Final Report

on

Inventorisation of Water Bodies in Bengaluru Metropolitan Area (BMA)

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ಅರಣ್ಯ, ಜೀವಿ ಪರಿಸ್ಥಿತಿ ಮತ್ತು ಪರಿಸರ ಇಲಾಖೆ

ಕರ್ನಾಟಕ ಸರ್ಕಾರ
Government of Karnataka

VANDITA SHARMA, I.A.S.
Additional Chief Secretary to Govt
Forest, Ecology and Environment Department

Message

Water bodies such as Lakes are a source of freshwater, which holds major impact on existence of life. They are part of hydrological cycle and are key component with potential to alter the ecosystem. The systematic management of water bodies play a vital role to safeguard a better environment for the future generations and to achieve sustainable balance between developmental activities and environmental quality which are in general inversely proportional to each other.

The baseline data on water bodies is considered to be vital information required for beginning the work towards conservation of water bodies. It is of great importance to keep a record of water bodies, especially in the metropolitan city like Bengaluru which is known as 'City of Lakes', witnessing increase in water demand, decline in ground water level and water bodies subjected to varied degree of degradation.

The Environmental Management and Policy Research Institute (EMPRI) project report entitled "*Inventorisation of water bodies in Bengaluru Metropolitan Area*" has focused on preparing database of water bodies located in Bengaluru Metropolitan Area, encompassing baseline data such as characteristics of Water bodies, water quality, biodiversity and Lake Atlas with manual cartography. EMPRI's determination and relentless efforts in making this immense report is admirable. It is anticipated that the array of deliverables of this report such as Water bodies Database and conservation strategies will serve as a way forward for conservation of Lakes in Bengaluru.

Vandita Sharma

VANDITA SHARMA

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PREFACE

Lakes are important fragile freshwater ecosystems which support rich biodiversity. Lakes provide myriad of benefits to mankind such as recharge of groundwater, water for irrigation and industrial purposes, mitigates floods and droughts, moderates micro-climate, and provides recreational and religious uses.

In Bengaluru city rapid urbanisation and economic diversification accompanied with increasing population has resulted in increased demand for land, water and other resources. This demand has led to drastic changes in the land use and land cover in the catchment area of the lakes, leading to pollution and deterioration of the lakes at an alarming rate.

It has become the need of the hour to safe guard this vulnerable and valuable resource by employing conservation strategies. Only meagre information on the existence and status of lakes in Bengaluru Metropolitan Area was available with the authorities. To overcome this lacuna, EMPRI has been entrusted the task of preparing extensive database along with Lake Atlas of the existing and disused lakes in Bengaluru Metropolitan Area, under the study "Inventorization of Water bodies in Bengaluru Metropolitan Area" by Karnataka Lake Conservation and Developmental Authority (KLCDA).

Centre for Lake Conservation team at EMPRI has studied 1521 water bodies in the study area, analysed 14 parameters for the collected water samples, and has used secondary data, maps and prepared extensive data base containing 64 attributes such as general morphometric characters, results of water quality, information on biota, current status, encroachment, liquid and solid waste dump, etc. A unique code to each water body in the study area using the EMPRI coding system has also been assigned. Detailed conservation strategies have been discussed to facilitate better management and conservational methods for the sustainability of water bodies.

I hope this study would be beneficial to the stakeholders especially the custodians and the decision makers in the successful management and conservation of water bodies in Bengaluru Metropolitan Area in the years to come.

Rt kakl

Ritu Kakkar, IFS

Director General, E M P R I

Foreword

Water bodies are an important source of surface water, which play a crucial role in storing freshwater, supporting aquatic biodiversity, delivering important ecological functions like ground water recharge, nutrient recycling, providing protection against conditions of scarcity and floods, and keep the surroundings cool and beautiful. Today the water bodies in Bengaluru Metropolitan region have shrunk due to changes associated with infrastructural development and pollution as well as the impact of climate change. If these issues are unaddressed, the pressure on the water bodies is going to exacerbate the sustainable water supplies, ecosystem services ultimately leading to unsustainable development of the city.

The EMPRI project report entitled "Inventorization of Water bodies in Bengaluru Metropolitan Area" provides comprehensive database for 1521 water bodies including both existing and disused water bodies, information on the current status, water quality, pollution issues, encroachments, and biodiversity along with detailed conservation strategies. Also, the study has prioritised lakes for conservation making it easier for the implementing authority for selection of lakes for implementation of action plan. The Atlas has been prepared for 497 lakes, which gives complete information on lakes along with cartography.

The hard work put in by the entire EMPRI team is praiseworthy, and it is hoped that this report will be a useful asset for the State, implementing authority and stakeholders to take more effective and timely decisions on implementation of action plan for conservation of lakes, abate pollution and use the findings to bring awareness on the role of water bodies in securing sustainable water supplies, in providing a range of vital ecosystem services and in combating urban heat island effect.

Smt. Seema Garg, *IFS*
Chief Executive Officer
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ABBREVIATIONS

≈	Approximately
%	Percentage
°	Degree
'	Minutes
' '	Seconds
°C	Degree Centigrade
A-G	Acres and Guntas
APHA	American Public Health Association
$BaCl_2$	Barium chloride
BBMP	Bruhat Bengaluru Mahanagara Palike
BCM	Billion Cubic Meter
BDL	Below Detection Limit
BDA	Bangalore Development Authority
BIAAPA	Bangalore International Airport Authority Planning Area
BIS	Bureau of Indian standards
BMA	Bengaluru Metropolitan Area
BMICAPPA	Bangalore-Mysore Infrastructure Corridor Area Planning Authority
BOD	Biochemical Oxygen Demand
BWSSB	Bangalore Water Supply and Sewerage Board
CDP	Comprehensive Development Plan
CETP	Common Effluent Treatment Plant
CFU	Colony Forming Unit
CITB	City Improvement Trust Board
CLC	Centre for Lake Conservation, EMPRI
cm	Centimeter
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
DMG	Department of Mines and Geology
DO	Dissolved Oxygen
DoEE	Department of Ecology and Environment, Government of Karnataka
DPR	Detailed Project Report
E	East
EC	Electric Conductivity
EMPRI	Environmental Management and Policy Research Institute
et al.	Et alia
Fig.	Figure
ft.	Feet
g	Gram
GIS	Geographical Information System
G.O.	Government Order
GoI	Government of India
GoK	Government of Karnataka
GP	Grama Panchayat

GPS	Global Positioning System
ha./Ha.	Hectare
Hon'ble	Honorable
ILBM	Integrated Lake Basin Management
ILEC	International Lake Environment Committee Foundation
IRS	Indian Remote Sensing Satellites
ISO	International Organization for Standardization
IT	Information Technology
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
KFD	Karnataka Forest Department
Kg	Kilogram
KIADB	Karnataka Industrial Areas Development Board
KLCDA	Karnataka Lake Conservation and Development Authority
Km	Kilometre
Km^2	Square Kilometre
KSPCB	Karnataka State Pollution Control Board
KSRSAC	Karnataka State Remote Sensing and Application Centre
KUWS&DB	Karnataka Urban Water Supply and Drainage Board
L	Liter
Lat.	Latitude
Long.	Longitude
LPCD	Liter Per Capita per Day
Ltd.	Limited
LU/LC	LandUse and LandCover
m	Meter
m^3	Cubic Meter
MoEF&CC	Ministry of Environment, Forest and Climate Change, Government of India
MoU	Memorandum of Understanding
MI	Minor Irrigation
ml	Millilitre
MLD	Million Liters per Day
mm	Millimeter
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MPN	Most Probable Number
N	North/ Normality
NA	Not Available
NGO	Non-Government Organization
NH	National Highway
nm	Nanometer
No.	Number
NRSC	National Remote Sensing Centre
NTU	Nephelometric Turbidity Unit
PDO	Panchayat Development Officer
pH	Negative logarithm of hydrogen ion concentration
PIL/W.P.	Pubic Interest Litigation/ Writ Petition

ppm	Parts Per Million
Pvt.	Private
RTC	Rights, Tenancy and Crops
RWA	Residents Welfare Association
RWH	Rain Water Harvesting
S	South
SH	State Highway
SOI	Survey of India
SOP	Standard Operating Procedure
sp.	Species
Sq. Km.	Square Kilometer
SSLR	Survey, Settlement and Land Records
STP	Sewage Treatment Plant
Sy. No.	Survey Number
t	Tonnes
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UGD	Under Ground Drainage
W	West
WHO	World Health Organization
yr.	Year
ZP	Zilla Panchayat
μg	microgram
μmhos	micromhos
μS	microsiemens

CONTENTS

Inventorisation of Water Bodies in Bengaluru Metropolitan Area (BMA)

Executive Summary

The urban water bodies are the main contributors for maintaining the groundwater-table of the City. But due to anthropogenic activities, these water bodies are highly under threat and are prone to water pollution. Thus, there is a need to conserve the urban water bodies on top priority. So far a comprehensive database on the water bodies in the Bengaluru City is not available for the decision makers. Hence, the Karnataka Lake Conservation and Developmental Authority (KLCDA) has entrusted the study to EMPRI entitled "Inventorisation of water bodies in the Bengaluru Metropolitan Area".

Objective of the project is to create a database on water bodies in Bengaluru Metropolitan Area (Jurisdiction of BBMP and BDA) by identifying the water bodies through physical verification; assessing the water quality class, based on the water quality analysis; to prepare the water body database and to prepare the lake atlas with manual cartography.

The study area for the project is the BMA (Bengaluru Metropolitan Area), which covers 62% of Bengaluru Urban (Nagara) District. The study area is under the administration and planning jurisdiction of Bruhat Bengaluru Mahanagara Palike (BBMP) and Bangalore Development Authority (BDA) respectively. The study area also covers the part of Bengaluru-Mysuru Infrastructure Corridor Area Planning Authority (BMICAPA) area which is located within the Bengaluru urban growth boundary. The study area of BMA covers an area of 1307 km^2 which spreads over 590 villages of the four talukas viz… Bengaluru North, Bengaluru East, Anekal and Bengaluru South.

Status of the water bodies in the BMA have been recorded in the field based on the village maps, Minor Irrigation tank maps, toposheets and satellite imageries. The inventorised water bodies are classified into three categories based on its extents such as *Kere* (those with area more than 3 Acres), *Gokatte* (those with area between 1 and 3 Acres) and *Kunte* (those with area less than 1 Acre). The disused water bodies are also included in the database of water bodies to account for the conversion of these water bodies into other land uses. Both the existing and disused water bodies have been coded using the EMPRI coding system based on the ISO-3166 Alpha Numeric Coding System and Hydrologic Unit Code. Location of the water bodies, elevation, custodian, extent, village survey no. and year of creation, type of the water body (perennial, seasonal, dry), average depth, number of islands, inlet drains, waste-weirs, sluice gate, culvert and check dam, type of fence used for

preservation, water usage, and location are some of the parameters of water bodies that are recorded during the physical verification.

There are 590 villages in the BMA. The present study revealed that there are 1521 water bodies in 512 villages of BMA and remaining 78 villages have no water bodies. Within the 1521 water bodies, there are 497 *Kere* (102 *Kere* have disused), 200 *Gokatte* (115 *Katte* have disused), 824 *Kunte* (620 *Kunte* have disused). About 55% of the water bodies have disused and most of them were *Kunte*. But the total area (extent) of water bodies showed that 88.83% of water bodies area are remaining as water bodies and 11.17% of water bodies area have disused. Mostly, the water bodies were converted to provide the public amenities such as the road, temple, graveyard, park, etc. Whereas, the existing water bodies are used for fishing, cattle feeding, religious activities, washing, recreational activities such as swimming, boating, etc. Most of the water bodies in the BBMP area have been protected by the chain link mesh fence in the boundary. In BDA area, most of the water bodies are protected by partial fences such as barbed-wire fence, walls, bio-fence, etc.

Water quality of 303 BMA lakes has been analysed for 14 water quality parameters. The water quality of the lakes has been analysed in the physico-chemical water quality and microbiology laboratories in EMPRI. EMPRI has established these State-of-Art Sophisticated laboratories by utilizing the funds provided by KLCDA. The water samples have been collected from the two points of lake that is inlet and outlet. If there is no water in the inlet, then only one sample has been collected from the lake. Three physical parameters such as the quantity of water inflow to the lake, light transparency and water temperature are analysed in the field and for the remaining physico-chemical parameters, the water samples have been collected, transported and analysed in water analysis laboratory in EMPRI as per CPCB guidelines. Water samples received in the water analysis laboratory are subjected to the analysis of pH, turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Kjeldahl Nitrogen (TKN), Total Phosphate (P) and Total Coliform (TC).

Analysis of 14 water quality parameters have been done based on the standard methods of sampling and test for water and wastewater (BIS:3025). About 369 water samples were collected from the 303 BMA lakes to analyse the water quality parameters. The study also found that the sewage influx in the BMA water bodies is the major reason for the deterioration of the water. The process of frothing and fire on the Bellandur lake are also discussed in this chapter.

Biota of the water bodies have been recorded in the field by following the visual-encounter method. Nine categories of the biota in and around the water bodies have been recorded such as the trees; herbs and shrubs; aquatic flora (include weeds) such as emergent, submerged, rooted floating and free floating; insects such as terrestrial, odonates and aquatic insects; macro benthic fauna; fish; herpetofauna such as amphibian and reptiles; avifauna and visiting mammals. The study recorded the species of 36 trees, 26 herbs, 22 shrubs; 36 macrophytes, 31 terrestrial insects, 46 aerial insects, four aquatic insects, 11 macro benthic fauna, 20 fish, 12 herpetofauna, 54 avifauna and 12 visiting mammals. *Prosopis* sp., *Eucalyptus* sp., *Pongamia* sp., and *Azadirachta indica* trees, and *Parthenium* sp. herb are common on the banks of water bodies. *Typha* sp. (emergent), *Hydrilla* sp. (submerged), *Eichhornia* sp. (free floating) and *Ipomea* sp. (rooted floating) are common aquatic weeds. Common insects recorded in the vicinity of water bodies are ant and spider (terrestrial insect); butterfly and dragonfly (aerial insect); and water strider (aquatic insect). Rarely, the snakes (reptiles), tortoise (amphibian) and fruit bat (mammals) are also recorded from the vicinity of water bodies.

