of plants.
6) Since time immemorial (before the birth of current breed of senseless consultants and civil engineers with fragmented knowledge of the subject) aquatic vegetation was considered for flow retardation, local treatment of water, groundwater recharge – without any contamination).
7) Surface flow velocities was maximum on sections with bare banks, whereas maximum flow velocity occurs under the water surface in both vegetative and open channels.
8) Vegetation cover changes uniform flow to non-uniform flow, showing a nonlinear distribution of Reynolds stress
9) Aquatic plants are flexible, they can be pushed over by currents, resulting in change in morphology called reconfiguration
10) Reconfiguration also reduces flow resistance
    a. Reduces the frontal area of the vegetation
    b. Reconfigured shape tends to be more streamlined
11) Drag on a plant increases more slowly with velocity.
12) Vegetation reduced the variation of drag
13) Vegetation growing in waterways and rivers increase turbulence
14) Within a cluster/Canopy, flow is forced to move around each branch or blade, so that the velocity field is spatially heterogeneous.
15) Flow resistance due to vegetation is determined primarily by the blockage factor, A strong correlation exists between blockage factor and Mannings roughness coefficient.
16) Vegetation is flexible, an increase in velocity is associated with a decrease in vegetation height
17) Vegetation drag increases with increasing depth ratio if plants area emergent, and if plants are submerged hydraulic resistance decreases.
18) Baffling of flow reduces bed stresses and vegetation creates region of sediment retention, enhances retention of organic matter, nutrients and heavy metals.
19) Because of the positive impacts vegetation provides for water quality, habitat and channel stability, researchers now advocate replanting and maintenance of vegetation in rivers.
20) Presence of vegetation in the beds mitigate bed souring, reducing bed impact.
21) In many vegetated flows, the near bed turbulent stress is zero, or close to zero.

22) In the recent years, vegetation has become a major component of erosion control and stream restoration

Solutions:

- Vegetation in the drain takes the load during peak monsoon, there is no need to concretise the channel (and waste public money)
- Vegetation allows groundwater recharge while treating the water (bioremediation);
- Drains with vegetation without any bottlenecks (hindrances) would be the best option to mitigate floods.
- Narrowing channel and concretizing would only increase the quantum of water and velocity, which would be disastrous.
- Objective should be towards mitigation of floods and not to generate high overland flows (with increased quantum and flow velocity)
- Experts should think sensibly with holistic knowledge (considering all subject knowledge) than fragmented narrow sectorial knowledge. Advice by pseudo experts would be detrimental as the society would be deprived of ground water, frequent floods and unnecessary livelihood threats.

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CAUSAL FACTOR 5: LOSS OF INTERCONNECTIVITY AMONG LAKES

The undulating terrain (varying from about 700 m to about 962 m AMSL) in the region aided in the formation of interconnected lakes in the region (Figure 2.2). Bangalore City was once aptly known as 'city of lakes' due to the presence of large number of lake (about 285 lakes in an area of 161 sq km, Spatial extent of Bangalore in 1980's). These lakes were all interconnected with canals / drains (*kaluveys*'s) to enable transferring excess water to the next lake. These lakes catered the basic needs such as maintaining and recharging ground water, drinking water to the surrounding people, habitat for fishes and other aquatic ecosystems, sustaining food (fish, etc.) and agricultural activities, etc.

The drainage network in Bangalore carries water to the River Cauvery through its tributaries Arkavathi, Pinakini or Pennar and Shimsha. The central, northern and eastern portion is undulating with the upland tracts occupied by scrubs, while the low lands occupied by series of tanks formed by embanking the streams along the valley. These valleys consists of varying size water bodies from small ponds to large lakes. The southern portion of the land consists of hills that are close together and are surrounded by thick jungles.

Bangalore being located on the ridge, forms three watersheds as precipitation flows as runoff in three directions along the valleys (Figure 2.2) - Koramangala Challaghatta Valley (K&C Valley), Hebbal Valley (H Valley) and the Vrishabhavati Valley (V Valley). Under the administrative boundary of Bruhat Bengaluru, K&C valley is the largest encompassing an area of 255 square kilometers, followed by Hebbal valley with an area of 207 square kilometers and Vrishabhavati valley with an area of 165 square kilometers. Both K&C valley and Hebbal valley joins at Nagondanahalli village (**BBMP Ward 94** – Hagadur) which further flow to Dakshina Pinakini River, where as Vrishabhavati valley joins Arkavathi river which is a tributary of river Cauvery.

During 1800, there were 1452 water bodies with the storage capacity of 35 TMC (in the current spatial extent of 741 sq.km.). The number of lakes in Bangalore has reduced from nearly 285 (spatial extent of Bangalore: 161 sq.km. in early seventies) to 194 (spatial extent of Bangalore: 741 sq.km. in 2006). Unplanned rapid urbanisation during late nineties, witnessed large-scale unrealistic, uncontrolled developmental activities in the neighborhood of lakes, which led to

(i) encroachment of lakes and storm water drains resulting in decline in ground water table, while increasing the instances of flooding;

(ii) dumping of solid waste (MSW), Construction debris, etc. in storm water drains, lake catchment and in lakes.;

(iii) sustained inflow of partially or untreated sewage, polluting existing surface and subsurface water resources;

(iv) reduced water holding capacity due to accumulation of silt; construction debris, etc.;

(v) topography alterations in the lake catchment; and

(vi) sustained inflow of untreated industrial effluents.

During the last four decades there has been 79% reduction in water bodies and the number of lakes in Bangalore is given in Figure 12. Loss of interconnectivity is evident in Figure 13 due to encroachments.

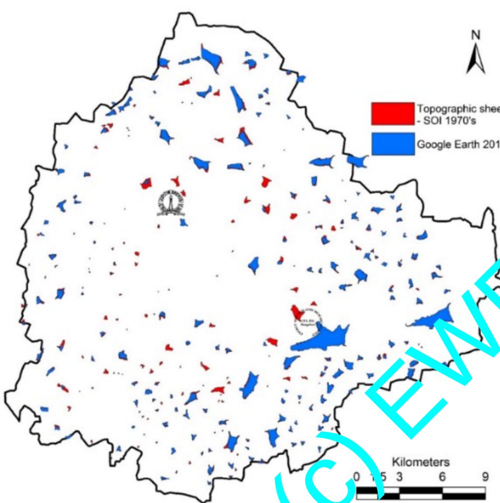


Figure 12: Status of Lake in Bangalore (Red colour indicate lost lakes between 1970's to 2016)

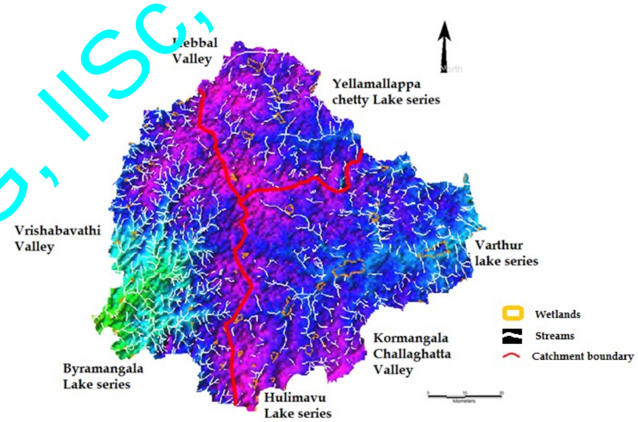


Figure 13: Loss of interconnectivity among lakes

2.0 BANGALORE: CITY OF LAKES

Most efficient way of rainwater harvesting is through lakes, which also help in mitigating floods, ground water recharge and sustain local livelihood (fish, fodder, etc.)

Bangalore (Figure 2.1) is located in the Deccan plateau, toward the south east of Karnataka state extending from 12°49’5”N to 13°8’32”N in latitude and 77°27’29” E to 77°47’2”E in longitude. Bangalore city is/was known with various names such as “GANDU BHOOMI” (land of heroes), “BENDAKAALURU” (land of boiled beans), “LAND OF LAKES” where a large number of lakes were constructed to store water, during the regime of Kings and British, along with it, numerous parks, gardens were created such as Lalbagh, Cubbon park etc. which gained the city with name “GARDEN CITY”. Taking the advantage of undulating terrain, earlier rulers had created inter connected water bodies (during 1800) to meet the drinking water and irrigation water requirement. There were 1452 water bodies in the current spatial extent (741 sq.km.) of Bangalore. Post-independence due to industrialization, growth in technology and science, the city acquired “Silicon Valley” status and provided job opportunities. However, during post independent era, with globalization the city lost its glory due to unplanned, unrealistic and irresponsible urbanisation.

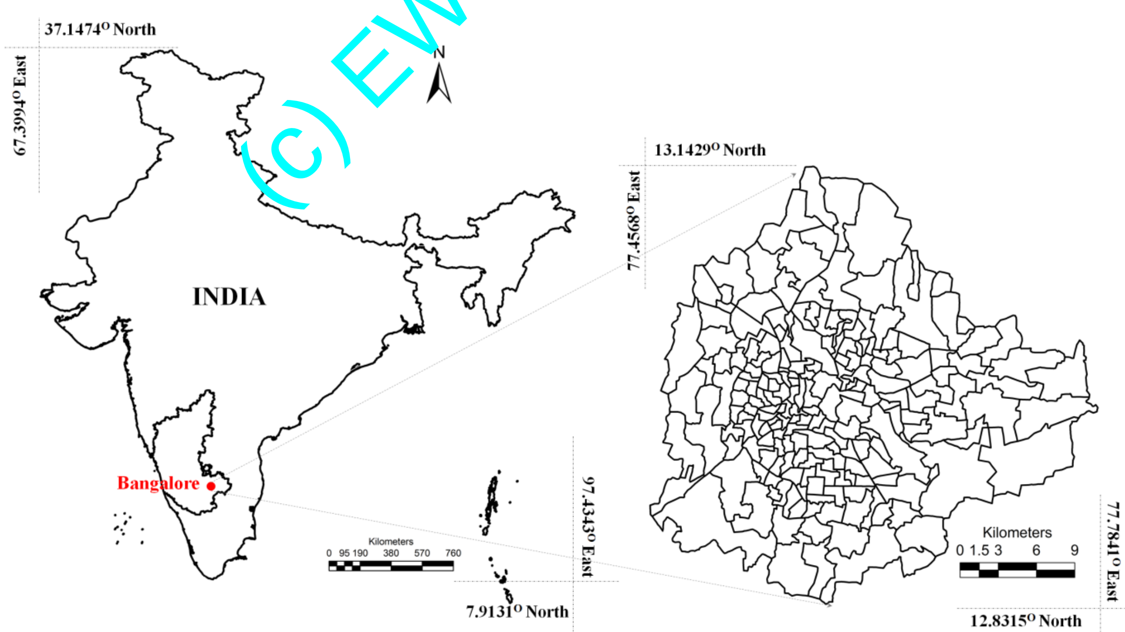


Figure 2.1: Bangalore (Bengaluru) City

Growth of Bangalore from *Pete*'s to Bruhat Bengaluru: Bangalore, the pride to India as the garden and cool city, is about 500 years old has grown from a small time settlement when Kempe-Gowda, the architect of Bengaluru, built a mud fort in 1537 and his son marked the city boundaries by erecting four watch towers. Within the fort the town was divided into *pete*'s (commercial localities) such as Chickpete, Dodpete, Balepete, Cottonpete and other areas earmarked for different trades and artisans. The town had two main streets, Chickpete Street ran east to west and Dodpete Street ran north to south, their intersection forming Dodpete Square, the heart of Bangalore. Chikkadeva Raya Wodeyar (1673 AD- 1704 AD) built an oval shaped fort south of the old mud fort. Later, Hyder Ali took over the throne until the British defeated him in 1790. During this period, the oval fort in the south was rebuilt with stone and palace was built within the fort, the town was about 5 kilometer's in circumference, with the fort at the south end, with well-planned streets and prosperous shops indicating a flourishing economy. A big market stretched from the north gate of the town to the oval fort, a predecessor of today's Avenue Road. Hyder Ali and Tippu Sultan also contributed towards the beautification of the city by building Lalbag Garden in 1760 AD, developed Bangalore into a commercial and military centre of strategic importance. The British after defeating Hyder Ali and Tippu Sultan, ceased Bangalore as strategic stronghold and built military base and cantonment in the city. Sooner Bangalore fort slowly passed into extinction, while the fort walls coming down in stages to make way for the expanding city. The Parade Ground, surrounded by a ride or mall called Rotten Row, was more or less the heart of Bangalore Cantonment. Around this, the Civil & Military Station (CMS) was developed. A civilian population of lower economic strata, attracted by the opportunities for employment and trade and offering subsidiary services to the military personnel, settled in a high density and congested locality. This area evolved into a general bazaar called Blackpally, today's Shivajinagar. During the British rule, several developments, led to the rapid growth of the city. The most important of these being the telegraph connections introduced to and from Bangalore to all the important cities of India in 1853 AD and the rail connection to Madras in 1864 AD. Hence, with city walls receding, giving way to an unprecedented growth with sprawl at ouskirts. By 1881 AD, Bangalore had two nuclei: one a high-density area around the fort and its market (K.R. Market area) in *pete* and the second Blackpally (Russel Market area) within the colonial city. Both of these comprised the inner city of Bangalore with Cubbon Park acting as a large green buffer. Several suburbs were built, by 1931 AD the CMS's population was 134,113 and that of Bangalore was 308,000. Post-

Independence the colonial cities were merged in 1949 since then Bangalore was retained the capital of Karnataka state. Bangalore continued to grow and several public sector industries were setup between 1940 and 1970 transforming the city to science and technology centre. By 1961, Bangalore had become the 6th largest city in India with a population of 1,207,000. Between 1971 and 1981, Bangalore's growth rate was 76%, the fastest in Asia. By 1988 the Electronic City had been developed and Bangalore emerged as India's software capital. Consequently the 1990's saw a construction boom fuelled by Bangalore's growing reputation as "India's silicon valley". Since the construction boom, many legal and illegal activities/developments has led to increase in land conversion from one form to constructed and paved surfaces violating the norms (CDP's). Table 2.1 lists chronologically the increase in city's spatial extent since 1700 (http://www.karnataka.com; *https://archive.org/details/**BangaloreGazetteer**1875*).