Issues in the water bodies such as encroachments, solid waste dumping and sewage inflow, and soil excavation were identified in the field and recorded with the help of GPS instrument and photography. The study found that 50.5% of water bodies are vulnerable to encroachment. Most of the water bodies have been encroached for the developmental activities such as roads, parks, graveyards, and temple's by the public and for agriculture, layouts, apartments, houses, commercial purposes by the private ltd. and local farmers. The study also found that the encroachment on few of the water bodies have been evicted and maintained as vacant land. The RTC of few of the water bodies have shown rights in the name of private individuals instead of ownership of the Government.

In 54.9% of water bodies, solid waste dump such as the domestic generated garbage, construction and demolition waste, agriculture waste were found in the water bodies. Sewage generated from domestic activities has entered in to water bodies and deteriorated the water quality. About 30% of water bodies are contaminated by the influx of sewage. Apart from sewage, the granite slurry also flows to the water bodies of BMA. Soil excavation and sand mining are also commonly observed in 19% of the BMA water bodies.

The prioritisation of BMA lakes for conservation was done by following the CLC (Centre for Lake Conservation) modified Battelle Method. Parameter Impact Unit (PIU) was measured based on the field data and weightage was given to the positive benefits of the lakes and negative impact caused by pollution and encroachment. The total Environmental Impact Unit (EIU) for each existing lake has been calculated and found that the 6% of lakes were very highly polluted (Black alert), which need immediate revival. About 44% of lakes were in the red alert category that needs immediate action for conservation and 42% lakes were in the yellow alert category that needs conservation. Whereas the 7% of lakes need action to mitigate pollution (green alert) and 1% of lakes needs preservation in future (blue alert).

Manual for inventorisation of water bodies has been prepared to identify the water bodies in other urban areas of Karnataka. These guidelines include three steps viz… preliminary, inventorisation and confirmation. Preliminary step will be the collection of secondary data and maps; the inventorisation step includes the planning and execution of the verification of water bodies in the field. The confirmatory step is to confirm the location and extent of the water bodies. The challenges encountered by the EMPRI team during the inventorisation of the water bodies from the preliminary to confirmation step have been documented as the lessons learnt during the study.

About 33 challenges were documented such as overlapping of villages between two different planning Authorities, two villages having same names and are under the two different planning Authorities; non availability of the map for the old Bengaluru City, partitioned, combined and updated village maps; intersecting administrative boundaries; village having two hamlets; lakes located in-between the two planning Authorities and in between two villages, confusion between *Kunte* with *GoKatte* mentioned in the village map; *Kunte* located in the reserved forest area; no survey numbers for attached lakes; confusion between the encroachment and the custodian; no clarity on the newly created and disused *Kunte*; confusion between the types and names of water bodies; confusion for declaring the *Kunte* as disused; no single source data for disused specific water body; inability to verify the water bodies located in the Central Government Agency like HAL and HMT; streams extended as water bodies; *Gokatte* extended as *Kere*, *Kere* shrunk as *Kunte*; RTC of water bodies in the name of private individuals were mismatched with SSLR data; water bodies surveyed by SSLR were mismatched with the water bodies GIS data published by SSLR; mis-nomenclature of hills as water bodies were surveyed by SSLR. The encountered challenges were resolved and compiled in this chapter as lessons learnt during the inventorisation of the water bodies. Further, the cause and effect of the challenges on the inventorisation of the water bodies has been plotted in a diagram.

Conservation Strategies for the sustainability of the water bodies in the BMA have been discussed in this chapter. The conservation strategies have been formulated by considering the suggestions from the stakeholders, RTAC (Research and Training Advisory Committee) of EMPRI and the Project Advisory Committee. The broad conservation strategies are as follows;

1. Decision on lakes located in between two Planning Authority jurisdiction
2. Notification of water bodies and its drainage
3. Official Communication to the Authorities on the clarity of the custodian of water bodies
    a. Segregate the type of Custodian (Type-A {<4 years}, B{4-10 years} and C{>10 years}) and handing over of the lakes through pre-formulated ‘Lake Handover Form’
    b. Gazette notification
    c. Confirmation of the custodian of water bodies
4. Protection of water bodies land and its drainages
    a. Recover the water body land
    b. Fencing
    c. Legal framework to protect the water body land and its drain
5. Protect water bodies from pollution
    a. Prevention of the entry of wastewater
        i. Through STP and using the treated wastewater
        ii. Monitor the STP through the STP Monitoring Committee
        iii. Installation of real-time monitoring buoy
        iv. Regulating the phosphate based detergent
    b. Preventing solid waste dump
    c. Legal framework to protect water bodies from polluters
6. Conservation of water bodies
    a. Rejuvenation by Authorities
        i. Formulate lake rejuvenation policy to stop unscientific desiltation and include installation of aerators, bio-strengthening of bunds, consideration of the time plan for conservation, etc.
        ii. Revival of storm water drains as a core activity during lake rejuvenation
        iii. Lake Series Rejuvenation or Priority based lake rejuvenation for biodiversity park or avifauna park or for lakes located in the flash flood prone areas
        iv. Monitoring of rejuvenation activities (Core and non-core activities)
    b. Community participation
7. Use the water bodies for Water Security Plan (WSP), Water Management Plan (WMP) and augment for drinking water supply through the biggest lakes and pisciculture
8. Monitoring and management of water bodies

    a. Lake warden shall submit the pre-formulated quarterly report on status of lake to the custodian
    b. Mechanical weed management using SPV (Special Purpose Vehicle)
    c. Regular water quality analysis using advanced technologies like drone sampler, automated water sampler, etc.
9. Research studies to be undertaken
    a. Baseline study to prepare bathymetric maps for major lakes as priority
    b. Estimation of water infiltration rate in the water bodies and studying the water balance in the lake catchment area through water sustainability plan
    c. Socio-economic study for major lakes and identification of the regional bio-indicators for rapid assessment of water bodies status
    d. Catchment Area Plan (CAP) should be prepared for major lakes and the same also be reflected in the Comprehensive Development Plan (CDP) prepared by Planning Authority
    e. Analysis of lake sediment and to develop cost-effective real time monitors for lakes augmented for water supply
10. Establish the relational database for water bodies
    a. Bridge the gaps in database such as history of lakes, previous custodians of lakes, metrological data, flood prone area water bodies
    b. Creation of mobile application for vigilance team and public to photograph and inform officials
11. Creating awareness on the importance of water bodies and its use in maintaining the microclimate, in Schools during World Environmental Day, World Water Day, etc.
    a. Conducting of '*Kere Habba*' (Lake Festival) on Kempegowda Birthday or "Lake Conservation Week" to create awareness
    b. Displaying the legal actions taken against the encroachers and polluters
12. Conducting training for officials, NGO, Residential Welfare Association (RWA), corporates to identify the status of water bodies

Database along with the **Lake Atlas** for the BMA lakes have been elaborated in the Volume-II. The database for BMA water bodies have 64 attributes, which encompass the general morphometric characteristic of water bodies, details on the present usage of disused water bodies, results of lake's water quality analysis and information on biota in water bodies and their vicinity, details about their issues such as vulnerabilities of water bodies for encroachment, dumping of solid wastes and wastewater inflow, etc. This database will provide the basic information of the water body and also their present status to the planning, administrative and conservation Authorities to implement the sustainable conservation strategies for conservation of water bodies in BMA. Lake atlas has been prepared for the 497 lakes which include the disused water bodies which includes the information on location of water bodies, code, extent, nature of catchment, upstream and downstream of the water body, pollutants, areas vulnerability to encroachment, water quality, biota, water usage, SSLR surveyed water body map (if available), village map, cartography, photography, satellite imagery, etc.

Highlights of the Study

1. There are 1521 water bodies in 1307 Km^2 (590 villages) of Bengaluru Metropolitan Area
2. The 684 water bodies are existing in BMA, comprising of 395 lakes (Above 3 acres), 85 Gokatte (Between 1-3 Acres) and 204 *Kunte* (Below one Acre)
3. About 837 water bodies have lost their characteristics and are no longer in existence in BMA for different activities. The *Kunte*s are more prone for the conversion i.e. 620 *Kunte* have been converted
4. All the 1521 water bodies are uniquely coded with its location
5. State-of-Art water analysis laboratory has been established in EMPRI to analyse the 14 parameters of water quality
6. Water quality has been analysed in existing 303 BMA lakes
7. Study recorded the species of 36 trees, 26 herbs, 22 shrubs; 36 macrophytes (aquatic plants), 31 terrestrial insects, 46 aerial insects, four aquatic insects, 11 macro benthic fauna, 20 fishes, 12 herpetofauna, 54 avifauna and 12 visiting mammals
8. Pollution and issues such as 48.85% of water bodies are vulnerable to encroachment, 44.5% have solid waste dump and 29% have sewage influx within the existing 681 water bodies
9. Lakes are prioritised for conservation and found that the 26 lakes need the immediate revival, 173 lakes need immediate action plan, 165 lakes need conservation, 28 lakes need conservation maintenance and three conserved lakes need to be maintained for future.
10. Prepared the manual for inventorisation of water bodies in other urban areas of Karnataka. Lessons learnt with 33 challenges during the study are also discussed
11. Database for 1521 water bodies have been generated with 64 attributes
12. Twelve major conservation strategies have been formulated for the conservation of BMA water bodies
13. Lake atlas for 497 BMA lakes has been generated with the cartography


Mattikere (JP Park)

CHAPTER

1

GENERAL INTRODUCTION

Chapter-1: General Introduction

Lakes have been defined differently in different dictionaries. As per the Oxford dictionary, a lake is defined as *a large area of water surrounded by land*. As per the Cambridge dictionary, a lake means *a large area of water surrounded by land and not connected to the sea except by rivers or streams.* According to the Merriam-Webster dictionary it is defined as *a considerable inland body of standing water*.

A comprehensive explanation is provided by Karnataka Lake Conservation and Development Authority Act, 2014, where *"Lake" is an inland water-body irrespective of whether it contains water or not, in revenue records mentioned as Sarkari Kere, Kharab Kere, Kunte, Katte or by any other name. It includes the peripheral catchment areas (Raja Kaluve) main feeder inlet and other inlets, bunds, weirs, sluices, draft channels, outlets and the main channels of drainages to and fro.*

There are millions of lakes in the world which are found on every continent and in every kind of environment— in plains, mountains, villages, cities, deserts, and even near the seashores. The area of the lakes varies from a few square meters to thousands of square kilometres. Likewise lakes also vary in depth. The physico-chemical characteristics of a lake are influenced by light, temperature, wind and chemicals such as nitrogen and phosphorus. Also, biological and geological process including human developments affects the chemistry of lake. Lakes age naturally over the course of hundreds or thousands of years, but with human influence the process can take only a few decades or years.

Lakes occupy less than 0.007% of the world's freshwater (2.53%) of the total volume of 1.4 billion km^3 (71%) of water on the earth. Of this 2.53% fresh water, 69.6% of water is locked in continental ice and in glaciers, 30.1% is available in underground aquifers, while only small portion of 0.26% is available in rivers and lakes as surface water (Ramachandra *et al*., 2001).

1.1. Functions of Lakes:

Lakes are fragile and highly productive ecosystems having unique characteristics, making them precious repositories of biodiversity by supporting the rare and endangered species. Healthy lakes with good biodiversity not only provide us with a number of environmental benefits but they influence our quality of life and strengthen our economy. Urban communities generally use the greatest amount of goods and services, which are all directly or indirectly drawn from lake ecosystems.

Lakes provide a myriad of benefits to mankind by delivering important ecological functions while storing water and supporting significant aquatic biodiversity. The categories of different values of water and water-based ecosystems are as following:

i. **Direct Values** (the Consumptive and non-consumptive use of resources): Lakes are used as source of drinking water, for irrigation, industrial uses, as means of transport, hydropower generation, recreational purpose, aquaculture providing food and employment to the people, serving as breeding ground for migratory waterfowl, etc.

ii. **Indirect Values** (Ecosystem functions and services): Lakes mitigate floods and droughts, recharges groundwater, purification of water, moderate the micro- climate, etc.

iii. **Option Values** (Premium placed on possible future uses and applications): Pharmaceutical, agricultural, industrial, leisure etc.

iv. **Non-use Values** (Intrinsic significance): Many lakes are sacred sites for religious and spiritual activities, providing heritage values, cultural values, also enhancing the aesthetic beauty of the landscape, etc. (The World Bank, 2001; Thomas and Victor, 2001).

1.2. Classification of Lakes

Limnologists classify lakes by three basic ways:

- Based on nutrients in the lakes?
- Based on Lake Turnover or mixing of water in lakes? and
- Based on the kinds of fish living in lakes?

Lakes are classified based on how the water mixes, or turns over from top (epilimnion) to bottom (hypolimnion), termed as Lake Turnover. In shallow lakes, mixing occurs all year long and has very little lake turnover, whereas deep lakes experience lake turnover on a large scale. Thermocline the middle layer of the lake mixes and turns over all through the year.

Turning in lakes occurs due to climate, nutrient variations, and geologic activity like earthquakes. During the autumn (fall) and spring, most lake turnover happens when the lake's cold and warm waters mix. The types of lakes include- Holomictic lakes (Mixing occurs within entire lake), Dimictic lakes (mixing occurs twice annually in the spring and in autumn, includes most common form of lake occurring in cool temperate latitudes), Cold monomictic lakes (are ice covered most of the year and mixing occurs during a brief summer in sub-polar regions), Warm monomictic lakes (mixing occurs once in a year, includes lake in temperate latitudes in subtropical mountains), Polymictic lakes (circulation and mixing occur in frequent periods in regions of low seasonal temperature variations), Oligomictic lakes (mixing in this lakes is unusual, irregular and of short duration, while, these lakes are relatively few in number and are mostly tropical) and Amictic lakes (mixing never happens as the lakes are usually ice covered all the year round, and occur in Polar Regions and high altitudes). Further, the lakes are classified based on trophic level as well. Oligotrophic lakes (lakes are generally clear with low concentrations of nutrients), Mesotrophic lakes (good clarity with average level of nutrients), Eutrophic lakes (high concentrations of nutrients), Hypereutrophic lakes (poor clarity with exceeding high nutrient concentrations) and Dystrophic (organic acids) lakes are different lakes based on the nutrient richness, primary productivity or trophic state. The First level of classification of lakes is defined by their origin. The lakes are classified as glacial lakes (ponded by ice), Tectonic lakes (crustal movements), Fluvial lakes (river meanders), Shoreline lakes (coastal lakes), Dammed lakes (rock slides), Volcanic lakes (volcanic activity), and Solution lakes (percolating water in water-soluble rocks). This classification however is in the context of lake use and assessment is of little value (Thomas *et al.*, 1996).

Criteria for classification of lakes are also followed based on Geographical location like Himalayan lakes, peninsular lakes, Coastal lakes; based on limnological criteria the lakes are classified as fresh water lakes, brackish water lakes, etc.; there are Ephemeral lakes (temporary lakes) like lakes of Bramputra basin e.g. *Beels* and *Jheels*; and also lakes are further classified based on their functions like irrigation tanks etc. Many people refer to lakes by size.

Further, based on how the lakes are maintained in a watershed the lakes are either seepage lakes or drainage lakes. The seepage lakes are with small watersheds, maintained primarily by groundwater flow. While, the drainage lakes are fed by inflowing streams or rivers. Hard water lakes are highly concentrated with calcium and magnesium, while the lakes with low concentrations of these ions are called soft water lakes.

The other way to classify lakes is by the kinds of fish they have. For example, in a cold-water lake one can expect to find trout a cold-water fish and a lake that has thick, muddy sediment is likely to have catfish. Historically the fish kills (Table-1.1) in Bengaluru is common and many lakes are auctioned on time contract for cultivation of fishes introduced by cultivator making it difficult to classify on this basis.

The lakes, ponds, tanks, wetlands, and other freshwater ecosystems are characterized as lentic (free standing water), while the rivers, streams, etc. are characterized as lotic (running water).

Table-1.1. Fish Kills in Bengaluru Lakes

Sl.No.	Date	Lake	Source
1.	Nov. 2005	Nellorahalli	Ramesha and Raju (2008)
2.	Jan. 2005	Ulsoor Lake	Ramesha and Raju (2008)
3.	June, 1995	Sanky Tank	Ramesha and Raju (2008)
4.	June, 2005	Puttenahalli lake	Ramesha and Raju (2008)
5.	June-July, 1995	Lalbag lake	Ramesha and Raju (2008)
6.	June, 2005	Sarakki-Jaraganahalli lake	Ramesha and Raju (2008)
7.	May, 2007	Lalbag lake	Ramesha and Raju (2008)
8.	March , 2016	Ulsoor	Bharadvaj (2016)
9.	May , 2016	Ulsoor	The Hindu (2016)

1.3. Factors influencing Lakes

Lakes, an important source of freshwater are balanced by the basic hydrological relationship. To understand the hydrological relationship it is important to know the hydrological cycle or water cycle. The water is constantly being recycled and reused through continuous movement of water from the Earth's surface into the atmosphere and back to the Earth's surface again. The driving force is the solar radiation. Water vapours in the atmosphere are formed due to evaporation of water from the land and water bodies (lakes, rivers, glaciers etc.); from trees and other plants through "transpiration"; evaporation from moist ground. Consequently, the clouds formed from these condensed water vapours in the atmosphere provide precipitation (rain, hail, snow, sleet) to start the cycle over again. During rains, the rainwater is absorbed by the ground or plants, rainwater flowing over land enters into water bodies, oceans and finally to atmosphere. Water recycling process repeats itself continuously.

The changes in water storage of lakes are governed by the water budget which is one of the hydrological characters of lake. Water budget includes both inflow and outflow of water into the lake system. Lakes receive inflow of water from rain, snowmelt, runoffs, groundwater sources and rivers, while the outflow of water occurs through evaporation, transpiration (through aquatic plants), and infiltration into the land in the form of ground water. The pattern of inflow and outflow of water in a lake system changes with both, season and climate.

The physical and chemical properties of a lake depend upon the shape of the basin, climatic condition, the nature of water flowing into the lake and the age of the lake. In the catchment area, water collects in the lowest area - the basin forming a lake. The characteristic of the lake is defined by its catchment's size, topography, geology, land use, nature of soil and vegetation. The catchment area or watershed is a contiguous area draining into a single water body (lakes, ponds, rivers, etc.). The catchment's drainage systems consist of river network, streams, wetland, underlying groundwater and also manmade channels, storm drains. The outlet of the watershed is the mouth of a lake, pond, or river. The watershed of a lake includes the streams entering the lake and the land area draining into those streams and eventually the lake. The catchments are separated from one another by high points such as hills or slopes in the area and differ from one another in size, shape, drainage pattern and features. Since the catchment is part of the natural water cycle its size and rain falling on it determines the volume of water entering the lakes.

Though the water cycle or hydrological cycle is entirely independent of human activity, the rate of movement of water through the cycle is altered dramatically through changes made to the land surface of the catchment by the humans, where the catchment has a critical importance in determining the ecosystem properties of freshwater lakes void of any human intervention. The terrain with vegetation cover and the wetlands in the catchment are porous and behave like sponge which during the rainy days absorbs and retains water eventually reducing the runoff. During dry times this absorbed and stored water is slowly released to the surrounding recharging the groundwater, and maintains water in the surface water bodies. But when the same vegetation and wetlands are replaced with the impervious surfaces such as roads, paving, parking areas, buildings, etc., apart from loss of useful flora and fauna, less water infiltrates into the ground, there is reduction in potential of nutrient attenuation of these areas, and more water flows (runoff) directly into lakes, rivers etc., through streams, drains and storm water drains. The increased runoff may cause a variety of problems like flooding, soil erosion, sedimentation, and pollution. During summer the adverse effect is felt in the form of severe paucity of water because as the infiltration is slowed, there is less build-up of groundwater, and the catchment behaving like a 'sponge' holding and slowly releasing the water is completely dry. The changes in land use and land cover in the catchment area have adverse effect on the water quality of the lakes. The nutrient level in the lake depends on nutrient available in the catchment and their potential for movement to the lake. The nutrient load and their movement are further altered by the anthropogenic activities.

1.3.1. Effects of Climate Change pertaining to the freshwater systems as per the Fifth Assessment report of Intergovernmental Panel on Climate Change (IPCC):

Lakes, a renewable water resource and one of the major reservoirs for storing the water on earth is also prone to the effects of climate changes in addition to the impacts from anthropogenic activities. Water is the agent that delivers many of the impacts of climate change to society via energy, agriculture, and transport sectors. Some of the effects of climate change on the freshwater systems as per IPCC are as follows:

- Approximately, 7% of the global population is projected to be exposed to atleast 20% decrease of renewal water resources which would lead to intensifying competition for water among agriculture, settlements, ecosystems, industry and energy production, affecting regional water, energy, and food security for each degree of global warming
- Freshwater species and terrestrial species are likely to face increased extinction risks under projected climate change during and beyond the 21st century since the climate change interacts with other stress such as habitat modification, overexploitation, pollution, and invasive species.
- Under projected climate change, raw water quality would reduce. There would be risks to drinking water quality even with conventional treatment. The sources of the risks are increase in temperature, nutrients, sediments and pollutant loads caused by heavy rainfall, reduced dilution of pollutants during droughts, and during floods disruption of treatment facilities.
- The increase in temperature and heavy rainfall are likely to change soil erosion and sediment yield depending on seasonal rainfall, land cover, and soil management practices.
- The abundance and distribution of both freshwater and marine harvested aquatic species are likely to be affected by climate trends. Also, the aquaculture production systems would be affected in different parts of the world. This will have negative impacts on nutrition and food security mostly in some tropical developing countries while there would be more aquatic food production in others regions of the world.
- The important ecological attributes of flow regimes would be changed in many rivers and wetlands due to changes in precipitation induced by climate change.
- Inland fisheries will continue to be vulnerable to a wide range of ongoing threats, including overfishing, habitat loss, water abstraction, drainage of wetlands, due to pollution, and dam construction, making the impacts of climate change hard to detect. Most concerns have centred on rising water temperatures and the potential impacts of climate change on flow regimes, which in turn are expected to affect the reproduction of many fish species.

Though in the long term not all ecosystem changes are detrimental to all people or to all species, the faster and further ecosystems change in response to new climatic conditions, the more challenging it is for humans and other species to adapt to the new conditions. The adaptation of human societies depends on the management of terrestrial and inland freshwater ecosystem. For fisheries and aqua culture key adaptations include policy and management to maintain ecosystems in a way that is resilient to change, allowing occupational flexibility, and development of early warning systems for extreme events.

1.4. Historical Background:

The communities of Karnataka knew the technique of constructing tanks and were aware of the importance of maintaining them as early as 300 B.C. (Vatsala Iyengar, 2004). Post-Mauryan period through thousands of inscription have provided complete information of canals, bunds, depth of water, costs for construction and every aspect of tank construction. Furthermore, the Hoysalas were considered master builders. The maximum numbers of water bodies were built during the period of Vijayanagar dynasty of South India (1336-1564). While, Wodeyars of Mysuru, promoted construction of tank through making land grants to individuals on condition that they used a portion of the land for the tank which they would build from their own resources.

Francis Buchanan who travelled to Mysore during 1800 has defined the *Kere*, *Katte* and *Kuntes*. The small reservoir supplying water for cattle to drink was called a *Katte*, while a large reservoir used for watering of lands was called *Kere*. A tank formed by digging a square cavity into the ground was called a *Kunte*. Also, tanks were described as river-fed tanks and rain-fed tanks. River-fed tanks drew their water from an anicut (dam) built across a river and supplied water to a series of tanks and channels. The rain-fed tanks were a series of reservoirs connected with each other and were formed by impounding the drainage from the catchment area alone by means of long embankments thrown across valleys, or by short embankments thrown across valleys. Most of the tanks in Karnataka belong to this group.

Major Sankey, Chief Engineer, Mysore (1866) has described the tanks as village tanks and terminal tanks. The village tanks were the small tanks serving the needs of a single village. Terminal tanks were big and were constructed in a valley at the point where the valley joins the main river. They were also called Doddakere or Piriyakere. Further some old lake were suffixed Samudra or Sagara which appeared to be based only on the fancy of the builder and was not an indication of it being very large (Dikshit *et al*., 1993).

At the end of the 19th century tanks became the life of people, because due to tanks there was sufficient food and water for men and cattle, generated wealth to the state, gave protection from floods, maintained high water table due to which the wells were filled with water, prevented soil erosion. As per the Irrigation Commission, 1901, in the wells of Bengaluru and Kolar, water could be found at a distance of just 3 to 4 feet from the surface.

The tanks in Karnataka are named based on their size and utilization as Kere, Katte, Sagara, Samudra and Tataka. Tanks are also described as Hiriyakere, Heggere, Piriyakere all meaning big tanks, Chikkakere meaning small tank and Kannegere a virgin (new tank). But the size of the tank or the area irrigated under them or the basis of classification is not defined.

The ancestors in Karnataka gave more importance to maintenance than to construction since they had realized that if there is no proper and timely maintenance and repair the tanks could get silted up or its bund getting weakened resulting in its breach or leakage of stored water through damaged sluices. Each tank has three parts (i) Catchment area through which the rainfall flows along the ground to the tank; (ii) tank bed, where the water is arrested; and (iii) the command area, is the area where the overflowing water from tank goes to the downstream area. The other parts/structures include sluice gate/valve (Toobu), waste weir (Kodi), etc. Sluice is used to let the water out of the lake into the canal system which conveys the water to the agricultural fields. Waste weir or Kodi is a part of the bund, which acts as a safety tool to let off the excess water from the lake. Presently all constructed tanks are called lakes.

1.4.1Bengaluru Tanks/Lakes:

Bengaluru, though deprived of the perennial rivers, our ancestors overcame the water problem through one of the genius works by constructing number of tanks/lakes to harvest and store the rainwater during 16th century. So many lakes were built that Bengaluru was referred to as '**Kalyananagara**', a city of kalyanis or City of lakes. **'Land of a Thousand Lakes'** was the description given to Bengaluru town in 1791 by the Britishers. During 20th century, the tanks/lakes were very important as they became a crucial element of city building throughout the century.

Bengaluru having hills and valleys that formed natural undulating terrain provided a very natural drainage pattern with small streams originating from ridges cascading down to form major streams in the three major valleys -Hebbal (Madavara lake series, Yelemallappachetty lake series), Vrishabhavathi (Byramangala series) and Koramangala & Challaghatta (Varthur lake series, Hulimavu lake series, Puttenahalli lake series). The interception of these streams was selected for impounding water forming a number of interconnected lakes/tanks or cascading lakes during this 16th century. These lakes/tanks formed the cradle for Bengaluru city to flourish and grow. In this cascading system of tanks/lakes, lakes are interlinked with each other to form a network of drainage which facilitated the surplus water from the lakes to flow into the downstream lakes, not allowing overflow of water out of the lake into its surrounding area. Even the additional quantity of seasonal water was transferred to other lakes thus forming a chain of reservoirs (small and medium sized) in each of the 3 valley system. Thus, water got distributed evenly, recharged the ground water and water bodies were kept alive perennially (Aboud Jumbe *et al.*, 2008). Requirement of water such as drinking, irrigation, livestock-management, industrial, infrastructure utilities was met. The two reservoirs Hesaraghatta constructed in 1894 and Tippagondanahalli constructed in 1926, formed the main source of drinking water for Bengaluru.

1.5. Present scenario- Karnataka:

Karnataka is blessed with 7 perennial river basins. But, it is the lakes/ tanks since time immemorial that have been extending water security to lakhs of people especially during non-rainy seasons as nearly 75% of Karnataka is drought prone area. The lakes by harvesting rainwater have been recharging the ground water and also have been nourishing rich biodiversity by evolving into wetland ecosystem. In the state there were about 38,000 lakes (Ramaswamy, 2007) but is reduced to 36,679 by 2003 (SoER, 2003) and presently there are only 36,000 existing lakes (SoER, 2011). Northern part of the state comprises of only 40% of the lakes, whereas majority of lakes 60% of the lakes are situated in the southern part. Over 90 percent of the drinking water supply schemes in the rural areas of the state are based on ground water. Ground water thus forms the major source of drinking water and is dependent on the status of the lakes or tanks. Hence good number of water bodies, well managed and unpolluted lakes are to be maintained to meet the needs of both present and future generation needs. But, today due to encroachment, illegal dumping of various solid wastes and due to discharge of industrial and sewage water into the lakes has made them toxic and most of the lakes are reduced to cesspools.