Table 2.1: Spatial increase of Bangalore city

Era	Year	Area in sq.km
Hyder Ali and Tippu Sultan	1700 - 1790	2
British	1800 - 1947	69
Mysore	1951	69
BDA	1963 - 1964	112
BDA	1969	134
BDA	1979	161
BDA	1995	226
BBMP	2006	696
BBMP	2011	741

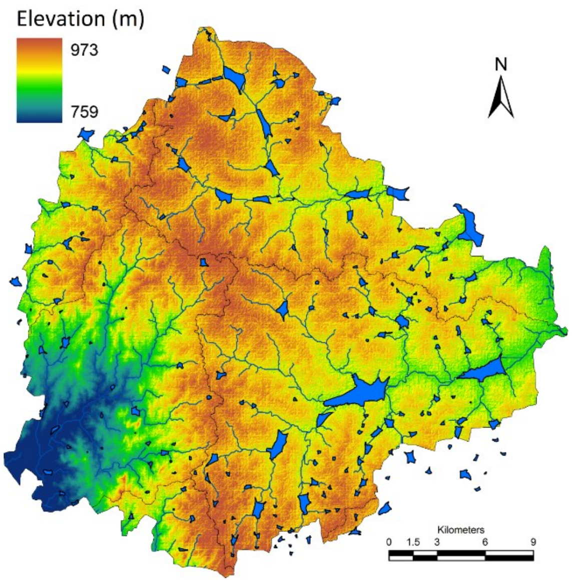
The decadal (during 2001 to 2011) increase in population for urban areas of India is 31.8% and in Karnataka is 31.5%, but Bangalore has a decadal increase of 44%, higher compared to that of the state and country. The decadal population (w.r.t BBMP limits) has increased from 5.8 Million (in 2001) to 8.4 Million (in 2011); the population density has increased from 7880 persons per square kilometer to over 11330 persons per square kilometer. Characterized by undulating topography with green cover and water bodies, the temperature varies from 22°C to 38°C during summer and 14°C to 27°C in winter. Bangalore receives an annual average rainfall of 800 mm. The undulating terrain (varying from about 700 m to about 962 m AMSL) in the region aided in the formation of interconnected lakes in the region.

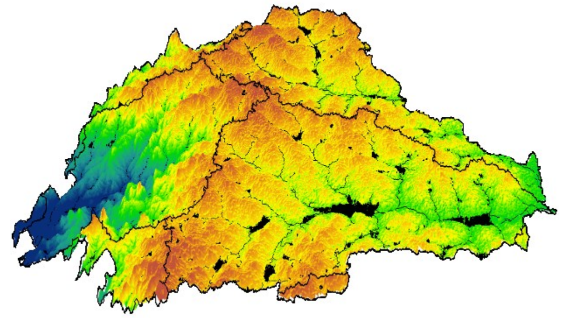
Geologically, the prevailing rocks are light to dark grey Biotite Granitic Gneiss and varies from place to place in texture, structure and appearance based on the fineness or coarseness of the grains, mode of disposition of dark minerals. The dark minerals are mostly biotite mica are generally arranged in parallel orientation, the light coloured are silicious minerals. The gneissic rocks have portions of uniform granitic texture; these gneissic masses have been styled as 'Peninsular Gneiss'. Schist's are not prominent, but isolated stringers of dark hornblend granulite are with light green pyroxene rocks. Other rocks include the dykes and dolerites. Kaolin is a good variety of clay, found in the silts of the lake (*http://www.geosocindia.org*).

Bangalore City was once aptly known as 'city of lakes' due to the presence of large number of lake (about 285 lakes). These lakes were all interconnected with canals / drains (*kaluveys*'s) to enable transferring excess water to the next lake. These lakes catered the basic needs such as maintaining and recharging ground water, drinking water to the surrounding people, habitat for fishes and other aquatic ecosystems, sustaining food (fish, etc.) and agricultural activities, etc.

The drainage network in Bangalore carries water to the River Cauvery through its tributaries Arkavathi, Pinakini or Pennar and Shimsha. The central, northern and eastern portion is undulating with the upland tracts occupied by scrubs, while the low lands occupied by series of tanks formed by embanking the streams along the valley. These valleys consists of varying size water bodies from small ponds to large lakes. The southern portion of the land consists of hills that are close together and are surrounded by thick jungles.

Bangalore being located on the ridge, forms three watersheds as precipitation flows as runoff in three directions along the valleys (Figure 2.2) - Koramangala Challaghatta Valley (K&C Valley), Hebbal Valley (H Valley) and the Vrishabhavati Valley (V Valley). Under the administrative boundary of Bruhat Bengaluru, K&C valley is the largest encompassing an area of 255 square kilometers, followed by Hebbal valley with an area of 207 square kilometers and Vrishabhavati valley with an area of 165 square kilometers. Both K&C valley and Hebbal valley joins at Nagondanahalli village (**BBMP Ward 94** – Hagadur) which further flow to Dakshina Pinakini River, where as Vrishabhavati valley joins Arkavathi river which is a tributary of river Cauvery.





3 Major valleys

- Hebbal Nagavara
- Koramangala Chellaghatta
- Vrishabhavathi

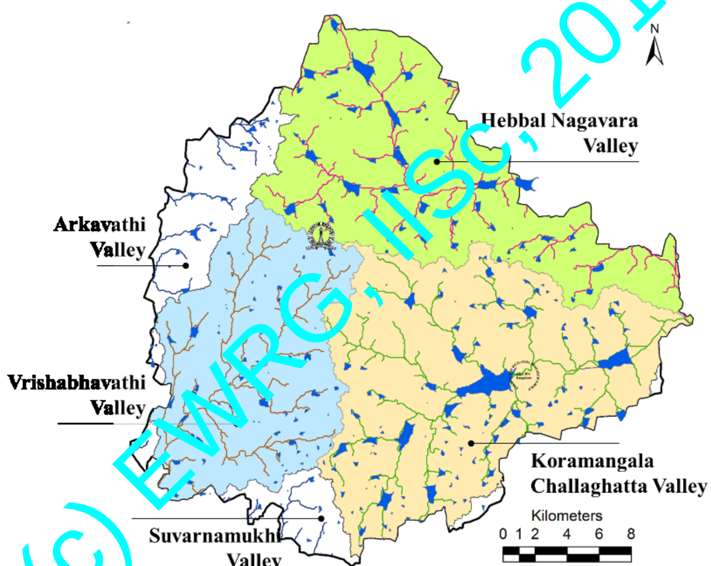


Figure 2.2: River and Lake network along the Major valleys

The number of lakes in Bangalore has reduced from nearly 285 (spatial extent of Bangalore: 161 sq.km. in early seventies) to 194 (spatial extent of Bangalore: 741 sq.km. in 2006). Unplanned rapid urbanisation during late nineties, witnessed large-scale unrealistic, uncontrolled developmental activities in the neighborhood of lakes, which led to

(vii) encroachment of lakes and storm water drains resulting in decline in ground water table, while increasing the instances of flooding;

(viii) decline in native species of biota in the lake ecosystem;

(ix) dumping of solid waste (MSW), Construction debris, etc. in storm water drains, lake catchment and in lakes.;

(x) sustained inflow of partially or untreated sewage, polluting existing surface and subsurface water resources;

(xi) reduced water holding capacity due to accumulation of silt; construction debris, etc.;

(xii) topography alterations in the lake catchment;

(xiii) sustained inflow of untreated industrial effluents; and

(xiv) pollution due to enhanced vehicular traffic.

Anthropogenic activities particularly, indiscriminate disposal of industrial effluents and sewage wastes, dumping of building debris have altered the physical, chemical as well as biological integrity of the ecosystem. This has resulted in the ecological degradation, which is evident from the current ecosystem valuation of wetlands. Valuation of goods and services from a relatively pristine wetland in Bangalore shows the value of Rs. 10,435/ha/day (much higher than global coastal wetland ecosystems with a total annual of US$ 14,785/ha), while the polluted wetland shows the value of Rs.20/ha/day (Ramachandra et al., 2005) and sewage fed Varthur wetland has a value of Rs.119/ha/day (Ramachandra et al., 2011). The pollutants and subsequent contamination of the wetland has telling effects such as disappearance of native species, dominance of invasive exotic species (such as African catfish, water hyacinth, etc.), in addition to profuse breeding of disease.

2.1 RAINFALL IN BANGALORE

Rainfall or precipitation data was collected from 18 monitoring stations (Figure 2.3) maintained by Indian Meteorological Department (IMD) and Directorate of Economics and Statistics – Karnataka between 1901 to 2015. 115 years average rainfall data was considered to understand the rainfall dynamics – spatio temporal variability, etc. in Greater Bangalore (Figure 2.4). Spatial Analysis of rainfall indicates that the western portion of Bangalore receives higher rainfall than the east. Monthly analysis (Figure 2.3, Figure 2.4) of rainfall indicated that rainfall in Bangalore is spread across 7 months i.e., 86.9% of rainfall occurs between the months of May to November, September being the highest with average rainfall of 156 mm (Figure 2.5).

Annual rainfall pattern (Figure 2.6) indicates higher variability in rainfall with respect to mean. The trend line and the moving averages indicate increasing rainfall

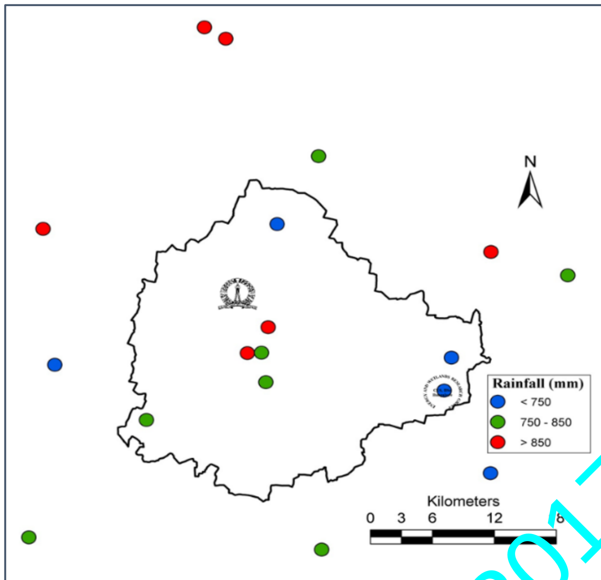


Figure 2.3: Rain gauge stations

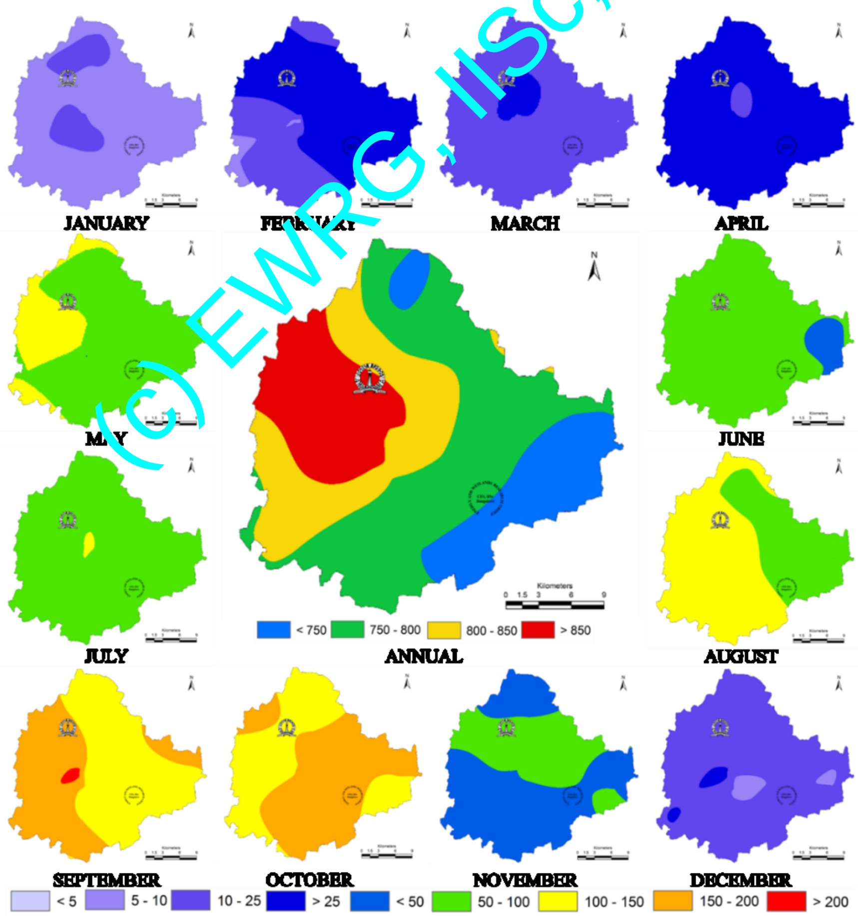


Figure 2.4: Spatial rainfall distribution pattern (all units in mm)

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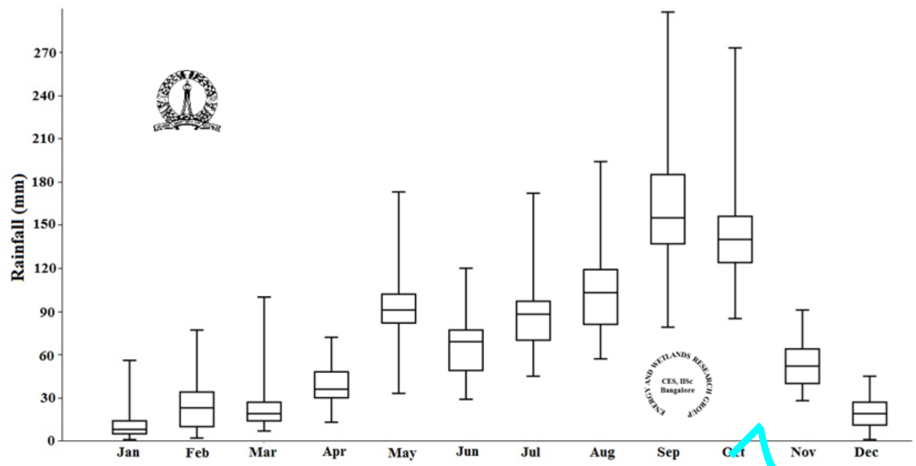