1.5.1. Bengaluru City:

Greater Bengaluru is a semi-arid tropic situated in the southern – eastern part of Karnataka, with an area of 741 km^2 and lies between the latitudes 12°39′00″ to 13°13′00″N and longitude 77°22′00″ to 77°52′00″E, located at a height of over 3,000 feet (914.4 m) above sea level. Bengaluru, the third largest city in India and the centre of India’s fifth-largest metropolitan area is bestowed with the name “Silicon Valley of India” because of its role as the nation’s leading information technology (IT) exporter. Today, Bengaluru is amongst the most preferred entrepreneurial locations in the world. As one of the world’s fastest growing cities, Bengaluru is experiencing a steady increase in population (3.25% annual growth rate). The city’s population is projected to be 10 million by 2021.The increasing population, socioeconomic development, unplanned urbanization has accelerated the consumption of resources which has led to deterioration of the lakes in this city. In Bengaluru city, the number of lakes has declined from 58 to 17, while in greater Bengaluru from 207 to 93 (Table-1.2).

Table-1.2. Status of water bodies in Bengaluru city limits and Greater Bengaluru

Year	Map/ Image	Bengaluru City		Greater Bengaluru	
		No. of water bodies	Area (in ha)	No. of water bodies	Area (in ha)
SOI 1973	Map	58	406	207	2342
1973	Image	51	321	159	2003
1992	Image	38	207	147	1582
2002	Image	25	135	107	1083
2007	Image	17	87	93	918

(Source: Ramachandra and Uttam, 2008)

Biodiversity and groundwater restoration in the city are being severely affected due to reduction of lakes. In 20 years, due to the disappearance of wetlands there has been a drastic increase in depth of the groundwater table from 35-40 to 250-300 feet (Ramachandra *et al*., 2005). Reduction of water storage capacity of lakes is resulting in flash floods in the urban district, even for a low intensity rainfall. Small water bodies which are feeders for major lakes are more vulnerable as compared to larger water bodies. Accompanied with catchment area destruction and the blockage of nallahs and Raja Kaluves restrain the entry of water to the lakes. Further, deforestation and land degradation in the catchment area have increased the rate of sedimentation. The decrease in inflow of water accompanied with the siltation has led to reduction in water holding capacity of the lakes which ultimately has led to disuse of lakes. Also, there is eutrophication of lakes due to inflow of sewage and dumping of various solid wastes into the lakes. Such lakes, due to negligence and without any management and conservation are prone for disuse and are easily prone for encroachment through conversion into different facilities such as buildings- residential and commercial, parks, stadiums, bus stands, golf course, universities, schools and colleges, etc. As per the report of the committee constituted by Hon'ble High Court of Karnataka to examine the ground realities and prepare an action plan for preservation of lakes in the city of Bengaluru, the list of the lakes (Table-1.3) which have lost their characteristics is given below.

Disused Water bodies

The water body that lost its water storage capability is called as disused or Non-existent (not existing or not used for real purpose) or vanished or disappeared water body.

Table-1.3. List of lakes that are diverted or have lost their characteristics

Sl. No	Name of the lake	Converted to
1.	Marenahalli lake	Marenahalli
2.	Sarakki Agrahara Lake/ Doresanipalya	J P Nagar 4th phase (Residential Area)
3.	Chinnagara Lake	Ejipura (Residential Area)
4.	Challaghatta Lake	Karnataka Golf Association
5.	Domulur Lake	Domulur IInd Stage (Residential Area)
6.	Siddapura Lake	Siddapura/Jayanagara 1st Block
7.	Geddalahalli Lake	RMV 2nd Stage, 1st Block
8.	Nagashettihalli Lake	RMV 2nd Stage, 2nd Block
9.	Kadirenahalli Lake	Banashankari 2ndStage
10.	Tyagarajanagara Lake	Tyagaraja Nagara
11.	Tumkur Lake	Mysore Lamps (Industry)
12.	Ramashettypalya kere	Milk Colony (playground)
13.	Agasana Lake	Gayathri Devi Park
14.	Ketamaranahalli Lake	Rajajinagar (Mahalakshmipuram/ Residential)
15.	Gangashetty Lake	Minerva Mills and Open ground
16.	Jakraya Lake	Krishna Floor Mills
17.	Dharmambundhi Lake	Kempegowda Bus Terminal
18.	Agarahar Hosa Lake	Cheluvadipalya
19.	Kalasipalya Lake	Kalasipalya
20.	Sampangi Lake	Kanteerava stadium
21.	Shule Tank	Ashok Nagar, Football stadium
22.	Akkithimmanahalli Tank	Sai Hockey Stadium
23.	Sunkal Lake	KSRTC Regional Workshop
24.	Koramangala Lake	National Dairy Research Institute
25.	Kodihalli Lake	New Tippasandra/Government Buildings
26.	Hoskere	Residential Railway Stockyard
27.	Sonnenahalli Lake	Austin Town (RES Colony)
28.	Gokula Tank	Mattikere
29.	Vidyaranyapura Lake	Vidyaranyapura (Jalhalli East)
30.	Kodugondanahalli Lake	Kodugondanahalli
31.	Hennur Lake	Nagavara (HBR Layout)
32.	Banaswadi Lake	Subbayapalya Extension
33.	Chennasandra Lake	Pulla Reddy Layout
34.	Vijanapura Lake (Kotturu)	Rajarajeshwari Layout
35.	Murueshpalya Lake	Murueshpalya
36.	Parangipalya Lake	HSR Layout
37.	Mestripalya Lake	Mestripalya (Open ground)
38.	Timeyard Lake	Timeyard Layout

Sl. No	Name of the lake	Converted to
39.	Gangodanhalli Lake	Gangodanhalli
40.	Vijayanagar Chord Road Lake	Vijayanagar
41.	Oddarapalya Lake	Rajajinagar (Industrial Area)
42.	Saneguruvanahalli Lake	Shivanahalli (play Ground/ KSPCB Buildings)
43.	Kurubarahalli Lake	Basaveshwara Nagar

1.6. Governance and Stakeholders of Bengaluru Water bodies:

The lakes of Bengaluru region were earlier individually or collectively managed by a number of government agencies such as Karnataka Forest Department, Minor Irrigation (MI) Department, Horticulture Department, Public Works Department (PWD), Bruhat Bengaluru Mahanagara Palike (BBMP), Bengaluru Development Authority (BDA), Karnataka State Tourism Department (KSTD), Bengaluru Water Supply and Sewage Board (BWSSB), Karnataka State Pollution Control Board (KSPCB), Fisheries Department, Revenue Department, Bengaluru Metropolitan Region Development Authority (BMRDA), Central Ground Water Board (CGWB), Town Planning Department, City Municipal Councils (CMC) and Panchayats (Zilla, Taluk and Grama). Since all these lakes are managed by several agencies, proper restoration has not been achieved so far. In order, to conserve, protect and restore the lakes, Government of Karnataka, following the directive of the Hon'ble High Court of Karnataka, established a separate authority in July 2002, known as Lake Development Authority (LDA). These governing bodies addressed the problems related to lakes and protect the lakes in and around Bengaluru city within BMRDA jurisdiction. But the required power was constituted to the authority by Government of Karnataka through passing "The Karnataka Lake Conservation and Development Authority Act, 2014" in 2015. The Act was passed for constitution of Karnataka Lake Conservation and Development Authority (KLCDA) with necessary power and functions to protect, conserve and rejuvenate the water bodies like the lakes, wetlands including their catchment areas, inlets and outlets for ensuring long term sustenance. The jurisdiction of the authority extends to all the water bodies within the limits of all the city corporations and BDA in the state. Water bodies which are identified in the state by the government are also included. Now LDA is KLCDA has the power to control and remove encroachments, impose fines and imprison the violators found discharging untreated sewage into the lake and dumping of construction debris.

Along with the above mentioned agencies, the other stakeholders are fishery contractors and local welfare associations. NGOs like Bengaluru Environment Trust (BET), Ashoka Trust for Research in Ecology and the Environment (ATREE), Environment Support Group (ESG), and many more are active in the conservation of lakes. Energy and Wetlands Research Group (EWRG) of Indian Institute of Science, Department of Environmental

Science and Department of Zoology, Bengaluru University, are also actively involved in the study of different issues of water bodies.

1.7. Rationale of the study:

The increasing population, urbanization, and industrialization are imposing great demand for water and land in urban and semi urban areas. In Bengaluru the surviving lakes are turned into dumping grounds for sewage, industries effluents, solid waste and other hazardous wastes. Also, the encroachment of the lakes (for agricultural activities, layout development, etc.) and developmental activities in the catchment area are apparently causing undesirable change in the microclimate and lake structure. The seasonal lakes are converted to perennial lakes with eutrophic condition due to continuous entry of sewage. The lakes at present are unable to deliver their ecological functions and ecosystem services effectively and are under severe paradigm shift from community property to private property. The biodiversity of this fragile ecosystem are under severe threat as the water quantity and the quality are getting deteriorated day by day. The extensive withdrawal of groundwater and surface water bodies for various purposes such as domestic, intensive irrigation, industrial needs and pollution has further intensified the effects of climate change on the water bodies.

Hence, further deterioration of water bodies (lakes, ponds, etc.) has to be stopped by employing the conservation strategies. New and effective strategies are required to be deployed holistically for lake restoration involving ecosystem approach, use of eco-technologies, integrating local communities, local NGOs, stakeholders and strict implementation of the rules and regulations aided with creation of awareness. The preservation and conservation of biological resources is essential for the well-being and the long-term survival of mankind. But, to initiate any action to conserve water bodies, data is needed and currently, there is very limited information available regarding existence and status of water bodies in Bengaluru City (Jurisdiction of BBMP and BDA). Hence, Centre for Lake Conservation (CLC) of Environmental Management & Policy Research Institute (EMPRI) has taken up the project entitled "Inventorization of Water bodies in Bengaluru Metropolitan Area" funded by Karnataka Lake Conservation and Development Authority (KLCDA) to formulate the database and conservation strategies.

The report of the Committee constituted by the Hon'ble High Court of Karnataka for Writ Petition No. 817/2008 & others under the chairmanship of Hon'ble Justice N.K. Patil (2011) to observe the ground realities and to prepare an action plan for preservation of lakes in the Bangalore City, formulated the action plan for Lake Development Authority and Revenue department to build up the database for all the lakes in Bangalore City based on the village maps. Further, the Empowered Committee meeting held on 27th August'2012 found that the detailed lakes database for Bangalore City should be prepared. Accordingly, the proposal entitled "Inventorisation of water bodies in Bangalore Metropolitan Region" was submitted to the LDA on 20th December'2012. LDA Technical Committee has approved the proposal on 18th Feb'2013 and the proposal budget was approved in the EC meeting of LDA held on 12th Feb'2014.

After the transformation of LDA into KLCDA by Karnataka Lake Conservation and Development Authority Act, 2014; the project title has been revised as "Inventorisation of water bodies in Bangalore Metropolitan Area".

Ullalu *Kere*

CHAPTER

2

OBJECTIVES & SCOPE

Chapter-2: Objectives and Scope of the Study

2.1. Objective:

The objective of the study is to create the database on water bodies in Bengaluru City (Jurisdiction of BBMP and BDA), which will be useful in the decision making for the KLCDA and other concerned stakeholders to act on imminent conservation needs of water bodies based on a comprehensive scientific understanding of threats and appropriate remedial actions. Apart from this, the study also seeks to strengthen the capacity for lake management through consultative and participatory inclusion of key stakeholders, which aims at fostering local ownership and which is essential for future sustainable interventions. The core objective of the study is

1. **To identify the water bodies** such as *Kere* (above three Acres), *Gokatte* (ranged between one and three Acres) and *Kunte* (below one Acre) based on the village maps, toposheets and Minor Irrigation tank map in the Bengaluru City of KLCDA jurisdiction.
2. To analyse the **14 water quality parameters** in the existing lakes and broadly document the biota in the lake and its vicinity area.
3. To prepare the **database for water bodies** in the *Excel* spread sheet, which include the details of water bodies such as morphometric characters, issues, its water quality and biota.
4. To prepare the **Water body Atlas**, which encompasses the collected data, visual cartographies, photographs and also surveyed lake sketch of SSLR (Department of Survey, Settlement and Land Records).

2.2. Scope of the Study:

The scope of the work is to inventorize the water bodies irrespective of size in Bengaluru City, the area under the jurisdiction of BBMP and BDA (include the BMICAPA [Bengaluru-Mysuru Infrastructure Corridor Area Planning Authority]) but exclude the BIAAPA (Bangalore International Airport Authority Planning Area) Jurisdiction.

1. To collect the jurisdiction map of BBMP and BDA to earmark the jurisdiction of KLCDA in Bengaluru City as well as the study area.
2. To list out the villages in the study area as well as in the BBMP and BDA area and collect the village maps (if available in digitized form) from SSLR.

3. To collect the baseline data for lakes (name, extent, village name, survey number, and custodian) through secondary data collection from the KLCDA, BBMP, BDA & Department of Forest, Zilla Panchayat, etc.
4. To identify the water bodies such as *Kere, Katte* and *Kunte* (both existing and disused) by considering the village maps, tank maps (Minor Irrigation Department), toposheets, Google Earth imageries and recording their locations using GPS (Global Positioning System).
5. To prepare the location of water bodies using GIS (Geographical Information System) on Google Earth Imageries.
6. To assign the unique codes (alpha numeric) for all the water bodies considering district, taluk, hobli, and village names.
7. To document the details like morphometric features, encroachment and pollution in 30m buffer zone of water bodies by field visit.
8. To establish the physico-chemical and microbiology water quality analysis laboratory in EMPRI to analyse the 14 water quality parameters according to the Project Advisory Committee recommendation.
9. To analyse the water quality of lakes and document the biota of the existing water bodies.
10. To create the electronic database of the water bodies in a Microsoft Excel spread sheet.
11. To generate water body cartographies for visual purpose and include the field data, photographs, Google Imageries and if available, SSLR surveyed lake sketch.
12. To derive the conservation strategies to sustainably conserve major lakes pertaining to the urban scenario.

2.3. Approach:

The list of villages in the study area has been collected from BBMP and BDA, and has been verified with the ward map of BBMP and RMP-2015 respectively. Further the village maps have been collected from the SSLR, and digitised village maps and available KMZ (Keyhole Markup Language Zipped) files are downloaded from the SSLR website (http://landrecords.karnataka.gov.in/service3/). Toposheets (57G/8, 57G/12, 57H/5 and 57G/9) on 1:50,000 scale published by survey of India and digitised tank maps published by MI (1937) also collected and water bodies were inventorised on each of these maps.

CLC (Centre for Lake Conservation) team of EMPRI has identified all these water bodies through field visits both irrespective to extent and extinct. Newly constructed water bodies have also been identified with the help of local inhabitants and the Google Earth Pro. All the inventorised water bodies have been positioned in the Google Earth Satellite Imagery by using the ArcGIS 10.3.1 and uniquely coded using ISO 3166-1 coding system. History, morphometric characteristics, usage and other primary information on water bodies have been gathered through field visits. The information available were analysed to understand the implementation issues during execution stages, which had adversely affected the water bodies and resulted in the disappearance of several water bodies.

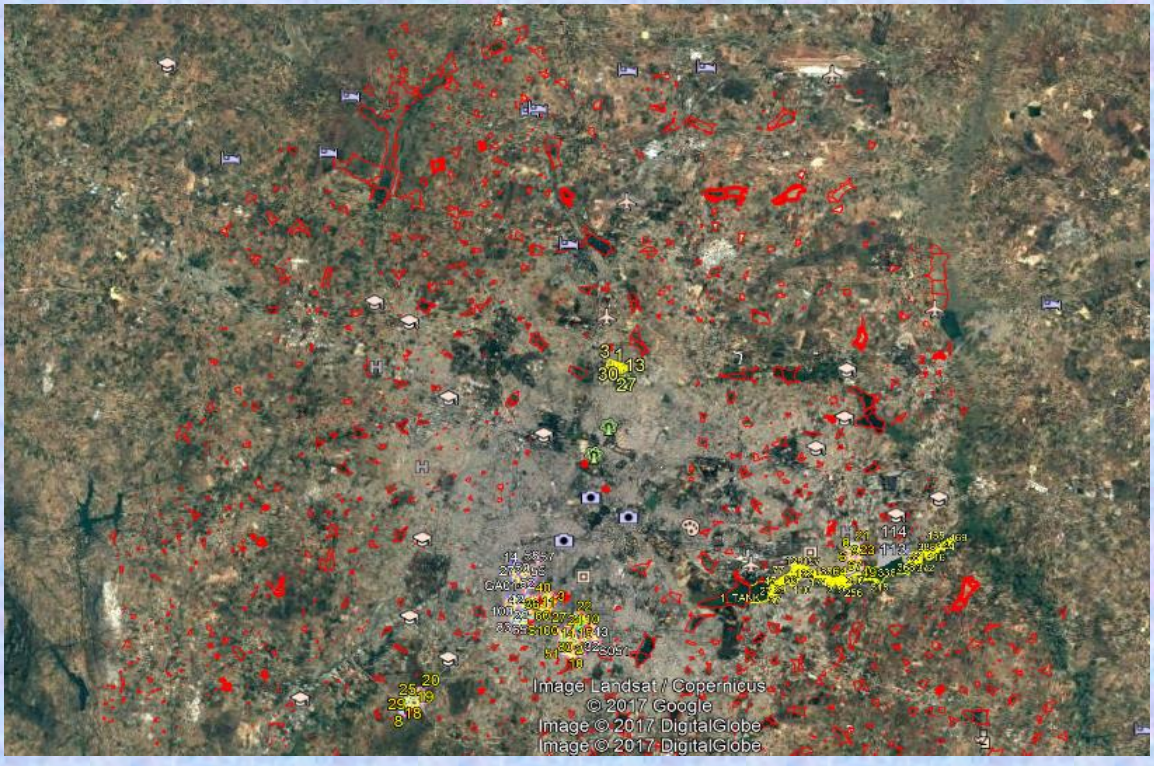
Morphological characteristics, issues, pollutants and pollution sources falling within the 30m peripheral area of the water bodies were recorded through visual observation while walking around the water bodies. Particularly, the encroachments on the water bodies have been assessed by overlaying the base map (Village map) on the satellite imagery. The observation on the encroachment has been verified with the SSLR lake survey details (http://landrecords.karnataka.gov.in/service3/Lakeencroachment.aspx), the draft K.B. Koliwad Legislative Assembly Committee Report (2014-15) and also confirmed in the field by physical verification.

The State-of-art water analysis laboratory has been established by following the guidelines of NABL (National Accreditation Board for Testing and Calibration Laboratory), OSHA (Occupational Safety & Health Administration) regulation and the Environment (Protection) Act, 1986 to analyse the 14 water quality parameters. Water temperature, light transparency in lake water and inflow of water into lake have been analysed in field itself. Water pH, TSS (Total Suspended Solids), TDS (Total Dissolved Solids), conductivity, turbidity, DO (Dissolved Oxygen), COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), TP (Total Phosphate), TKN (Total Kjeldhal Nitrogen) and Total Coliform are the 11 parameters that have been analysed in the EMPRI water analysis laboratory by following the BIS 3025 standards.

Biota such as trees, shrubs, herbs, aquatic plants, fish, herpetofauna, insects, birds and animals have been qualitatively documented in each and every existing water bodies by following the standard guidelines. All the primary data generated from field visits with the secondary data have been used to prepare the electronic water bodies database. The database were prepared in the Microsoft Excel spread sheet with 65 attributes, which have four sheets such as morphometric characteristics, details of disused water bodies, water quality and biota details, and the pollution and issues of the water bodies.

Cartography was prepared for all the water bodies, which includes the map of water body, location of pollutants, encroachment details and issues observed (activities which harm the water bodies) during the field visits. The stakeholders' meetings have been conducted in four taluks' at Taluk Panchayat level with Grama Panchayat officials of Bangalore North, Bangalore East, Anekal and Bangalore South in order to understand their perspectives on the conservation of the water bodies and also to formulate the conservation strategies.

Using all the primary, secondary information and the Google Earth Imagery time series map of water body between the year 2005 and 2016; the Water body Health Report Card has been prepared to give the status of water bodies at a glance and also for future reference.



CHAPTER

3

STUDY AREA

Chapter-3: Description of Study Area

The entire study area (1307 km^2) is located in the Bengaluru urban (*Nagara*) district, which is situated in the heart of the South-Deccan plateau in peninsular India to the South-Eastern corner of Karnataka State between the latitudinal parallels of 12^o 39' N to 13^o 18' N and longitudinal meridians of 77^o 22' E to 77^o 52'E at an average elevation of about 900 meters (Satya Priya, 2017). The study area is the whole Bruhat Bengaluru Mahanagara Palike (BBMP) and Bengaluru Development Authority (BDA) areas (Figure-3.1) of Bengaluru Metropolitan Area (BMA).

3.1. Bengaluru Urban (Nagara) District:

Bengaluru Urban district is surrounded by the Bengaluru Rural district on the West, East and North and the Krishnagiri district of Tamil Nadu State on the South-East. The study area has been spread over about 62% of the total district area, which is located in the jurisdiction of BDA area for planning (including BBMP). Bengaluru Urban district came into being in 1986, with the partition of the erstwhile Bengaluru district into Bengaluru Urban and Bengaluru Rural districts. Bengaluru Urban has four taluks: Bengaluru North, Bengaluru East, Bengaluru South and Anekal. The city of Bengaluru is situated in the Bengaluru Urban district. The Bengaluru Urban district has 17 hoblies, 613 villages and the Bengaluru City (BBMP area). This is the most advanced district in Karnataka. It had a population of 9,621,551 in the 17 hoblis and 86 Grama Panchayats with a sex-ratio of 916 females/males with the density of 4,378 persons/sq.km. as per 2011 Census. The geographical area is 2208 km^2. Whereas the rural population is 8,71,607 and the urban population is 87,49,944. The projected population for 2020 is 136,24,529. The average rainfall received from 1941-2014 is 854mm with the 56 rainy days in the year 2014 as per the 23 rain gauge stations in the district. Paddy, jower, maize and ragi are mostly cultivable in 11,684 ha. of net area and irrigation with the help of 15,844 tube-wells. About 41,115 tons of the chemical fertilisers are used in these agriculture lands. Apart from agriculture, there are 248 Panchayat Raj and 112 Minor Irrigation (MI) tanks are utilized for the fisheries with a yield of 10,877.70 tons during the year 2013-2014. About 2655 and 6945 families are dependent on fisheries as full time and part time respectively in the Bengaluru North taluk (DoES, 2015).

3.2. BDA (Bangalore Development Authority) Area:

The study area for the inventorisation of the water bodies are demarked as the BDA planning area, which comprises the area of BBMP, Conurbation of Bengaluru City and the part of the BMICAPA. The study area is surrounded by the different planning Authorities of BMRDA such as BIAAPA (Bangalore International Airport Area Planning Authority) in

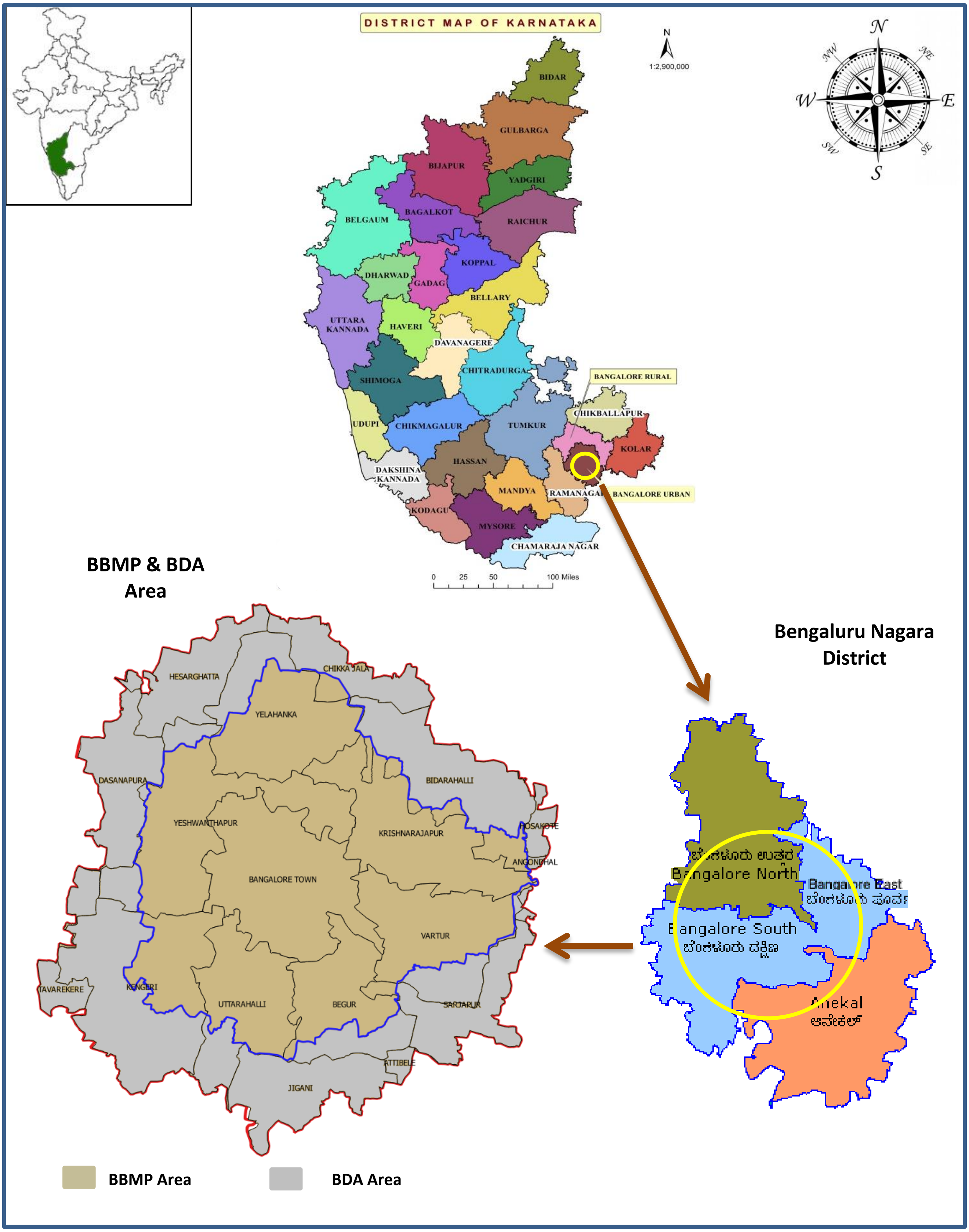


Figure-3.1: Study area map (BBMP & BDA Areas) the North, HPA (Hosakote Planning Authority) in the East, APA (Anekal Planning Authority) in the South, KPA (Kanakapura Planning Authority) and RCUDA (Ramanagara-Channapatna Urban Development Authority) in the South West, MPA (Magadi Planning Authority) in the West and NPA (Nelmangala Planning Authority) in the North West.

LDA upgraded to KLCDA

The LDA (Lake Development Authority) had sanctioned the project to prepare the water bodies database in the entire BMR (Bengaluru Metropolitan Region), which is under the planning jurisdiction of BMRDA.

In 2015, the LDA was upgraded into KLCDA as per KLCDA Act, 2014. The KLCDA has the jurisdiction of 11 Corporations in the State of Karnataka for conservation and development of lakes. Accordingly, the project study area has been demarked as the Bengaluru City Corporation area, which is administrated by BBMP and planned for further development by BDA, has been considered as the KLCDA jurisdiction for the conservation of lakes as well as the project study area.

BDA is the planning Authority for the BMA, which comprises 1307 km^2 (Revised Master Plan, 2015) and spread over 590 villages. As the planning Authority, the BDA has been mapping the Urban Growth Boundary (UGB) for Bengaluru City through the Comprehensive Development Plan (CDP) and the same will be revised once in 10 years as per the Karnataka Town and Country Planning Act, 1961. The preparation of Revised Master Plan (RMP-2035) for the BMA is in progress. The description of the study area is as follows:

Urban Growth Boundary (UGB)

UGB is defined as an officially adopted and mapped line that separates an urban area from its surrounding greenbelt of open lands, including farms, for a set period of time with intent to contain urban development within the planned urban areas (Sayer, 1997).