Figure 2.5: Monthly rainfall variations

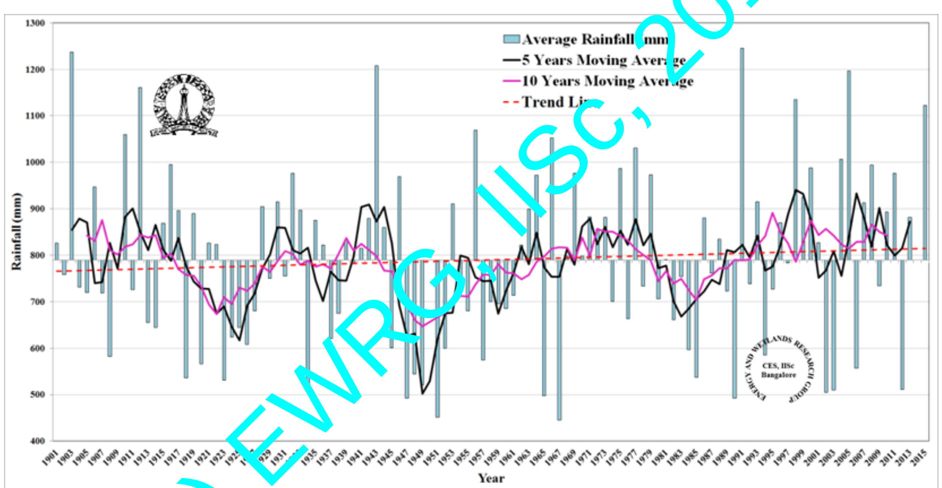

Figure 2.6: Annual rainfall variations (hyetograph)

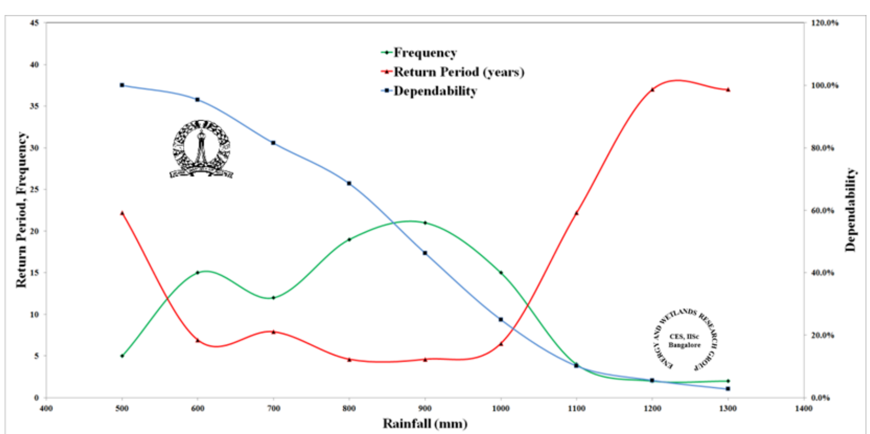

Figure 2.7: Rainfall characteristics - frequency, dependability (%) and return period (years)

Statistical analysis (Figure 2.7, Table 2.1) of annual rainfall indicates that average annual rainfall in Bangalore is 787 mm with 75% dependability and return period of 5 years. The coefficient of variation is 0.23 which indicates that there would be 23% variability in rainfall between consecutive years (http://dimtecrisk.ufs.ac.za/nc/precipitation.html). Rainfall distribution as per the IMD classification (http://www.imd.gov.in) of rainfall conditions nearly 67.7% of the time at least normal rainfall can be observed in Bangalore, 20.7% drought and 11.7% deficient rainfall conditions. The return period of normal rainfall is 3.5 years.

Table 2.1: Rainfall characteristics

Rainfall (mm)	**Frequency**	**Probability of Occurrence**	**Dependability**	**Return Period (years)**
500	5	0.05	100.0%	22
600	15	0.14	95.4%	7
700	12	0.13	81.5%	8
800	19	0.22	68.5%	5
900	21	0.22	46.3%	5
1000	15	0.15	25.0%	7
1100	4	0.05	10.2%	22
1200	2	0.03	5.6%	37
1300	2	0.03	2.8%	37
Minimum	445 mm	Maximum	1245 mm	
Mean	787 mm	Median	784 mm	
Standard Deviation	±184 mm	Coefficient of Variation	**0.23**	
***Indian Meteorological Department** – Rainfall distribution all India scenario*				
Rainfall Distribution	***Condition***	***Rainfall***	***Probability of Occurrence***	***Return Period (Year)***
Excess	*> 10% Average*	*> 866 mm*	*0.369*	*2.7*
Normal	*± 10% Average*	*709 – 866 mm*	*0.288*	*3.5*
Deficient	*10% > Average< 20%*	*630 – 709 mm*	*0.117*	*8.5*
Drought	*20% > Average< 40%*	*472 – 630 mm*	*0.207*	*4.8*
Severe Drought	*> 60% Average*	*< 472 mm*	*0.018*	*55.5*

2.2 WATER YIELD

Runoff yield in Bangalore is calculated spatially based on the empirical equation (eq 1) using GIS

$$Q = C*A*P/1000 \qquad \ldots\ldots\ldots 1$$

(Raghunath, 1985; Subramanya 2005; Ramachandra et al., 2013, Ramachandra et al 2014)

Where, Q = runoff in cubic meters; C = runoff coefficient (depends on land use of each pixel); C = 0.85 – 0.95 for paved surfaces (Built-up); C = 0.40 – 0.60 for open/agriculture and horticulture; A = area (pixel or catchment) in square meters; P = precipitation as mm

Runoff (mm/year) is depicted in figure 2.8 and higher surface runoff were observed in the localities with higher paved surfaces. Water retaining capacity in the catchment is higher dominated by vegetation cover and water bodies, and with this, lower overland flow or surface run-off were observed during monsoon.

Catchment wise water yield analysis indicates that about 49.5% (7.32 TMC) in the Vrishabhavathi valley (including Arkavathi and Suvarnamukhi), followed by 35.2% (5.2 TMC) in Koramangala Challaghatta valley and 15.3% (4.2 TMC) in Hebbal valley and the total annual water yield is about **14.80 TMC**.

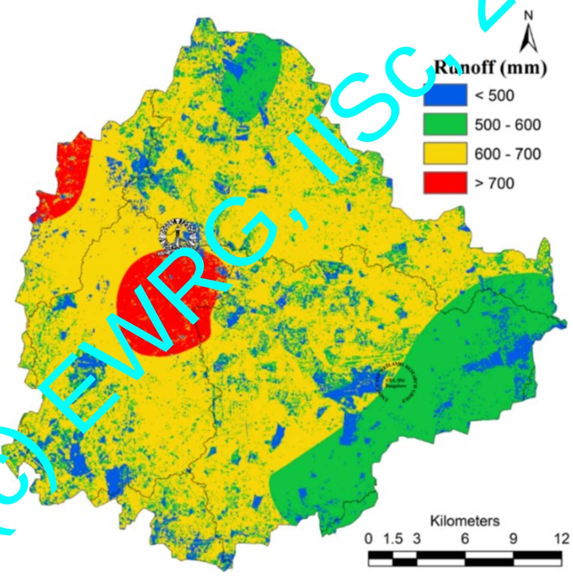

Figure 2.8: Runoff (mm/year) in Bangalore

2.3 STATUS OF LAKES – SCOPE FOR HARVESTING RAINWATER

The number of lakes in Bangalore has reduced from nearly 285 (1970's; spatial extent of Bangalore is 161 sq.km) to 194 (2016; spatial extent is 741 sq.km). During the last four decades there has been 79% reduction in water bodies and the number of lakes in Bangalore is given in Figure 2.9.

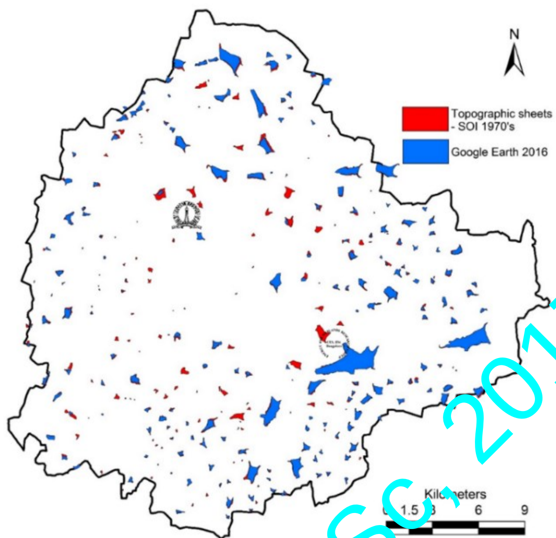

Figure 2.9: Status of Lake in Bangalore
(Red colour indicate lost lakes between 1970's to 2016)

During 1800, there were 1452 water bodies with the storage capacity of 35 TMC (in the current spatial extent of 741 sq.km.). The current capacity of lakes (193 lakes) is about 5 TMC and due to siltation, the current storage capacity of the lakes is just about 1.2 TMC, i.e., nearly 387 hectares of water bodies lost apart from reduction in the storage capacity by 60%. Bangalore being located on the ridges, forms three watersheds – Koramangala Challagatta valley, Vrishbhavathi valley and Hebbal Nagavara valley. Earlier rulers of the region, created interconnected lake systems taking advantage of undulating terrain. Number of lakes in Koramangala Challaghatta valley is about 81, followed by the Vrishabhavathi valley (56) and the Hebbal Nagavara valley (46). In order to enhance the water retaining capability in the catchment, it is essential to harvest rain water. Lakes are the optimal means of rainwater harvesting at community level. This entails

(i) Reestablishing interconnectivity among lakes (needs to remove all encroachments without any consideration, as the water security of a region is vital than the vested interests, who have unauthorisedly occupied without respecting future generation's food and water security. This would also reduce the frequency of floods and consequent damage to life and property,

(ii) removal of all encroachments of lakes and lake bed,

(iii) rejuvenation and regular maintenance of water bodies - this involves desilting of lakes to (a) enhance the storage capacity to retain rainwater, (b) increase the recharge potential – will improve groundwater table, (c) ensure recharging without any contamination,

(iv) allowing only treated sewage (removal of chemical and biological contaminants) through adoption of integrated wetlands ecosystem (Jakkur lake model),

(v) creation of wetlands with native vegetation and regular harvesting of macrophytes; food and fodder, which supports local people's livelihood, and

(vi) maintaining at least 33% green cover with native vegetation (grass, trees, shrubs) in the catchment and maintaining riparian vegetation in the buffer region. This would help infiltration of water and retain this water.

Sufficient water is available to meet everyone's requirement (Figure 2.10: Optimal water management through 5R's): (i) water harvesting is undertaken through surface water bodies (14.8 TMC); this requires rejuvenation of lakes and reestablishment of interconnectivity; harvesting of rainwater (at decentralized levels), treatment; (ii) treatment and reuse of sewage (16.04 TMC). However, the success of sustainable water path depends on the political will, bureaucracy shedding their colonial style of functioning and more importantly citizen's assertion for their right for equal quantity and quality of water.

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

(ii) Sewage treatment with complete removal of nutrients and chemical contaminants can be achieved by adopting decentralized treatment plants similar to the success model (secondary treatment plant integrated with constructed wetlands and algae pond) at

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

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

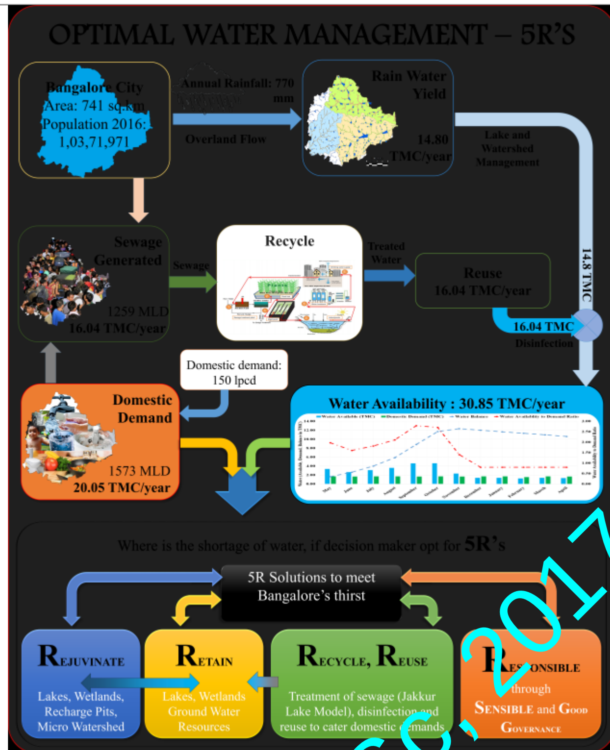

Figure 2.10: Sustenance of Water through Optimal water management with 5R's

3.0 REMEDIAL MEASURES –

INTEGRATED WETLAND SYSTEM-JAKKUR MODEL

Integrated wetlands system consists of sewage treatment plant, constructed wetlands (with location specific macrophytes) and algal pond integrated with a lake (figure 3.1). Constructed wetland aid in water purification (nutrient, heavy metal and xenobiotics removal) and flood control through physical, chemical, and biological processes. When sewage is released into an environment containing macrophytes and algae a series of actions takes place. Through contact with biofilms, plant roots and rhizomes processes like nitrification, ammonification and plant uptake will decrease the nutrient level (nitrate and phosphates) in wastewater. Algae based lagoons treat wastewater by natural oxidative processes. Various zones in lagoons function equivalent to cascaded anaerobic lagoon, facultative aerated lagoons followed by maturation ponds. Microbes aid in the removal of nutrients and are influenced by wind, sunlight and other factors (Ramachandra et al., 2014). This model is working satisfactorily at Jakkur. The sewage treatment plant removes contaminants (evident from lower COD and BOD) and mineralises organic nutrients (NO_3-N, PO_4^{3-} P to inorganic constituents. Integration of the conventional treatment system with wetlands [consisting of reed bed (with typha etc.) and algal pond] would help in the complete removal of nutrients in the cost effective way. Four to five days of residence time in the lake helps in the removal of pathogen apart from nutrients. However, this requires regular maintenance through harvesting macrophytes and algae (from algal ponds). Harvested algae would have energy value, which could be used for biofuel production. The combined activity of algae and macrophytes helps in the removal of ~45% COD, ~66 % BOD, ~33 % NO_3-N and ~40 % PO_4^{3-}P. Jakkur lake acts as the final level of treatment that removes ~32 % COD, ~23% BOD, ~ 0.3 % NO_3-N and ~34 % PO_4^{3-}P. The lake water with a nominal effort of sunlight exposure and filtration would provide potable water. Replication of this model in rapidly urbanizing landscapes (such as Bangalore, Delhi, etc.) would help in meeting the water demand and also mitigating water scarcity through recharging of groundwater sources with remediation.

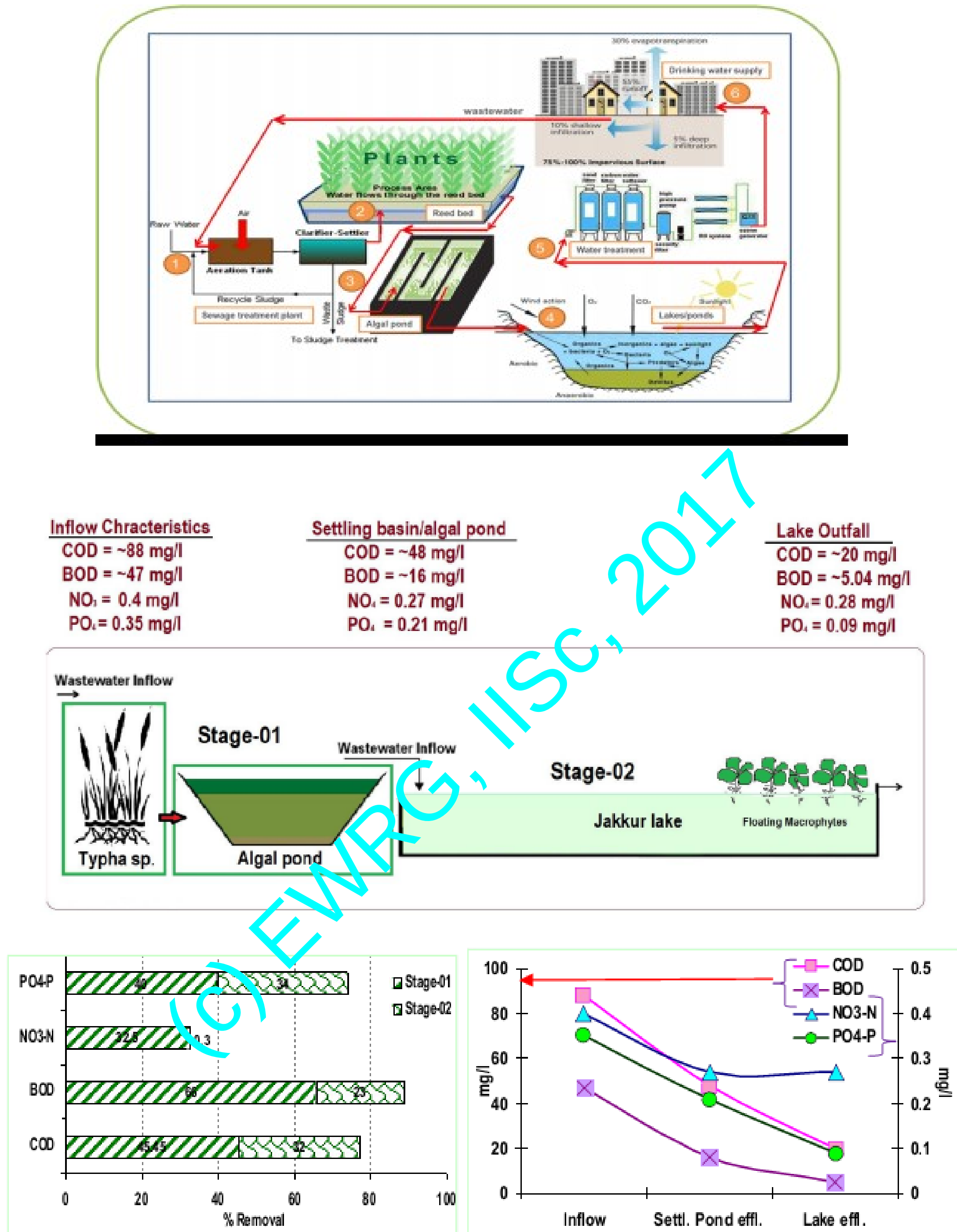

Figure 3.1: Jakkur model

PROPOSED CONSTRUCTED WETLAND MODEL AT BELLANDUR

Bellandur lake, located in south eastern part of Bangalore city along the Koramangala Challaghatta valley, that joins Dakshina Pinakini river flowing to the Bay of Bengal. Bellandur lake has a catchment area about 279 sq.km, while the lake being the largest in Bangalore has an area about 366.9 hectares. The lake has three major inlets from i) Agaram ii) ST bed iii) HAL, sides respectively receiving at least 400 MLD water. Inlet from Agarma side contributes nearly 128 MLD of sewage and inlet from ST bed side of the lake contributes to 102 MLD of sewage (Figure. 3.2), which can be biologically treated at the inlets of the lake. RMP of 2015 indicates a treatment facility at the Agaram Bellandur side of the lake, whereas the same area is now being used for SEZ (Figure 3.3). The under construction SEZ has encroached the lake bed, violated the norms of minimum buffer zones with respect to the drainage networks, altered the drainage lands (encroached kharab lands). As per NGT, the encroached lake bed has to be recovered by the government. The SEZ is being built in the valley zone (contrary to RMP 2015) is to be shifted elsewhere and the recovered wetlands area will aid in creating integrated water treatment systems (fig 3.3.1).

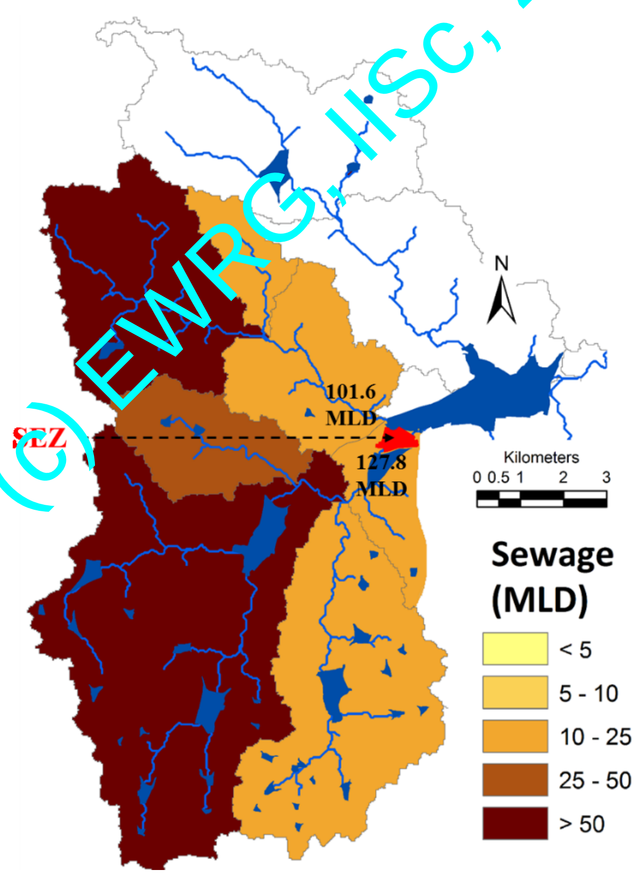

Figure 3.2: Sewage generated at Bellandur Inlets

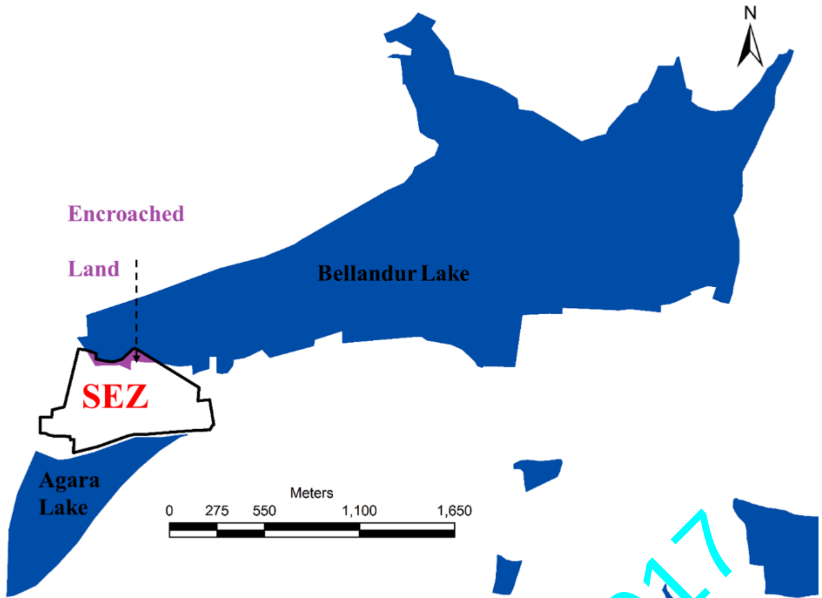

Figure 3.3: SEZ, Bellandur and Agara lakes.

In order to treat the water from Agaram and ST bed side inlet of the lakes, biological treatment methods can be adopted and is as described in Figure 3.4.

Figure 3.3.1: Proposed Sewage Treatment with wetlands

Along the Agaram side of the lake, about 35 MLD of 128 MLD is planned to be treated upstream of Agaram lake by the government agency, and remaining 93 MLD can be treated by planning SBR and constructed wetland in the current said SEZ area (Site A) and is as described in Table 1 and Figure 3.4. SBR treatment on an average requires nearly ~0.045 hectares of land for treating 1 MLD of water (Ramachandra, et.at., 2017 – ETR 116), based on this, to treat about 95 MLD,

~4.3 hectares (~10.5 – 12 acres) of land is required for having SBR system. The sewage at Bellandur has a BOD ranging between 120 – 410 mg/l, COD 190 -960 mg/l, Total Suspended Solids 90 – 390 mg/l, though SBR treatment, BOD can be reduced to less than 10 mg/l, COD < 50mg/l, TSS < 10. (Ramachandra et al, 2017 – ETR 116). The constructed wetlands in the downstream of the SBR has the ability to take up the nutrients in the systems, the advantage of constructed wetlands area they are efficient, cost effective and requires a very low maintenance. Frequent harvesting of the macrophytes is necessary to maintain the constructed wetlands. To treat 95 MLD of water from the SBR outlet, an area of nearly 73.8 acres (30 hectares) is necessary. The area of the wetlands is estimated using the equation

$$A = Q_d \frac{\ln(C_i) - \ln(C_e)}{K_{BOD}}$$

Where A is the area of the constructed wetland in square meters, Qd is the average inflow as cubic meters per day. C_i and C_e are the influent and effluent BOD as milligram per litre, K_{BOD} is a factor (0.1) Table 3.1 indicates various parameters and area requirement under the wetlands.

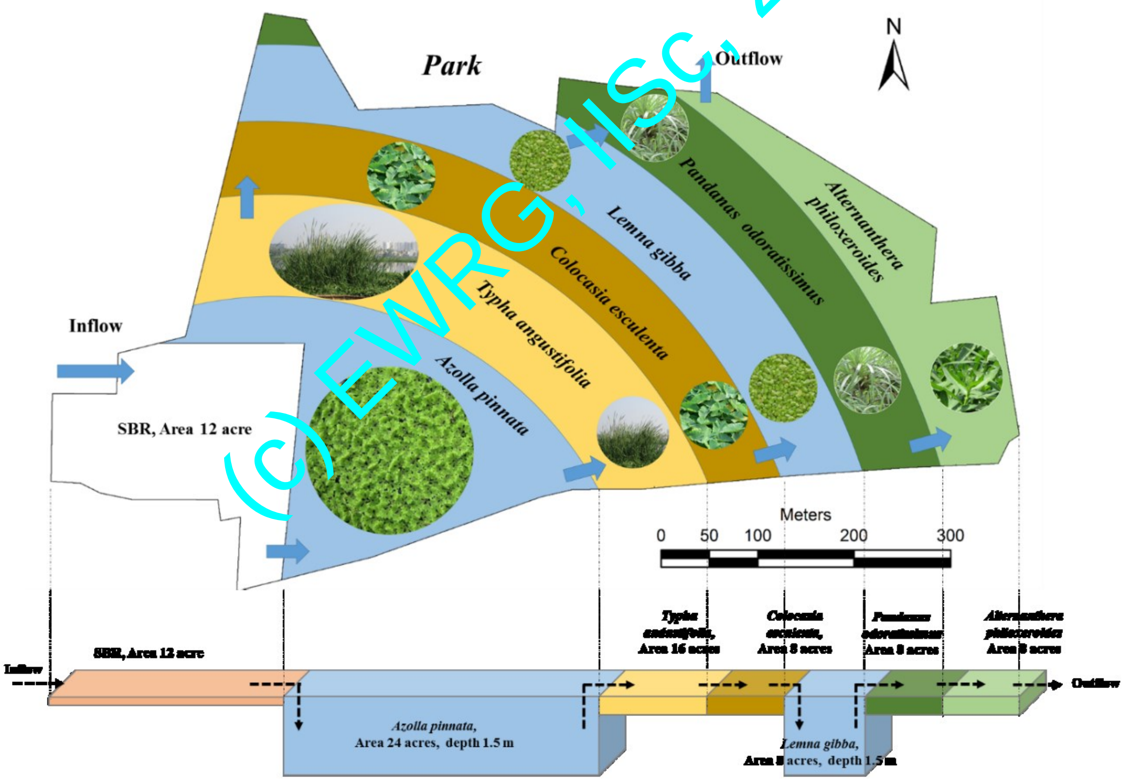

Figure 3.4: Conceptual treatment model at Bellandur inlet: 95 MLD (A)

Various macrophytes that can be grown in the wetlands are depicted in sequence in Figure 3.4, along with the depth requirements.