3.2.1. Bruhat Bengaluru Mahanagara Palike (BBMP):

BBMP is the fourth largest municipal corporation in India, which is spread over 762km^2 with a population of around 6.8 million as per population census (2011). The projected population for 2020 is 119,56,606. BBMP has the administrative boundary for 198 wards (Figure-3.2) within the Bengaluru Metropolitan City to regulate the zoning, building regulations, health, licensing, trade, education, infrastructure and environment such as water bodies, parks and greenery. For the ease of administration, the BBMP area has been segregated into eight zones (Figure-3.3) and further classified to 32 divisions to include the 64 revenue sub-zones to administrate the 28 Assembly constituencies (Figure-3.4). Further, the BBMP area has been surrounded by the City conurbation area, which is earmarked for the development by the BDA. The ward-wise details and 391 villages of the BBMP area are tabulated in the Table-3.1 and Table-3.2 respectively.

Bengaluru Metropolis is one of the fastest growing Cities in Asia with the average growth rate of about 12 Km² per year (Suresh, 2001). Tree-lined streets, numerous parks established by Tippu Sultan (Iyer *et al.*, 2012) and abundant greenery have led to it being called the *Garden City* of India. The Bengaluru City is transitioning from bean City to Boom City by the growth of IT (Information Technology) based industries and is known as the *Silicon Valley of India* (Revised CDP, 2009) and also *IT Hub of Asia*. The city is also called as *Pensioners Paradise*.

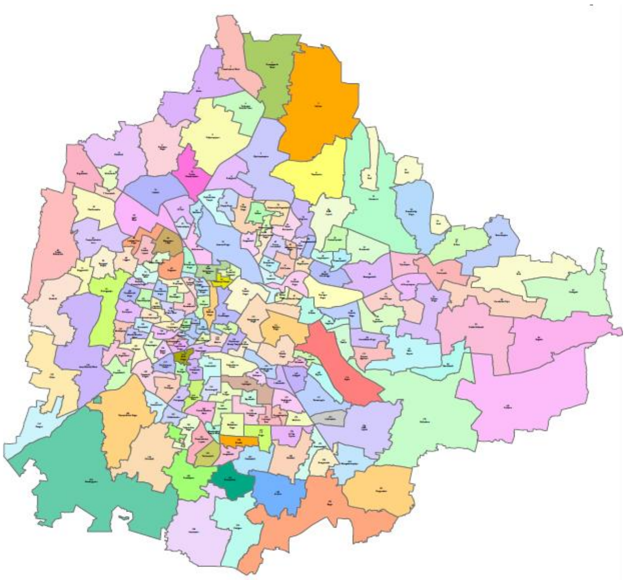


Figure-3.2. BBMP (198) ward map

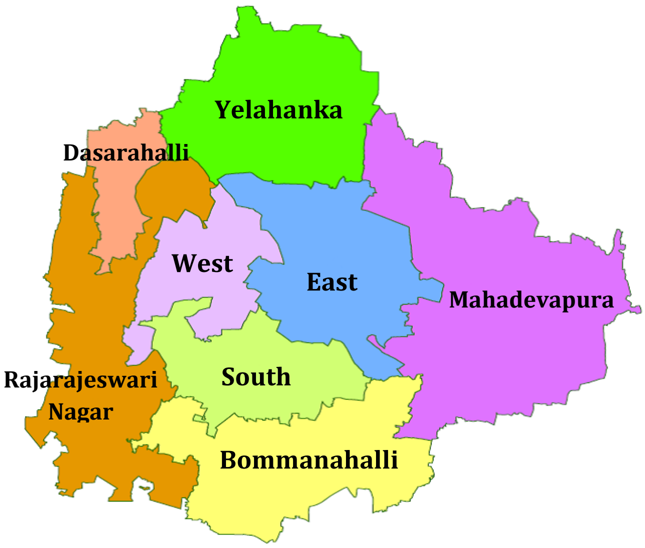


Figure-3.3. BBMP adminstrative (8) zone map

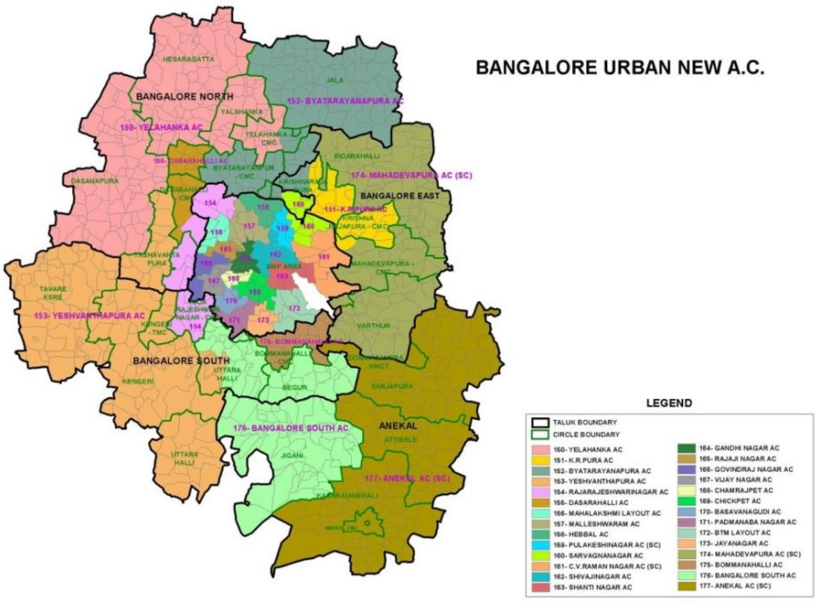


Figure-3.4. BBMP area (28) Assembly constitutions map

3.2.2. Conurbation of Bengaluru City:

Bengaluru metropolis and its conurbation have grown at the cost of agricultural land and water bodies. The conurbation of Bengaluru City has been administrated by the three tier panchayat system such as Zilla Panchayats (ZP), Taluk Panchayats (TP) and Grama Panchayats (GP) according to Panchayat Raj Institution of 73rd Constitutional amendment and Karnataka Panchayat Raj Act, 1993.

3.2.2.1. Zilla Panchayat (ZP):

Zilla Panchayat or Zilla Parishad is the district level panchayat to monitor the developmental activities and facilitate schemes. ZP is funding for development of villages in the Bengaluru urban district, which has also been involved in the revival of lakes.

3.2.2.2. Taluk Panchayat (TP):

Taluk Panchayat (TP) is the rural local government at the intermediate level in the Panchayat raj system between ZP and GP. The jurisdiction will be the taluka level and govern the villages tahsil. TP also called as Mandal Panchayat, Panchayat Samiti and Block Panchayat. TP collects the eventual plans from the GP and submit to the ZP for funding by evaluating for financial constraints, social welfare and priorities of issues. Four taluk's of Bengaluru urban district has been administrated by their respective TP (Figure-3.5) namely Bengaluru North, Bengaluru East, Anekal and Bengaluru South.

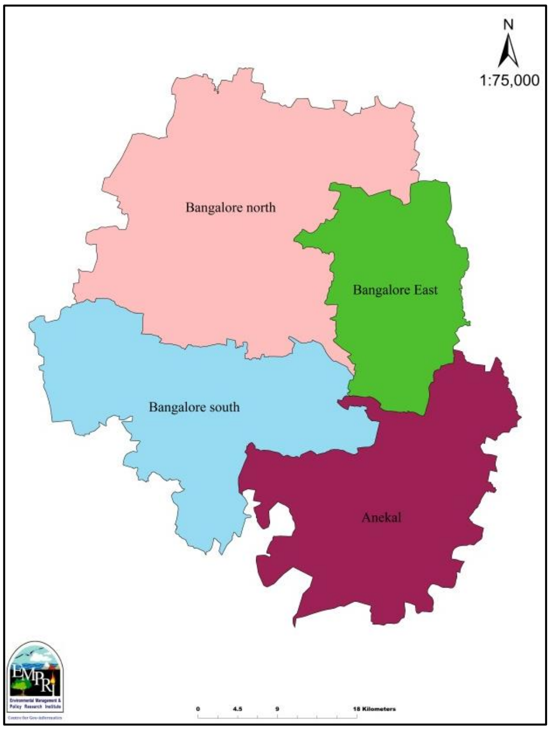


Figure-3.5. Taluk map of the Bengaluru nagara district

A. Bengaluru North Taluk:

Bengaluru North taluk is a level plateau lying between the elevation of 839 and 962msl. A prominent ridge runs from NNE to SSW through the middle of this area with the highest elevation point in the Doddabettahalli (962msl). Most of the City area is situated south of this ridge, whereas the gentle slopes and valleys on either side of this ridge are utilised for ground water extraction. Low lying areas are populated by a series of shallow tanks of varying sizes. The drainage pattern of the Bengaluru North taluk is towards the East and made up of a network of nalas, generally flowing from West to East with storage tanks along the nalas, ultimately feeding the South Pinakini River on the Western half, the nalas generally flow from East to West, ultimately draining into the Arkavati River.

The geographical area of the Bengaluru North taluk is 490km^2 with the population of 3,52,420 in the 85,722 houses as per 2011 census, which is the 3.66% share of the Bengaluru Urban district population. The projected population for 2020 is 4,99,042. The average rainfall received from 1941-2014 is 944.5mm with the 56 rainy days in the year 2014 as per the nine rain gauge stations located in the Bengaluru North taluk. There are about 98 seasonal tanks used for the irrigation of 2,102 ha. land. The biggest tank in the taluk is Hesaraghatta with a catchment area of 490Km^2, which was used as the drinking source for Bengaluru City. Paddy, jower, maize and ragi are mostly cultivable in 4415 ha. of net area as irrigation with the help of 6392 tube-wells. About 11,276 Tonnes of the chemical fertilisers are used in these agriculture lands (DoES, 2015).

Apart from the agriculture, there are 152 and 49 tanks under the Panchayat and MI respectively, utilized for the fisheries with a yield of 8,406 tonnes during the year 2013-2014. About 650 and 1623 families are dependent on fisheries as full time and part time respectively in these Bengaluru North taluk (DoES, 2015).

There are six hoblis and 39 Grama Panchayats in this taluk, the hobli's are Bengaluru Kasaba, Yeshwanthpur, Yelahanka, Jala, Hesaraghatta and Dasanapura. Peenya is one of the important industrial area in the Bengaluru North taluk. The entire Bengaluru Kasaba, Yeshwanthpur and Yelahanka hoblis villages are added to the BDA jurisdiction and the remaining villages are in the BIAAPA jurisdiction. The study area has been demarcated in the Bengaluru North taluk (Figure-3.6) and the 252 villages in the study area are tabulated in the Table-3.2.

B. Bengaluru East Taluk:

The geographical area of the Bengaluru East taluk is 96km^2 with the population of 1,02,607 as per 2011 census. The projected population for 2020 is 4,45,296. The average rainfall received from 1941-2014 is 745mm with 53 rainy days in the year 2014 as per the three rain gauge stations located in Bengaluru East taluk. Paddy, jower, maize and ragi are mostly cultivable in 987 ha. of net area as irrigation with the help of 2829 tube-wells. About 5,050 Tonnes of chemical fertilisers are used in these agriculture lands. Apart from agriculture, there are 19 Panchayat and 24 MI tanks utilized for the fisheries with a yield of 768 tonnes during the year 2013-2014. About 670 and 3103 families are dependent on fisheries as full time and part time work respectively (DoES, 2015).

There are three hoblis and 11 Grama Panchayats in this taluk; the hobli's are Varthuru, Krishnaraja (KR) Puram and Bidarahalli. The entire Varthuru, KR Puram and most of the villages in the Bidarahalli hoblis are added to the BDA jurisdiction and the remaining villages are in the APA and HPA jurisdictions. The study area has been demarcated in the Bengaluru East taluk (Figure-3.7) and the 134 villages in the study area are tabulated in the Table-3.2.