Table 3.1: Estimation of Wetland Area requirements

Slno	Description	Units of measurement	Quantity
1	Q - Discharge	MLD	95
2		cum/day	95000
3	SBR area requirement	Ha/MLD	0.045
4		Ha	4.3
5		Acre	**10.6**
6	Sewage treatment plant area	Acre	**12**
	WETLAND		
7	Ci - input BOD	mg/ltr	10
8	Co - output BOD	mg/ltr	7
9	K_{BOD} – BOD factor		0.1
10	Area	Ha	30
11		Acre	**73.8**
	TOTAL AREA		
12	Required area	Acre	**85.8**
13	Available SEZ area	Acre	**85.8**

Total area about 85.8 acres is necessary for treating 95 MLD of 128 MLD of sewage water generated at Agaram side of the catchment. The treated water can be directly let to the lake downstream of site C.

A bund like structure could be constructed to divert 95 MLD of water in to the SBR-wetland treatment system. The excess water at inlet of 95 MLD treatment plant can be partially treated at the channels joining Agaram and Y junction of Bellandur (Figure 3.5).

Figure 3.5: Treatment model along channel connecting Agaram Bellandur Lakes (B)

About 102 MLD of untreated sewage water comes into the Bellandur lake from ST lake bed side catchment. The area of the wetland is nearly 105 acres in the Bellandur lake upstream, and the depth varies between 0.5 m to about 1.5 m with an approximate average depth of 0.8 m. with the existing area and depth, volume of water that can be stored in the wet land is nearly 340 Million Liters. With respect to the discharge of Sewage at 102 MLD, residence time of 3.3days is available at the wetland portion of the lake. The existing macrophytes pockets in the wetlands is as depicted in Figure 3.6a (white coloured polygons). These macrophyte clusters needs to be retained in the system in order to treat the incoming sewage. The flow of sewage can be regulated (Figure 3.6a – yellow arrows) through planned channels without disturbing the existing clusters of macrophyte cover, and providing more residence time, and contact with the macrophytes. A broad crested weir at the outlet of the planned wetland would also help in increasing the residence time and improving aeration at the fall. Figure 3.6b provides the suggested wetland (with meandering drains – allowing the gravity flow) with tree (native species) barricades.

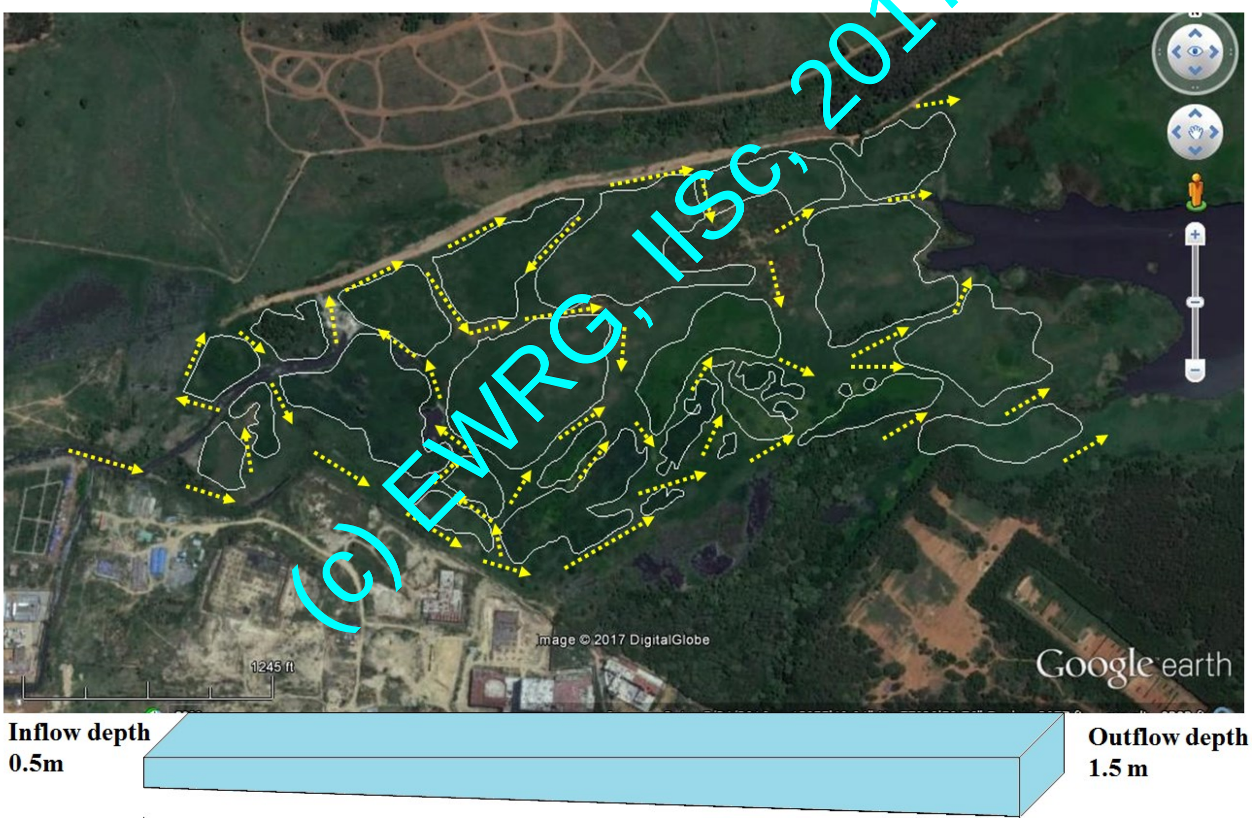

Figure 3.6a: Treatment model at Bellandur Lake (C)

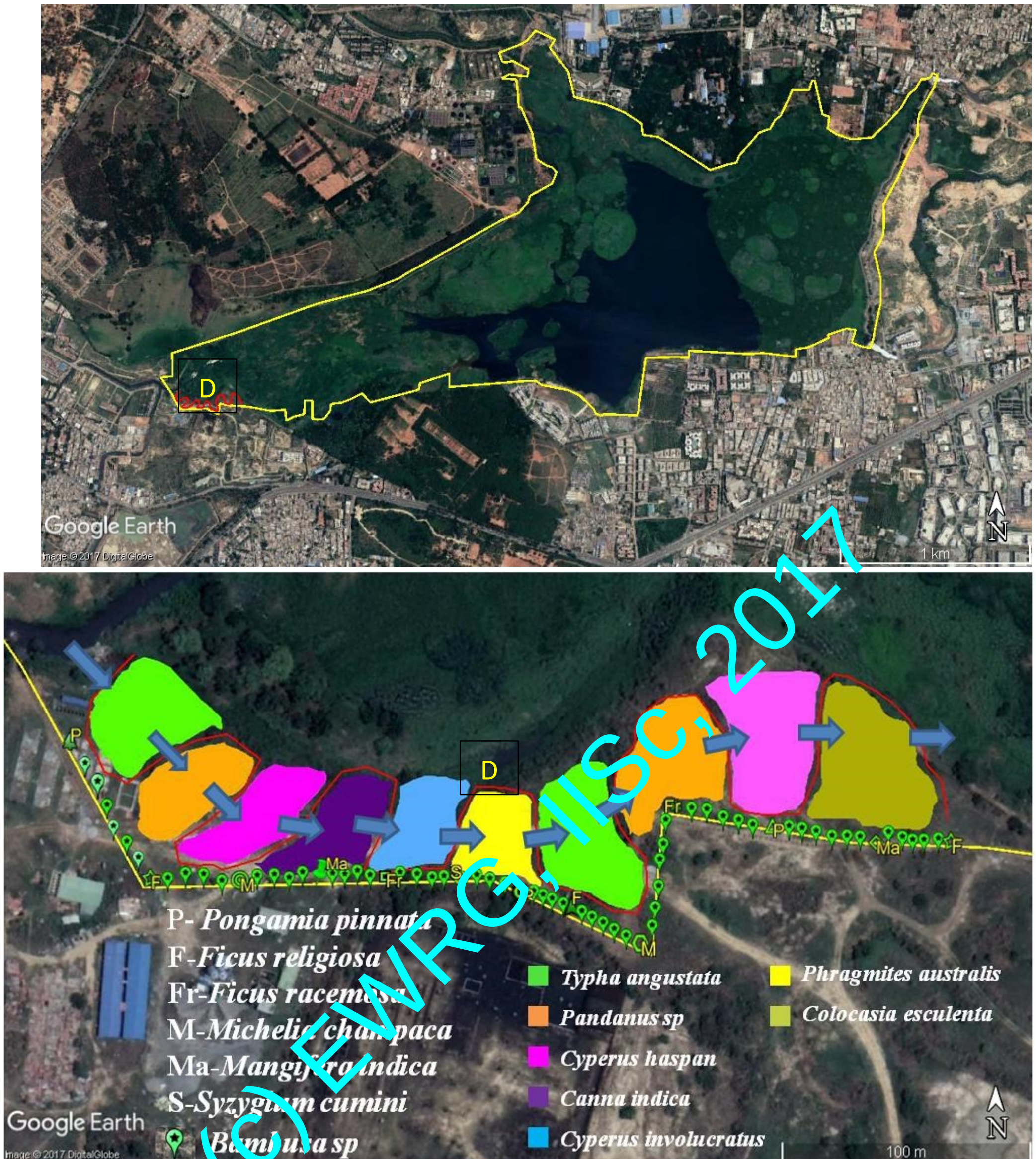

Figure 3.6b: Treatment model at Bellandur Lake (D) - with meandering drains, wetland plants at the meander and tree (native species) barricades

4.0 STOP UNPLANNED URBNAISATION IN BANGALORE: NON-RESILIENT AND UNLIVABLE WITH UNABATED SENSELESS CONCRETISATION

1028% INCREASE IN PAVED SURFACE DURING 1973 TO 2017 (FIGURE 4.1)

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

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

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

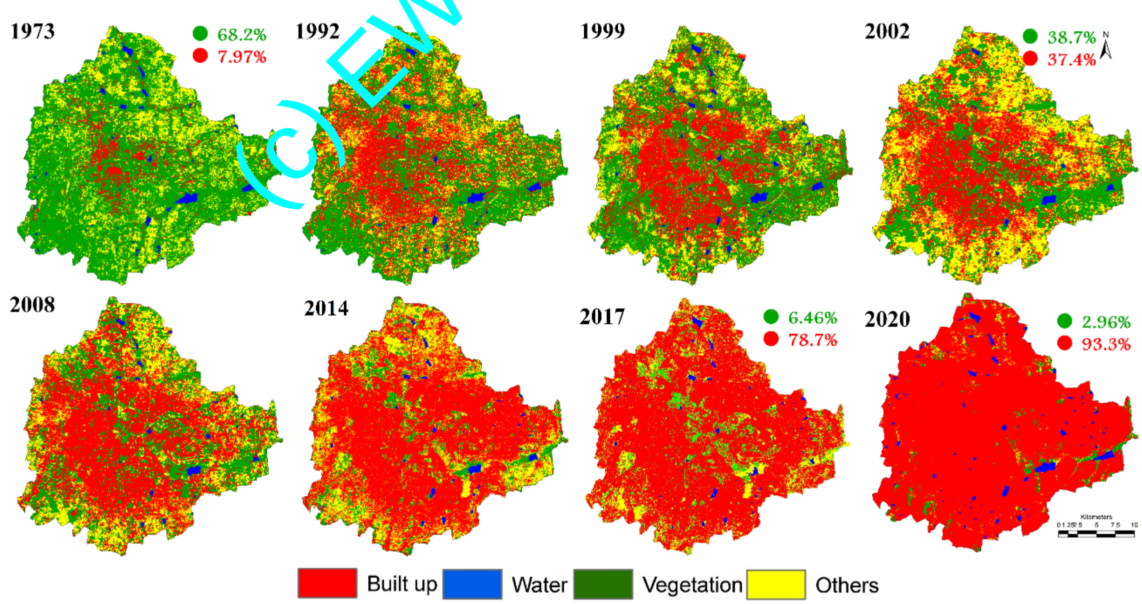

Figure 4.1: Land use dynamics in Bengaluru

Table 4.1: Land use dynamics of Bangalore

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

Urbanisation and loss of natural resources (wetlands and green spaces): Urbanisation during 1973 to 2017 (1028% concretization or increase of paved surface) has telling influence on the natural resources such as decline in green spaces (88% decline in vegetation), wetlands (79% decline), higher air pollutants and sharp decline in groundwater table. Figure 4.1 depicts the unrealistic urban growth during the last two decades. Quantification of number of trees in the region using remote sensing data with field census reveals that there are only 1.5 million trees to support Bangalore's population of 9.5 million, indicating one tree for every seven persons in the city. This is insufficient even to sequester respiratory carbon (ranges from 540-900 g per person per day). Geo-visualisation of likely land uses in 2020 through multi-criteria decision making techniques (Fuzzy-AHP: Analytical Hierarchal Process) reveals calamitous picture of 93% (Table 4.1) of Bangalore landscape filled with paved surfaces (urban cover) and drastic reduction in open spaces and green cover. This would make the region GHG rich, water scarce, non-resilient and unlivable, depriving the city dwellers of clean air, water and environment.

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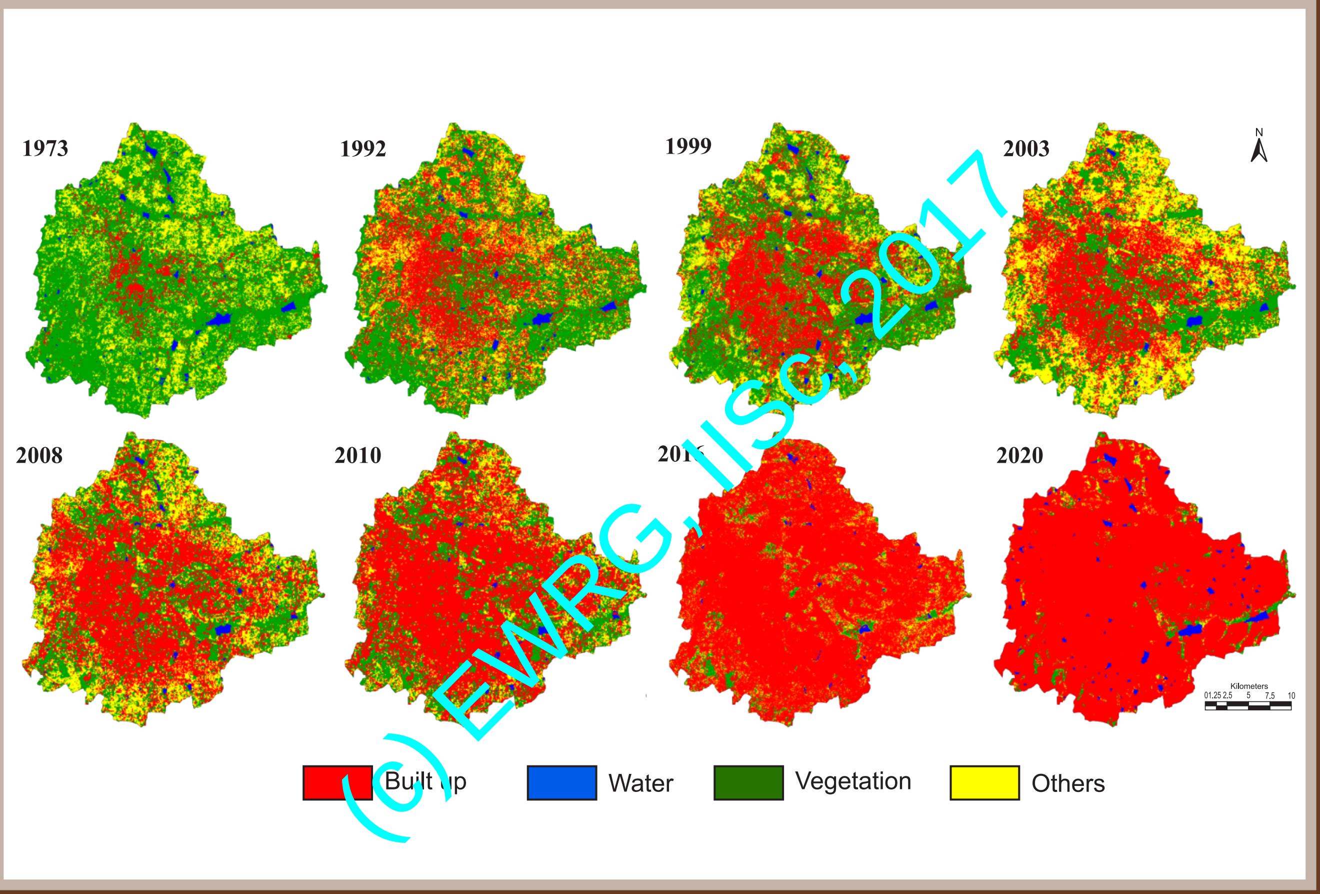

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GUEST EDITORIAL

Bengaluru's reality: towards unlivable status with unplanned urban trajectory

The origin of cities can be traced back to the river valley civilizations of Mesopotamia, Egypt, Indus Valley and China. Initially these settlements were largely dependent upon agriculture; however, with the growth in population the city size increased and economic activity transformed to trading (Ramachandra, T. V. *et al.*, *TEMA J. Land Use, Mobility Environ.*, 2014, **7**(1), 83–100). The process of urbanization gained impetus with the Industrial Revolution 200 years ago and accelerated in the 1990s with globalization and consequent relaxation in market economy (Ramachandra, T. V. *et al.*, *Int. J. Appl. Earth Obs. Geoinf.*, 2012, **18**, 329–343).

Urbanization refers to the growth of towns and cities due to large proportion of the population living in urban areas and its suburbs at the expense of rural areas (*op. cit*). In most of the countries, the total population living in urban regions has extensively accelerated since the Second World War. Rapid urbanization is evident from the increase in global urban population from 13% (220 million) in 1900 to 49% (3.2 billion) in 2005, and is expected to increase to 60% (4.9 billion) by 2030 (*op. cit*). Current global population is 7.4 billion and urban population has been increasing three times faster than the rural population, mainly due to migration in most parts of the world. People migrate to urban areas with the hope of better living, considering relatively better infrastructural facilities (education, recreation, health centres, banking, transport and communication), and higher per capita income. Unplanned urbanization leads to the large-scale land-use changes affecting the sustenance of local natural resources. Rapid unplanned urbanization in most cities in India has led to serious problems in urban areas due to higher pollution (Ramachandra, T. V. *et al.*, *Renew. Sustain. Energy Rev.*, 2015, **44**, 473–495) (air, water, land, noise), inequitable distribution of natural resources, traffic congestion, spread of slums, unemployment, increased reliance on fossil fuels, and uncontrolled outgrowth or sprawl in the periphery. Understanding spatial patterns of urban growth and visualization is imperative for sustainable management of natural resources and to mitigate changes in climate. This would help the city planners to mitigate the problems associated with the increased urban area and population, and ultimately build sustainable cities.

Bengaluru is experiencing unprecedented rapid urbanization and sprawl in recent times due to unrealistic concentrated developmental activities with impetus on industrialization for the economic development of the region. This has led to large-scale land-cover changes with serious environmental degradation, posing serious challenges to the decision makers in the city planning and management process, such as climate change, enhanced emissions of greenhouse gases (GHGs), lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water and sanitation) in many localities. Apart from these, major implications of urbanization are the following.

Urbanization and loss of natural resources (wetlands and green spaces): Urbanization during 1973–2016 (1005% concretization or increase of paved surface) has had a telling influence on the natural resources, such as decline in green spaces (88% decline in vegetation), wetlands (79% decline), higher air pollutants and sharp decline in groundwater table. Figure (see Cover Page of this issue) depicts the unrealistic urban growth during the last four decades. Quantification of the number of trees in the region using remote sensing data with field census reveals that there are only 1.5 million trees to support Bengaluru's population of 9.5 million, indicating one tree for every seven persons in the city (Ramachandra, T. V. *et al.*, *ENVIS Technical Report 75*, IISc, 2014, p. 75). This is insufficient even to sequester respiratory carbon (ranges from 540 to 900 g per person per day). Geovisualization of likely land uses in 2020 through multicriteria decision-making techniques (Fuzzy-AHP) reveals a calamitous picture of 93% of Bengaluru's landscape being filled with paved surfaces (urban cover), and drastic reduction in open spaces and green cover. This would make the region GHG-rich, water-scarce, non-resilient and unlivable, depriving the city-dwellers of clean air, water and environment.

Field studies during 2015–16 of 105 lakes revealed that 98% of the lakes have been encroached for illegal buildings (high-rise apartments, commercial buildings, slums, etc.) and 90% of the lakes are sewage-fed. Also, lake catchments are being used as dumping yards for either municipal solid waste or building debris. Indiscriminate disposal of solid and liquid waste (rich in organic nutrient) has enriched nitrate levels in the surrounding groundwater resources, threatening the health of residents (such as kidney failure, cancer, etc.). Washing, household activities, vegetable cultivation and even fishing was observed in few contaminated lakes. Unauthorized construction in valley zones, lakebeds and storm water drains highlight the apathy of decision-makers, while mirroring weak and fragmented governance. This is correlated with the increase in unauthorized constructions violating town planning norms (city development plan), which has severely affected open spaces and water bodies in particular.

Large-scale fish mortality in recent months further highlights the level of contamination and irresponsible management of water bodies. Sustained inflow of untreated sewage has increased the organic content beyond the threshold of remediation capability of the respective water bodies. Increasing temperatures (34–35°C) with the onset of summer, enhanced the biological activities (evident from higher ammonia and biochemical oxygen demand) that lowered dissolved oxygen levels leading to fish death due to asphyxiation.

Floods: Conversion of wetlands to residential and commercial layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetation cover, and reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000.

Decline in groundwater table: The water table has declined to 300 m from 28 m, and 400–500 m in intensely urbanized area such as Whitefield, over a period of 20 years.

Heat island: Surface and atmospheric temperatures have increased due to the loss of natural cover (trees and water bodies) with an increase in artificial materials having high heat conductivities. Temperature has increased by ~2–2.5°C during the past three decades, highlights the implications of explosive urban growth on local climate, necessitating appropriate mitigation strategies.

Increased carbon footprint: Drastic increase in electricity consumption has been observed in certain corporation wards due to adoption of inappropriate building architecture in tropical climate. Per capita electricity consumption in the zones dominated by high-rise building with glass facades ranges from 14,000 to 17,000 units (kWh) per year compared to zones with eco-friendly buildings (1300–1500 units/person/yr)[3].

Emissions from the transport sector is about 43.83% (in Greater Bengaluru) on account of large-scale usage of private vehicles, and mobility related to job accounts for 60% of total emissions due to lack of appropriate public transport system and haphazard growth with unplanned urbanization. Majority commute longer distances with private vehicles, thus contributing to emissions. Apart from these, mismanagement of solid and liquid waste has aggravated the situation with emission of GHGs (methane, CO_2, etc.)

Unplanned cities thus not only contribute to global climate change by emitting the majority of anthropogenic GHGs but are also particularly vulnerable to the effects of climate change and extreme weather. This emphasizes the need to improve urban sustainability through innovations while addressing technical, ecological, economic, behavioural and political challenges to create cities that are low-carbon, resilient and livable.

The 'Smart Cities Mission' launched by the Government of India recently (June 2015) envisages developing physical, institutional and social infrastructure in select cities with central assistance targeted at improving the quality of life as well as economic visibility of the respective urban centres (http://smartcities.gov.in/ (last accessed on 20 May 2016)). Four strategic components are: (i) green field development through smart townships by adopting holistic land management; (ii) pan-city development through adoption of smart applications like transport, reuse and recycle of wastewater, smart metering, recovering energy from solid waste, etc. (iii) retrofitting to make existing areas more efficient and livable by reducing GHG footprint, improving power and treated water supply, improving communication and infrastructure connectivity and security, and (iv) re-development of existing built-up area, creation of new layouts through mixed land use, adoption of appropriate floor area index considering the level of existing, and scope for improvement of infrastructure and basic amenities, which helps in keeping the city's growth within the region's carrying capacity, and also urban infrastructure becomes inclusive. This entails efficient decision-making through (i) integrated land-use planning according to the city's requirements; (ii) enhancement of the functional capacity through user-friendly and economic public transport support; (iii) development of mass rapid-transport systems, and (iv) effective use of ICTs as enabling technologies. These measures have to be implemented quickly as most cities are in a civic and financial disarray because of senseless unplanned rapid urbanization.

Environmentally sound urban centres with essential basic amenities and advanced infrastructure (such as sensors, electronic devices and networks) would stimulate sustainable economic growth and improvements in citizen services. The effective and coordinated governance supports social and urban growth through improved economy and active participation of citizens. Indian cities, while exhibiting technological innovations and connectedness, should also focus on increased living comfort through adequate infrastructure, green spaces and essential basic amenities to every citizen.

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5.0 VIOLATIONS IN VALLEY ZONES AND BUFFER ZONES OF WATER BODIES

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

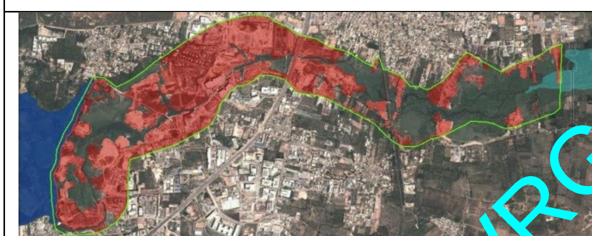
Valley zones*:* Bangalore has the distinction of having inter connected lake systems. Valley zones connecting two lakes are to be protected to ensure the continuation of hydrological functions of the drains and flood plains. These have been designated as sensitive regions as per the revised master plan 2015 (RMP 2015 of BDA). However, valley zones in Bangalore are being abused despite norms to protect these fragile ecosystems. For example, Pristine Bellandur-Varthur wetland ecosystem has been experiencing threat due to the large scale catchment alterations with changes in the land use land cover. The region forms a part of primary valley, which is sensitive regions as per the revised master plan 2015 (RMP 2015 of BDA). The landscape forms an integral part of the protected area (as it is in valley zone) as per the CDP 2015. This wetlands is now being converted with mixed land use i.e., Built-up with both residential and office complexes. Alterations in the wetland began in 2004 and aggravated post 2008. The alterations of these wetlands initiated by filling the low lying areas with excavated earth debris, followed by other construction activities. The land fillings have breached both rajakaluve and lakes. Rajakaluve have reduced in width from as high as 35m to less than 8 m, apart from the loss of natural stream network connecting the lakes and rajakaluveys. Major violations in Bellandur-Varthur wetlands are:

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

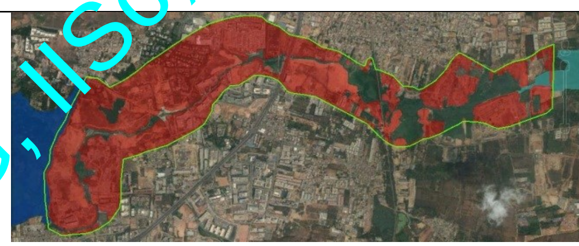
Figure 5.1 depicts the landscape dynamics in the valley zone between Bellandur and Varthur Lakes. Large scale landscape changes found to occur since 2004, and the process of urbanization is occurring from west to east (Bellandur to Varthur). The wetlands and agriculture lands encompassing 98.5% of the valley zone in 2002 have drastically decreased to 25.68% by the year 2016 which is due to land use conversion for construction (residential/commercial/infrastructure) which has increased from 1.44% in 2002 to 74.32% in 2016. This rampant growth in the valley zone have removed lakes and raja kaluveys that altered the function of natural system of cleansing water, recharging ground water. Table 5.1 highlights extent of landscape alterations and unauthorized occupation of Valley zone.