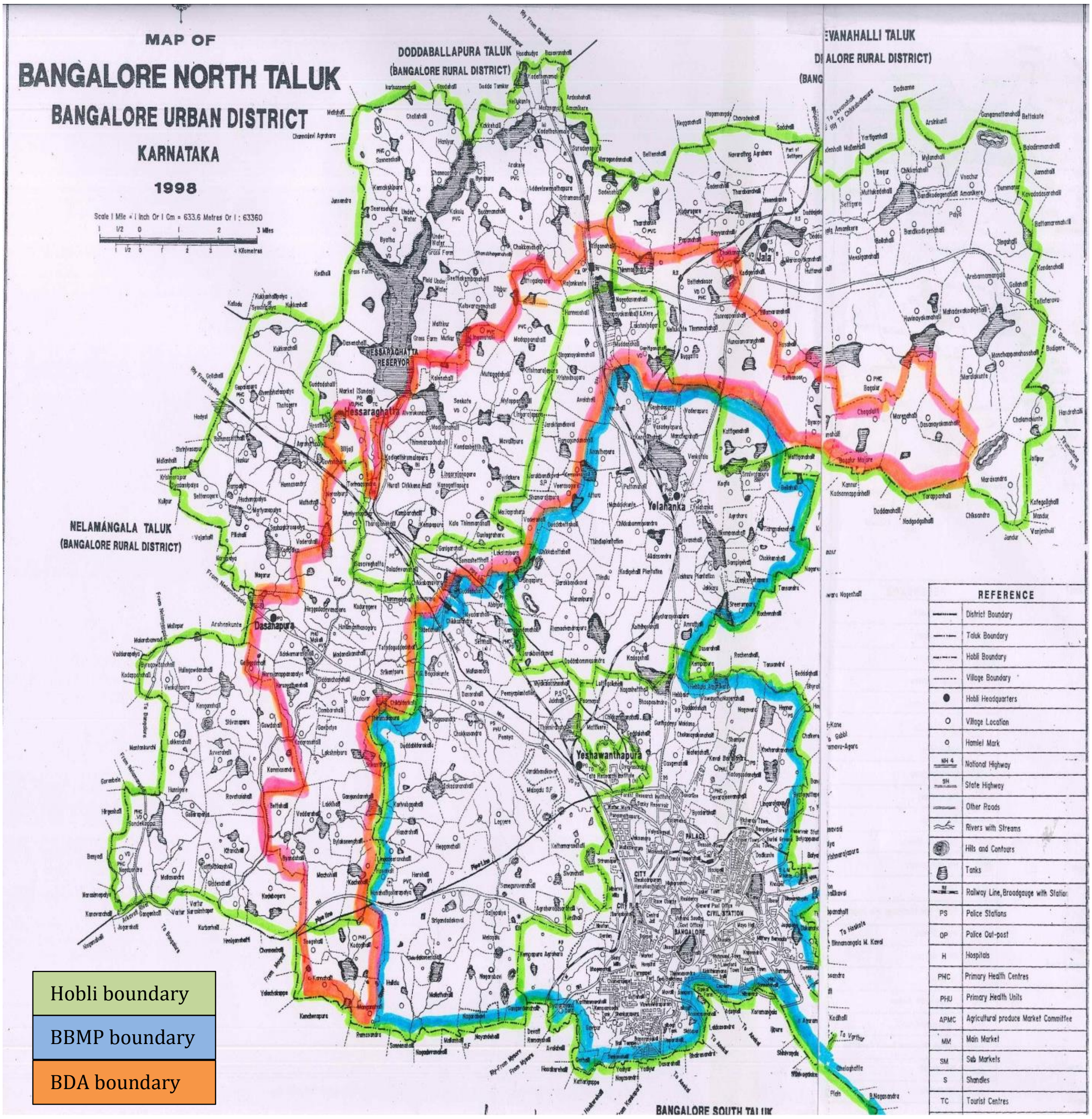


Figure-3.6. Study area demarcation on Bengaluru North taluk map

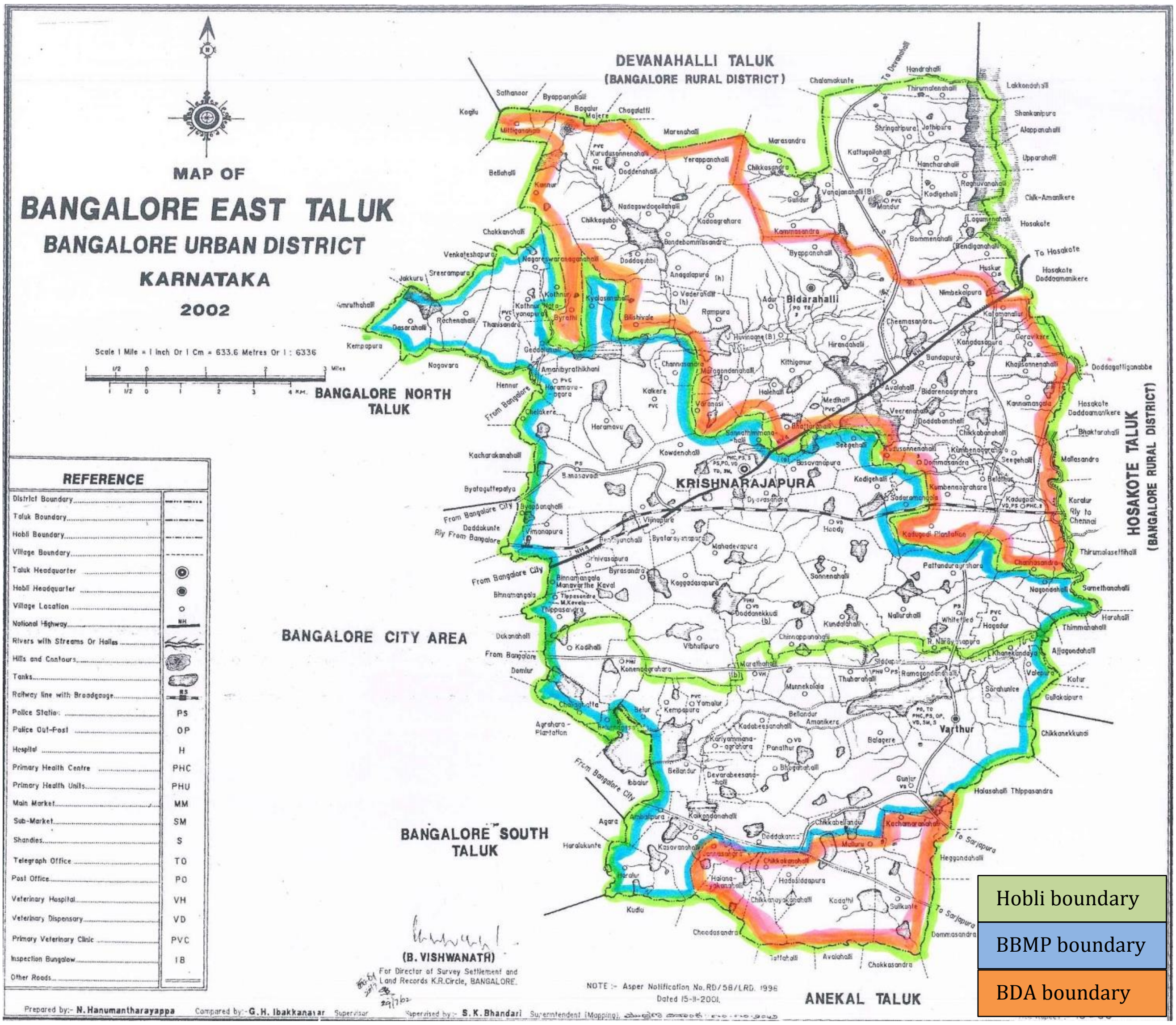


Figure-3.7. Study area demarcation on Bengaluru East taluk map

C. Anekal Taluk:

The geographical area of the Anekal taluk is 532km^2 with the population of 5,17,575 as per 2011 census. The projected population for 2020 is 7,32,908. The average rainfall received from 1941-2014 is 794mm with the 54 rainy days in the year 2014 as per the four rain gauge stations located in the Bengaluru North taluk. Paddy, jower, maize and ragi are mostly cultivable in 4564 ha. of net area as irrigation with the help of 1196 tube-wells. About 14,872 Tonnes of chemical fertilisers are used in these agriculture lands. Apart from agriculture, there are 50 Panchayat and 25 Minor Irrigation (MI) tanks utilized for the fisheries with a yield of 8,406 tonnes during the year 2013-2014. About 480 and 659 families are dependent on fisheries as full time and part time work respectively in Anekal taluk (DoES, 2015).

There are four hoblis, 18 Grama Panchayats and 234 villages in this taluk; the hobli's are Sarjapura, Attebele, Anekal and Jigani. Electronics City, the pride of India and hub of Bengaluru's Information Technology companies is also situated in Anekal Taluk. Only the few villages in the Sarjapura, Attebele and Jigani hoblis are added to the BDA jurisdiction and the remaining villages falls under the APA (Anekal Planning Authority) jurisdiction. The study area has been demarcated in the Anekal taluk (Figure-3.8) and the 55 villages in the study area are tabulated in the Table-3.2.

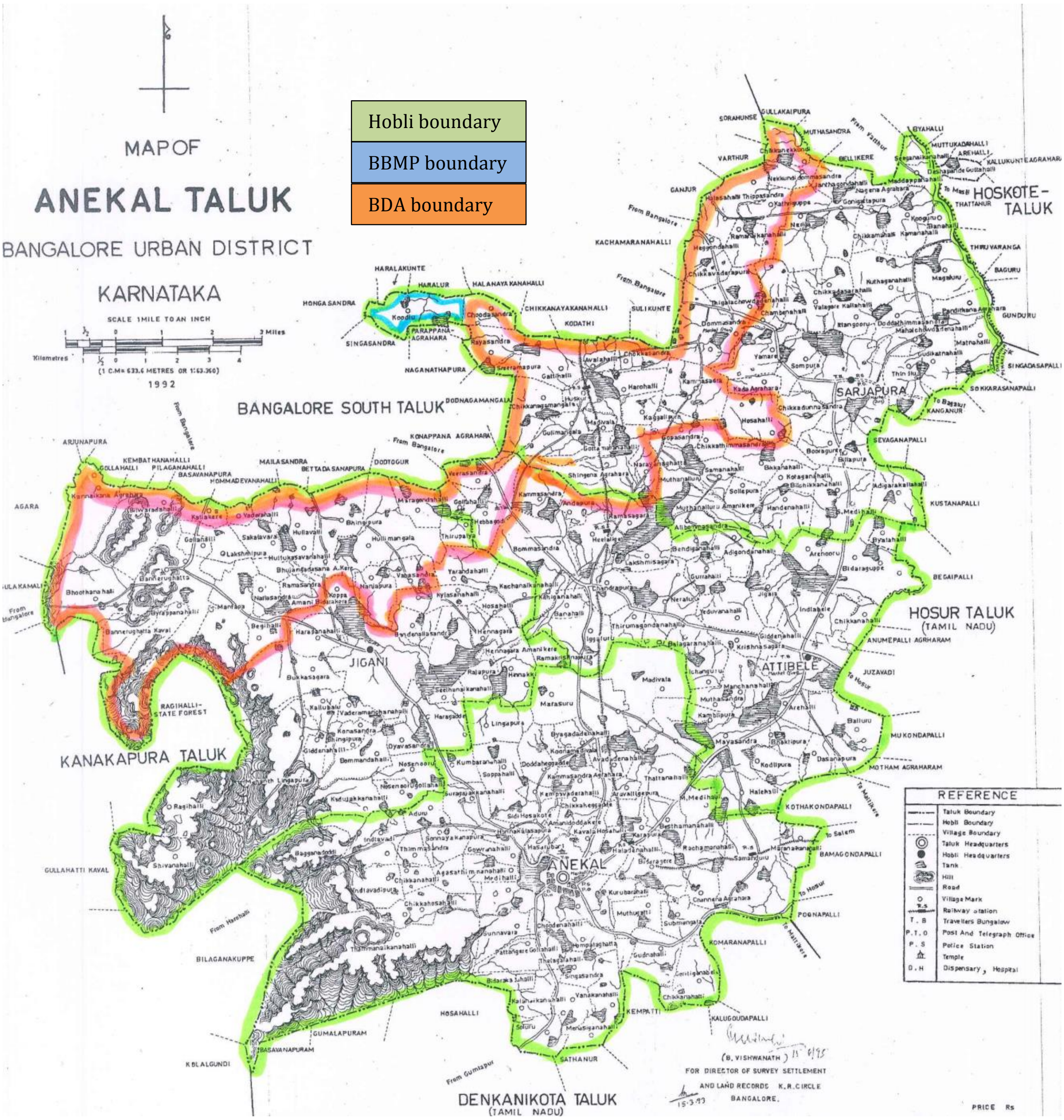


Figure-3.8. Study area demarcation on Anekal taluk map

D. Bengaluru South Taluk:

Bengaluru South taluk represents an uneven landscape with intermingling of hills, valleys and bare rocky outcrops of granites and gneisses, which raising from 30-70 meters above ground level are common. The highest point is 908m and the lowest at 720m above msl. Southern and Western portions present a rugged topography composed of Granitic and Gneissic masses. The Eastern portions of the taluk form an almost featureless plain with minor undulations. This taluk drains to the East into the South Pinakini basin and to the West into the Arkavati basin. The Vrishabhavati is the only minor river which flows in the taluk and ultimately joins the river Arkavati.

The geographical area of the Bengaluru South taluk is 381km^2 with the population of 2,05,274 as per 2011 census. The projected population for 2020 is 2,90,677. The average rainfall received from 1941-2014 is 932mm with the 59 rainy days in the year 2014 as per the seven rain gauge stations located in the Bengaluru South taluk. This taluk has about 166 tanks irrigating about 4,450 ha of land. The major tanks include those of Bellandur and Varthur with a catchment area of 3.5 and 1.8Km^2 respectively. The taluk includes parts of Chamarajaendra reservoir and Hoskote tanks. Paddy, jower, maize and ragi are mostly cultivable in 1718 ha. of net area as irrigation is with the help of 5427 tube-wells. About 9,917 Tonnes of chemical fertilisers are used in these agriculture lands. Apart from agriculture, there are 27 Panchayat and 14 Minor Irrigation (MI) tanks which are utilized for the fisheries with a yield of 975 tonnes during the year 2013-2014. About 855 and 1560 families are dependent on fisheries as full time and part time work respectively in these Bengaluru South taluk (DoES, 2015).

There are four hoblis and 15 Grama Panchayats in this taluk; the hobli's are Begur, Uttarahalli, Kengeri and Thaverekere. Entire Begur and Kengeri hoblis and part of villages in the Thaverekere and Uttarahalli hoblis are added to the BDA jurisdiction and the remaining villages fall under the NPA (Nelamangala Planning Authority) and KPA (Kanakapura Planning Authority) jurisdiction. The study area has been demarcated in the Bengaluru South taluk (Figure-3.9) and the 149 villages in the study area are tabulated in the Table-3.2.