2002

2008



2012



2016

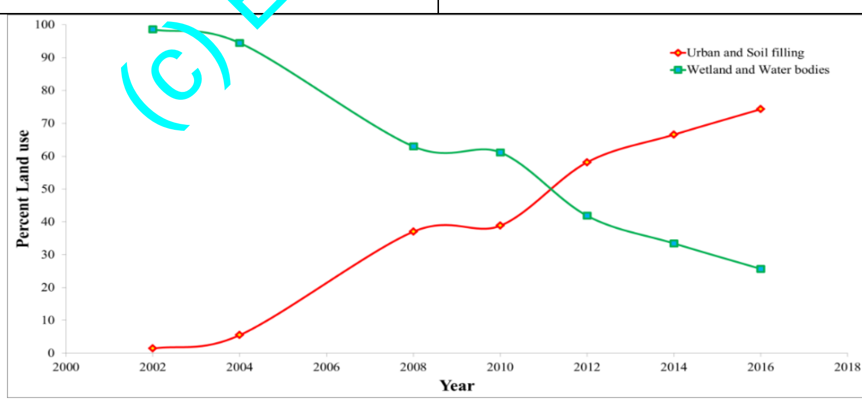


Figure 5.1: Land use dynamics in Bellandur Varthur Valley Zone

Table 5.1: Land use changes in the valley zone (Virtual Globe: Google earth)

	Area in Hectares						
Land use / Year	**2002**	**2004**	**2008**	**2010**	**2012**	**2014**	**2016**
Urban and Soil filling	5.2	20.2	135.3	141.9	212.4	243.2	271.5
Wetland, Agriculture and Water bodies	360.0	345.0	230.0	223.4	152.9	122.2	93.8
	Area in Percent						
Urban and Soil filling	1.44	5.53	37.04	38.84	58.15	66.56	74.32
Wetland, Agriculture and Water bodies	98.56	94.47	62.96	61.16	41.85	33.44	25.68

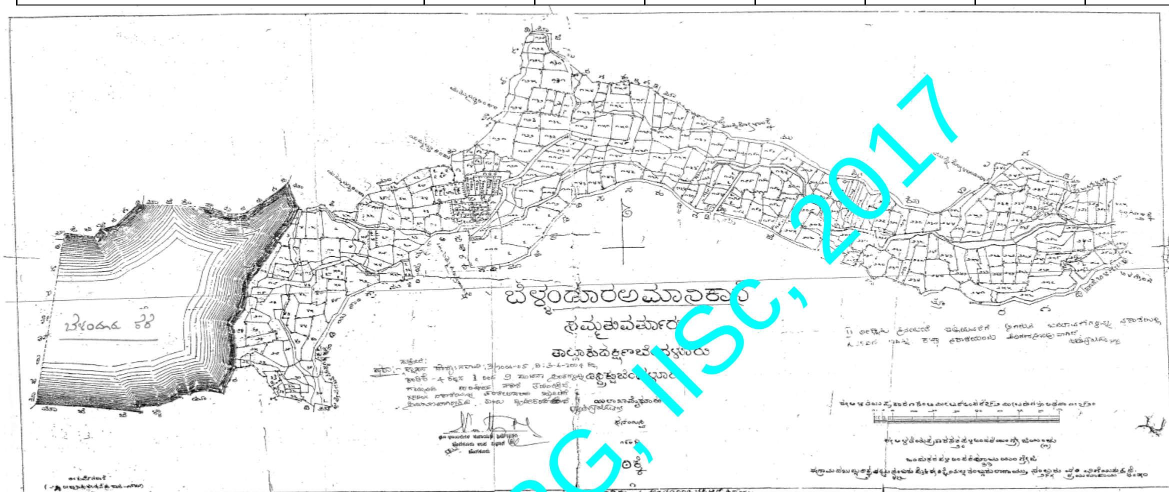
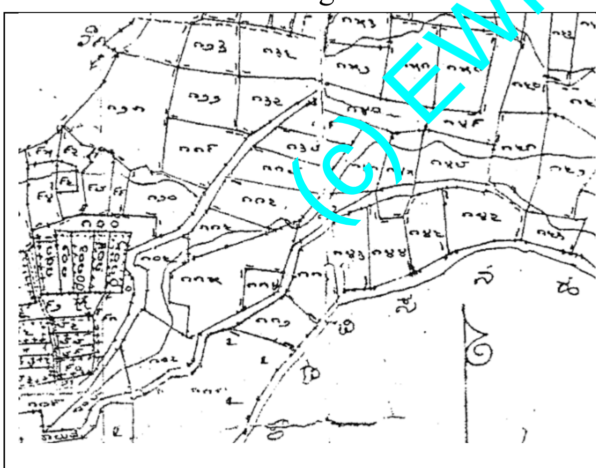
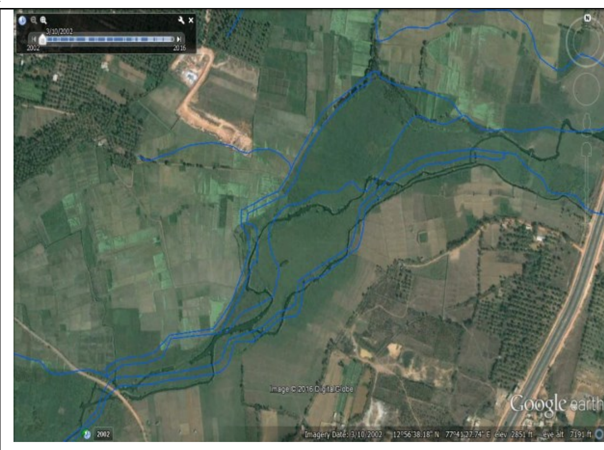
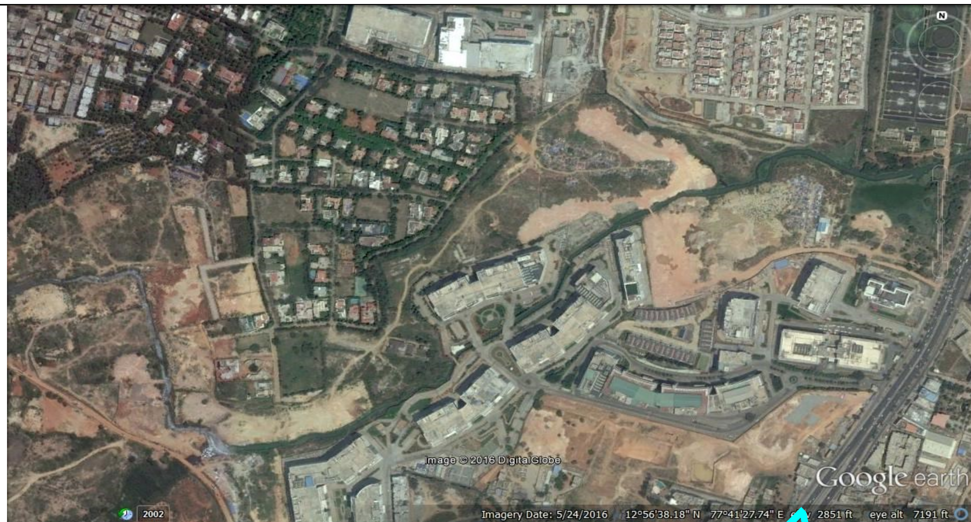


Figure 5.2: Revenue Map of Bellandur Ammanikere

	
1904 (Revenue Map)	2002 (map overlaid on Google earth)



View of landscape in 2016 (Google earth)

Figure 5.3: Alteration of natural drains and rajakaluveys

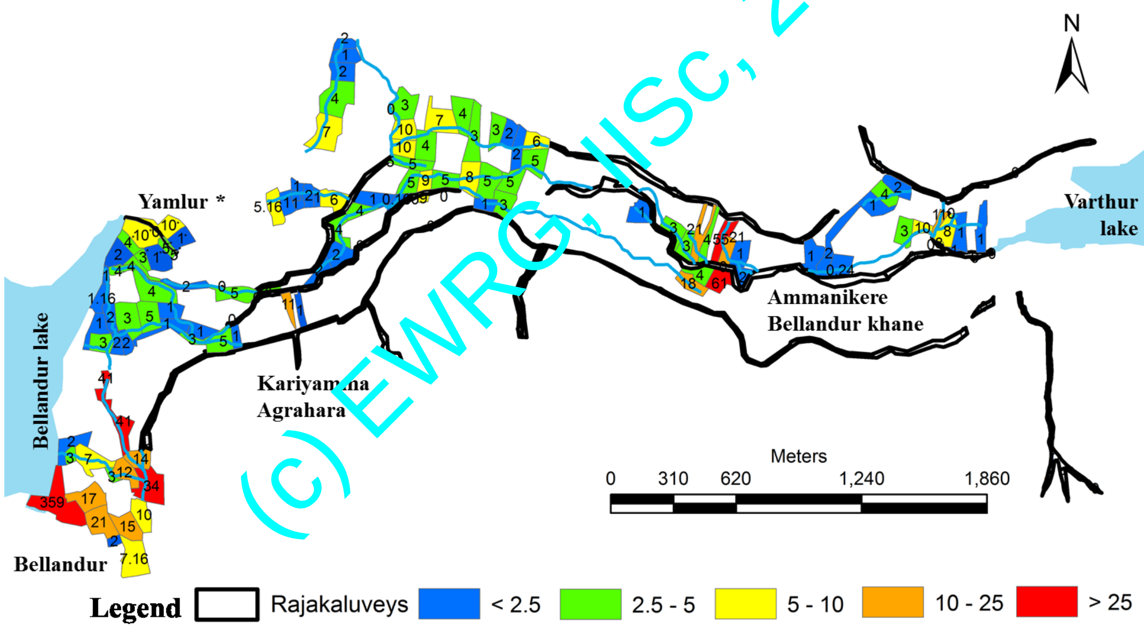


Figure 5.4: Kharab lands in the Valley zone between Bellandur and Varthur lakes

Table 5.2: Kharab lands in the valley zone

Ammanikere Bellandur Khane					
Survey Number	Area (Gunta)	Survey Number	Area (Gunta)	Survey Number	Area (Gunta)
2	1	98	2	168	3
3	1.16	99	1	169	2
6	4	106	4	170	2
7	4	107	2	171	6

8	1	108	2	172	5
9	1	116	4	201	1
10	5	117	1	209	3
11	3	120	6	212	3
12	2	124	7	213	21
13	2	125	4	215	4
14	2	126	2	217	4
15	3	127	1	218	18
16	1	128	2	221	61
25	2	140	5	222	21
26	3	141	5	223	55
27	7	142	0.16	227	1
30	12	145	9	228	2
31	3	148	5	241	1
38	34	151	4	244	1
39	14	152	10	245	2
42	41	153	10	248	2
53	3	154	3	249	4
54	1	157	7	250	1
55	5	159	4	253	0.24
56	1	160	3	256	14.08
63	5	161	8	272	10
64	2	162	5	273	3
93	5.16	163	1	280	11
94	2	164	3	282	8
96	1	165	5	283	1
97	1	166	2	285	1
Total Area (Guntas)			**570.8**		
Total Area (Acres)			**14.27**		

Bellandur		**Yamlur ***		**Kariyamma Agrahara**	
Survey Number	Area (Gunta)	Survey Number	Area (Gunta)	Survey Number	Area (Gunta)
4	359	54	20	17	4
8	17	55	1	19	11
10	10	56	10	22	1
11	15	57	1	**Total (Gunta)**	**16**
13	21	58	3	**Total(Acre)**	**0.4**
14	2	59	4		

18	7.16	60	2
Total (Gunta)	**431.16**	**Total (Gunta)**	**41**
Total(Acre)	**10.78**	**Total(Acre)**	**1.025**

* Verification required

Total Area (Guntas)	**1058.96**
Total Area (Acres)	**26.47**

Figure 5.2 depicts the revenue map of Bellandur Varthur valley zone (Bellandur Ammanikere). Rampant landscape changes in the valley zone have reduced the width (Figure 5.3) or encroached the natural drainages and rajakaluveys. Rajakaluveys of 25m to 35 m width have reduced in width to less than 5m to 8 m (example is depicted in Figure 5.9). Figure 5.4 and Table 5.2 details kharab lands in the valley zone between Bellandur and Varthur lake. 1058.96 Guntas (26.47 Acres) of land in the valley zone falls under the category of kharab lands and is distributed in villages of Ammanikere Bellandur Khane, (570.8 Guntas), Bellandur (431.2 Guntas), Kariyamma Agrahara (16 Guntas), Yamlur* (41 Guntas).

Bellandur-Agaram Valley zone: Figure 5.5 depicts the landscape dynamics during 2000 to 2015 (mapped on temporal Google Earth data – http://*earth.google.com*). The remote sensing data of 2009 – 2015 substantiates the unabated construction activities in the valley zone (without proper compliance and gross violations of environmental norms). Table 5.4 highlights extent of landscape alterations and unauthorized occupation of wetlands (Agara-Bellandur wetland). Figure 5.6 gives cadastral map (1904, scale: 1 in 7920) of the region with land uses - drainage network, agriculture land parcels, tank boundaries, etc.

Table 5.4: Extent of encroachment and illegalities

Year	wetland
2007	63 Acres 37.5 Guntas
2010	66 Acres 32.3 Guntas
2012	72 Acres 15.9 Guntas
2013	74 Acres 12.1 Guntas
2015	74 Acres 12.1 Guntas

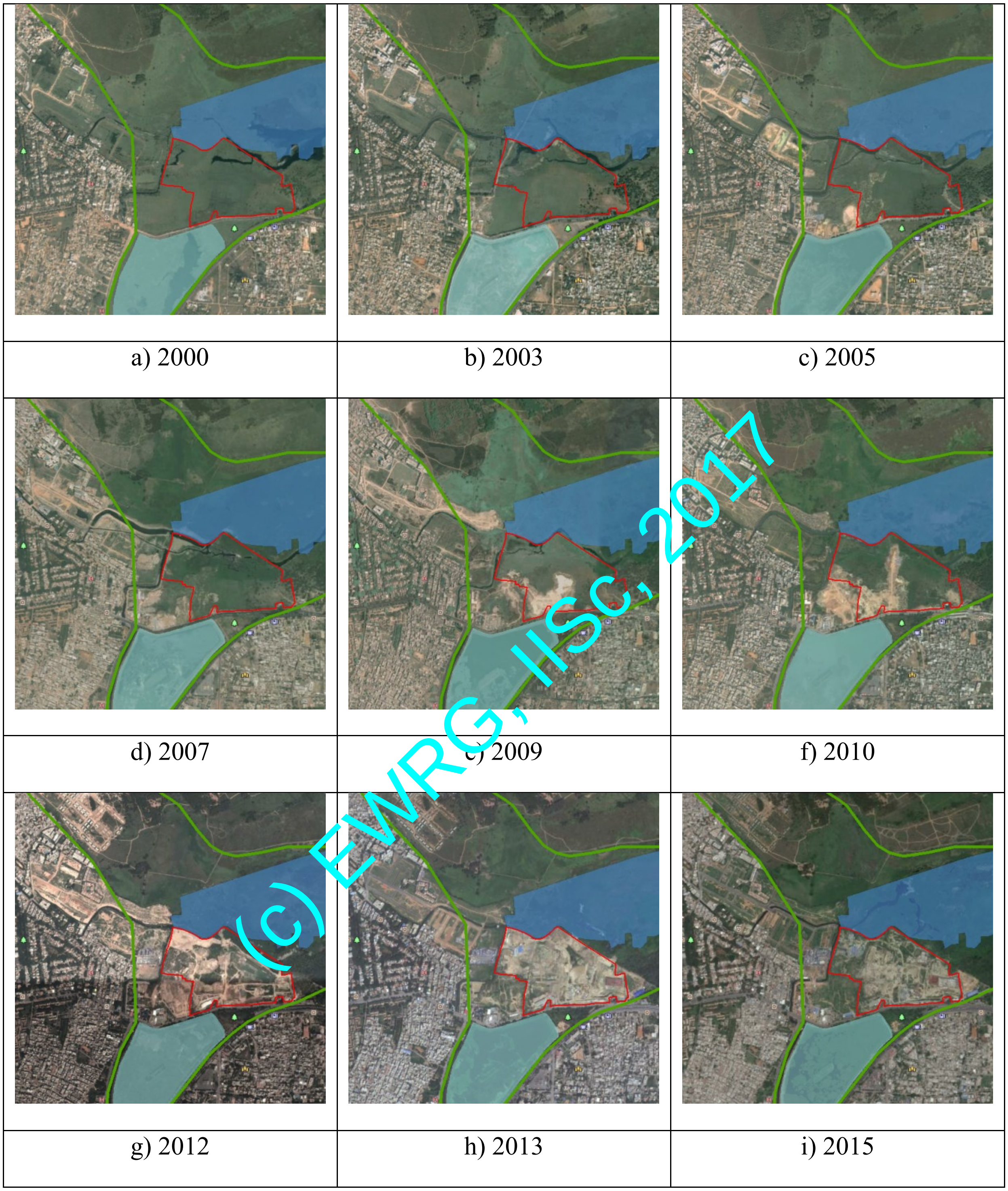


Figure 5.5: Land cover dynamics in the valley zone

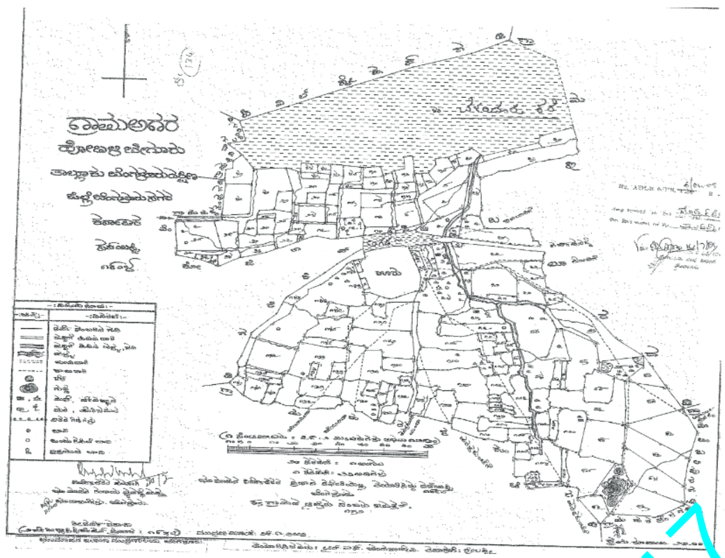


Figure 5.6: Cadastral Map with lakes (1904)

Figure 5.7: Rajakaluve, streams and lakes as per cadastral maps, satellite data and RMP 2015

Figure 5.7 highlights interconnected lake system in Agara-Bellandur region with rajakaluves and stream network. Figure 5.7 also indicates the narrowing down of rajakaluves for the period 2000 to 2015, (for the cross sections A, B, C, D). Rajakauluves have declined between 23% and 57% of the original width during the year 2000 to 2015. Table 5.5 lists applicable various norms for wetlands conservation.

Table 5.5: Various norms for lakes and rajakaluve conservation

Activities around lakes	**Norms to protect and conserve Wetlands**
Encroachment of lake bed and loss of interconnectivity among	The Hon'ble Supreme Court in Civil appeal number 1132/2011 at SLP (C) 3109/2011 on January 28,2011 has expressed concern regarding encroachment of common property resources, more particularly lakes (and

lakes	raja kaluves) and it has directed the state governments for removal of encroachments on all community lands. Eviction of encroachment: Need to be evicted as per Karnataka Public Premises (eviction of unauthorised occupants) 1974 and the Karnataka Land Revenue Act, 1964
Buildings in the buffer zone of lakes	In case of water bodies, 75.0 m buffer of 'no development zone' (as per recent National Green Tribunal direction) is to be maintained around the lake (buffer region to be as per revenue records) • As per BDA, RMP 2015 (Regional Master Plan, 2015) • Section 17 of KTCP (Karnataka Town and Country Planning) Act, 1961 and sec 32 of BDA Act, 1976 • Wetlands (Conservation and Management) Rules 2010, Government of India; Wetlands Regulatory Framework, 2008.
Construction activities in the valley zone (SEZ by Karnataka Industrial Areas Development Board (KIADB)) **in the valley zone**	This is contrary to sustainable development as the natural resources (lake, wetlands) get affected, eventually leading to the degradation/extinction of lakes. This reflects the ignorance of the administrative machinery on the importance of ecosystems and the need to protect valley zones considering ecological function and these regions are 'NO DEVELOPMENT ZONES' as per CDP 2005, 2015
Alterations in topography	Flooding of regions would lead to loss of property and human life and, spread of diseases.
Increase in deforestation in catchment area	Removing vegetation in the catchment area increases soil erosion and which in turn increases siltation and decreases transpiration
Documentation of biodiversity	• The biodiversity of every water body should form part of the School, College, People's Biodiversity Registers (SBR, CBR, PBR). • The local Biodiversity Management Committees (BMC) should be given necessary financial support and scientific assistance in documentation of diversity. • The presence of endemic, rare, endangered or threatened species and economically important ones should be highlighted • A locally implementable conservation plan has to be prepared for such species
Implementation of sanitation facilities	• The lakes are polluted with sewage, coliform bacteria and various other pathogens • Preserving the purity of waters and safeguarding the biodiversity and productivity, dumping of waste has to be prohibited

	• All the settlements alongside the water body should be provided with sanitation facilities so as not to impinge in anyway the pristine quality of water
Violation of regulatory and prohibitory activities as per Wetlands (Conservation and Management) Rules, 2016 and 2010; Regulatory wetland framework, 2008	Environment Impact Assessment (EIA) Notification, 2009. **Wetlands (Conservation and Management) rules 2010, Government of India; Regulatory wetland framework, 2008** **Regulated activity** • Withdrawal of water/impoundment/diversion/interruption of sources • Harvesting (including grazing) of living/non-living resources (may be permitted to the level that the basic nature and character of the biotic community is not adversely affected) • Treated effluent discharges – industrial/ domestic/agro-chemical. • Plying of motorized boats • Dredging (need for dredging may be considered, on merit on case to case basis, only in cases of wetlands impacted by siltation) • Constructions of permanent nature within 50 m of periphery except boat jetties • Activity that interferes with the normal run-off and related ecological processes – up to 200 m **Prohibited activity** iv. Conversion of wetland to non-wetland use v. Reclamation of wetlands vi. Solid waste dumping and discharge of untreated effluents
Damage of fencing, solid waste dumping and encroachment problems in Varthur lake series	High Court of Karnataka (WP No. 817/2008) had passed an order which include: • Protecting lakes across Karnataka, • Prohibits dumping of garbage and sewage in Lakes • Lake area to be surveyed and fenced and declare a no development zone around lakes • Encroachments to be removed • Forest department to plant trees in consultation with experts in lake surroundings and in the watershed region • Member Secretary of state legal services authority to monitor implementation of the above in coordination with Revenue and Forest Departments • Also setting up district lake protection committees
Polluter Pays principle	**National Environment Policy, 2006** The principal objectives of NEP includes :

	• Protection and conservation of critical ecological systems and resources, and invaluable natural and man-made heritage • Ensuring judicious use of environmental resources to meet the needs and aspirations of the present and future generations • It emphasizes the "Polluter Pays" principle, which states the polluter should, in principle, bear the cost of pollution, with due regard to the public interest
Prevention of pollution of lake	**National Water Policy, 2002** Water is a scarce and precious national resource and requires conservation and management. Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted. The water resources should be conserved by retention practices such as rain water harvesting and prevention of pollution.
Discharge of untreated sewage into lakes	**The Environment (Protection) Act, 1986** • Lays down standards for the quality of environment in its various aspects • Laying down standards for discharge of environmental pollutants from various sources and no persons shall discharge any pollutant in excess of such standards • Restriction of areas in which industries, operations or processes shall not be carried out or carried out subject to certain safeguards
The water pollution, prevention and its control measures were not looked upon	**Water (Prevention and Control of Pollution) Act, 1974** • It is based on the **"Polluter pays"** principle. The Pollution Control Boards performs the following functions : • Advice the government on any matter concerning the prevention and control of water pollution. • Encourage, conduct and participate in investigations and research relating to problems of water pollution and prevention, control or abatement of water pollution. • Inspects sewage and effluents as well as the efficiency of the sewage treatment plants. • Lay down or modifiy existing effluent standards for the sewage. • Lay down standards of treatment of effluent and sewage to be discharged into any particular stream. • Notify certain industries to stop, restrict or modify their procedures if the present procedure is deteriorating the water quality of streams.

Pathetic water scenario and insufficient drinking water in Bangalore	The depletion of ground water and drying up off lakes has affected the water availability to meet the current population. At the 4% population growth rate of Bangalore over the past 50 years, the current population of Bangalore is 8.5 million (2011). Water supply from Hesaraghatta has dried, Thippagondanahalli is drying up, the only reliable water supply to Bangalore is from Cauvery with a gross of 1,410 million liters a day (MLD). There is no way of increasing the drawal from Cauvery as the allocation by the Cauvery Water Disputes Tribunal for the entire urban and rural population in Cauvery Basin in Karnataka is only 8.75 TMC ft (one thousand million cubic – TMC ft equals 78 MLD), Bangalore city is already drawing more water-1,400 MLD equals 18 TMC—than the allocation for the entire rural and urban population in Cauvery basin
KLCDA Act 2014	Acts prohibited in lakes (1) use the lake for any purpose other than storage or impounding of water or for the purpose mentioned in clause (9) of section 5; (2) construct any structure on lake land, occupy any lake land or part thereof or cause any obstruction at the natural or normal course of inflow or outflow of water into, or from, the lakes on the upstream and or downstream; (3) construct any commercial, recreational or industrial complexes or houses or carry on any industrial activity within the distance to be notified by the Government depending on the water spread area of the lake; (4) dump debris, municipal solid wastes, mud or earth soil or liquid wastes or any pollutants, into the lake by using vehicle or otherwise; (5) discharge untreated sewage into the lake directly or indirectly; (6) construct roads, bridges and likewise other structures within the lake area including the tank bund; (7) breach bund, waste weir including lowering the height of the waste weir from its original height or remove fence, boundary stones or any hoarding or any sign board erected by the Authority; and (8) do any other act which is detrimental directly or indirectly to the lakes.

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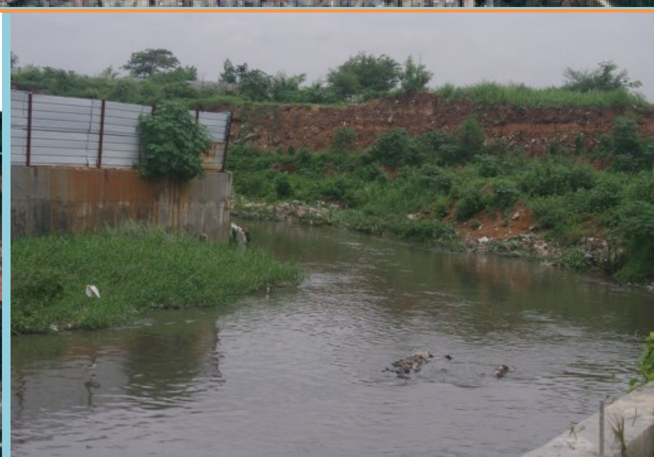
Agara-Bellandur Lake and inter connecting Streams

Agara-Bellandur (Buffer zones)

Buffer from edge : 75 m from Lakes, 50 m from Rajakaluvey and 25 m from streams as per NGT



CIVIC AGENCIES – APATHY & INEFFICIENCY

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