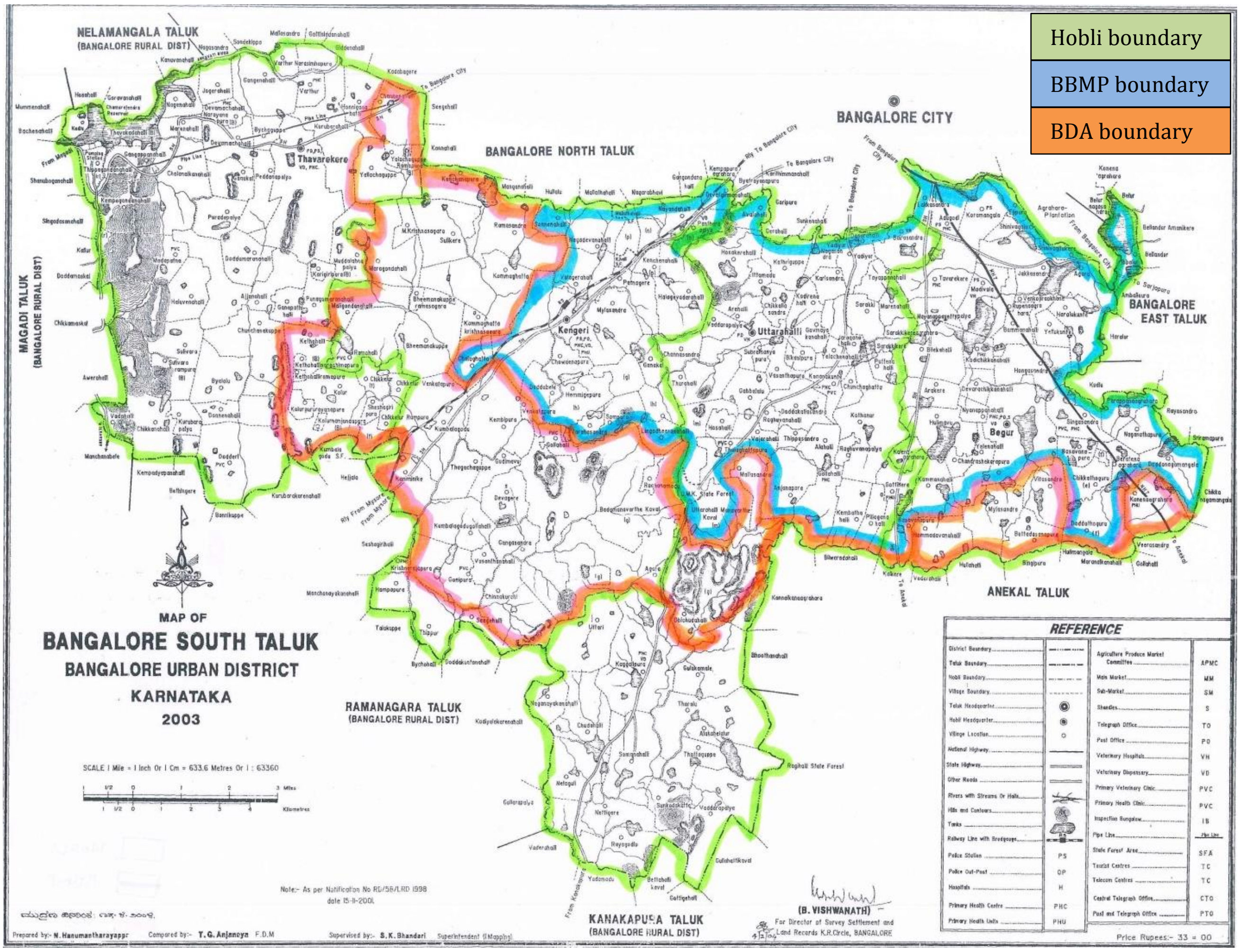


Figure-3.9. Study area demarcation on Bengaluru South taluk map

3.2.2.3. Grama Panchayat (GP):

Grama Panchayat (GP) has been formed to administrate locally by providing the services at village level. There are 95 GP in the Bengaluru urban district, within that 49 GP are falls under the BDA area (Table-3.1). The numbers of GP in the study area are 25 of 39 GP in Bengaluru North, 10 of 11 GP in Bengaluru East, 5 of 27 GP in Anekal and 9 of 18 GP in Bengaluru South hoblis. Small water bodies such as the *Gokatte* and *Kunte* have been maintained by the specific GP in the study area.

3.2.3. Bangalore Mysore Infrastructure Corridor Area Planning Authority (BMICAPA):

BMICAPA is an Authority to implement and maintain the corridor between the two Cities of Bengaluru and Mysuru. The jurisdiction of the Authority covers a total area of 701.96Km^2 including the entire 140 villages and part of 54 villages as per the Government notification No. 130 dated 20.11.2001. BMICAPA has collaborated with the BDA for preparation of planning a map for their jurisdiction. BMICAPA has developed the 41 km of peripheral road around Bengaluru City with 9.1km of link road, 13km of expressway road and eight interchanges located within the Bengaluru City. About 87.5Km^2 of BMICAPA area falls under the jurisdiction of the BDA planning area (BDA, 2012), which comprise of entire 12 villages and part of 49 villages. The BMICAPA area, which falls in the BDA jurisdiction is also included in the present project study area and the BMICAPA villages in the study area are tabulated in the Table-3.3.

3.3. Geology of Study Area:

The topography of the study area is an upland plain, surrounded by undulating conurbation area. Bengaluru is approximately located in the Centre of Mysore Plateau, part of Precambrian Deccan Plateau with granites and gneisses, which are prominently exposed as a central ridge running NNE - SSW in Bengaluru North. Pegmatitic and aplitic veins and basic xenolithic patches gently crisscross granitic gneisses. The rocks are highly jointed and act as good hard rock aquifers. These rock formations have suffered considerable weathering particularly in the low-lying nala sections and also act as an aquifer. Granites and gneisses are intruded by a number of basic dykes that are oriented East-west and North-south. Dykes form a barrier to groundwater movement in this region.

Laterite capping is found at the high elevations, overlying deeply weathered gneisses producing various shades of clay. Laterite areas represent old erosional surfaces that have a thicker layer of weathered horizon than the lower areas. In Bengaluru South, granitic gneisses are exposed as continuous chains of mounds rising 30 to 70m. Granites are medium to coarse grained hard, compact and massive. Granites and gneisses have undergone different degree of alteration and decomposition. The southern and eastern areas have deep weathered zones in valleys, in a highly dissected terrain. Apart from the lateritic soil, the upland also covered by red loamy soil with depth range from 2 to 5 m; below the soil is a weathered zone of 5 - 20 m depth. In general, productive aquifers range from 100 to 110 m depth.

Bengaluru is situated almost equidistant from both the eastern and western coasts of the South Indian peninsula. Bengaluru North is almost flat surface and Bengaluru South has uneven landscape with many hills and valleys. The topography is flat excluding a central ridge running from NNE to SSW. The highest point measured is Doddabettahalli, which is 962 m and lies above this ridge.

3.4. Climatology of Study Area:

The Bengaluru City is situated at an altitude of 920m above mean sea level. Due to its altitude, the City experiences a tropical savanna climate with distinct dry and wet seasons. The city is blessed with a pleasant weather throughout the year. Though with the urbanization, the City's temperature has increased to a maximum of 36°C, the weather in the City is still considered to be one of the coolest Cities of India. The annual precipitation over the study area is 900mm with 50 rainy days with a mean temperature of 27°C. It rains intermittently from June to December and the area receives both Southwest and Northeast monsoon rains (Nayaka *et al*., 2003). About 85% of the rainfall is recorded between 4 P.M. and 7 P.M. in the evening. A relatively higher precipitation has brought Bengaluru to 'Stand Still' condition due to water inundation. This is a common phenomenon in every rainy season. The mean monthly relative humidity reaches as low as 44% in the month of March and reaches the other extreme of 80 to 85% in the period from June and October. Surface winds in Bengaluru has seasonal variations (either East or West), with Eastern winds dominating the year. General wind speed averages from 9 km/h to 17 km/h.

3.5. Hydromorphology of Study Area:

The undulating topography of the terrain facilitated the creation of a large number of water bodies in the past, providing for the traditional uses of irrigation, drinking, fishing and washing. These water bodies had also ameliorated the local climate within City, and maintained a good water balance in the neighborhood. The undulating topography, featured by a series of valleys radiating from a ridge, forms three major watersheds namely the Hebbal Valley, Vrishabhavathi Valley and, Koramangala and Challaghatta Valleys that holds rain water and is utilized in dry periods. Lakes in Bengaluru City form a hydrological chain. The monsoon runoff flow of water runs from North to South East as well as the South West along the natural gradient. These lakes act as a six chain of reservoirs in all the three valleys (Figure-3.10). From the ridges, of each of these three valleys, small streams originate. These channels then cascade down to form major channel systems in three valleys. All three valleys of Bengaluru, Hebbal in the North, Koramangala and Challaghatta in the East and Vrushabhavati in the Southwestern zones are broken up into two series, which in turn

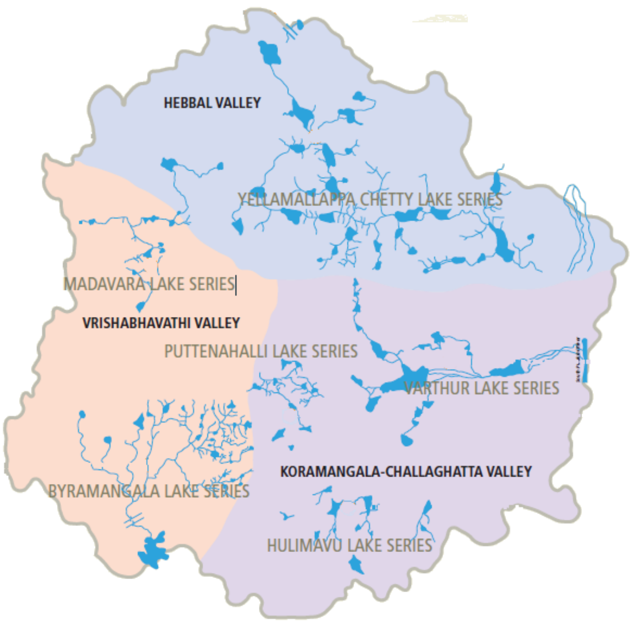


Figure-3.10. Valley map of the study area comprise many lakes. This lake series has both, within the valley and inter valley connectivity. The entire network facilitates the downward flow of excess water from lakes in the upper ridges. This system also serves as flood controllers.

Bengaluru is not blessed with any major river. The Arkavati river flows through Bengaluru North Taluk for a short distance. Vrushabhavati river originates from Basavanagudi within the City and flows to join the river Arkavati as tributary near Muduvadidurga. The area of the Bengaluru South drains to the East into the South Pinakini basin and to the West into the Arkavati basin. The eastern portion of Bengaluru is marked by a series of tanks of varying size (Shankar, 2008). At present, Arkavathi and Vrishabhavathi rivers carry most of Bengaluru's sewage.

3.6. Demography of the Study area:

Bengaluru urban area of the Bengaluru urban district had 6.5 million of population in 2001, which was 9.5 million in 2011. The urban population is 15.69% of the total population of Karnataka State. About 84% of the Bengaluru urban district population is living in the Bengaluru urban agglomeration alone (Umesh, 2013). The urban social structure is complex with the fusion of native and migrant cultural groups and the migrants comprising of rural communities and cultural environments. The different social background, education levels, aspirations, etc. have made the urban life more heterogeneous and competitive. Bengaluru housed a population of 8.5 million in 2011, which made it the third most populous city in India after Mumbai and Delhi (Census of India, 2011). In addition to informal settlements, there is a floating population of about 0.5 million annually (Bhattacharjee and Yadav, 1993). In 2016, the population grew to 11.5 million. The population density was 2,985 in 2001 and grew to 4,378 in 2011. The decadal growth of the population in the Bengaluru City is tabulated in the Table-3.4.

Table-3.1. Details of BBMP area

Ward No.	Ward Name	Sub-Zone	Division	Zone	Assembly Constituency No.	Assembly Constituency Name
1.	Kempegowda Ward	Yelahanka	Yelahanka	Yelahanka	150	Yelahanka
2.	Chowdeshwari Ward					
3.	Attur	Yelahanka Satellite Town				
4.	Yelahanka Satellite Town					
5.	Jakkur	Bytarayanapura	Bytarayanapura		152	Bytarayanapura
6.	Thanisandra					
7.	Bytarayanapura	Kodigehalli				
8.	Kodigehalli					
9.	Vidyaranyapura	Vidyaranyapura				
10.	Doddabommasandra					
11.	Kuvempu Nagara					
12.	Shettyhalli	Shettyhalli	Dasarahalli	Dasarahalli	155	Dasarahalli
13.	Mallasandra					
14.	Baagalakunte	T. Dasarahalli				
15.	T. Dasarahalli					
16.	Jalahalli	Yeshwanthpur	Yeshwanthpur	Rajarajeswari Nagar	154	Rajarajeswari Nagar
17.	J.P. Park					
18.	Radhakrishna Temple Ward	Hebbal	Hebbal	East	158	Hebbal
19.	Sanjay Nagar					
20.	Ganga Nagar					
21.	Hebbala					
22.	Vishwanath Nagenahalli	J.C. Nagar				
23.	Nagavara	H.B.R Layout	Sarvagna Nagar		160	Sarvagna Nagar
24.	H.B.R Layout					
25.	Horamavu	Horamavu	K.R. Puram	Mahadevpura	151	K.R. Puram
26.	Rammurthy Nagar					
27.	Banaswadi	Maruthiseva Nagar	Sarvagna Nagar	East	160	Sarvagna Nagar
28.	Kammanahalli					
29.	Kacharakanahalli	H.B.R Layout				
30.	Kadugondanahalli					

31.	Kushala Nagar	K.G. Halli	Pulakeshi Nagar		159	Pulakeshi Nagar
32.	Kavalbyrasandra					
33.	Manorayanapalya	J.C. Nagar	Hebbal		158	Hebbal
34.	Gangenahalli					
35.	Palace Nagar	Mathikere	Malleshwaram	West	157	Malleshwaram
36.	Mathikere					
37.	Yeshwanthpura	Yeshwanthpur	Yeshwanthpur	Rajarajeswari Nagar	154	Rajarajeswari Nagar
38.	H.M.T	Lakshmidevi Nagar				
39.	Chokkasandra	Peenya Industrial Area	Hegganahalli	Dasarahalli	155	Dasarahalli
40.	Doddabidarakalu	Herohalli	Kengeri	Rajarajeswari Nagar	153	Yeshwanthpur
41.	Peenya Industrial Area	Peenya Industrial Area	Hegganahalli	Dasarahalli	155	Dasarahalli
42.	Lakshmidevi Nagar	Lakshmidevi Nagar	Yeshwanthpur	Rajarajeswari Nagar	154	Rajarajeswari Nagar
43.	Nandini Layout	Mahalakshmi Layout	Mahalakshmi Layout	West	156	Mahalakshmi Layout
44.	Marappanapalya					
45.	Malleshwaram	Mathikere	Malleshwaram		157	Malleshwaram
46.	Jayachamarajendra Nagar	J.C. Nagar	Hebbal	East	158	Hebbal
47.	Devarajeevanahalli	Pulakeshi Nagar	Pulakeshi Nagar		159	Pulakeshi Nagar
48.	Muneshwaranagar	K.G. Halli				
49.	Lingarajapura	Maruthiseva Nagar	Sarvagna Nagar		160	Sarvagna Nagar
50.	Benaganahalli	C.V. Raman Nagar	C.V. Raman Nagar		161	C.V. Raman Nagar
51.	Vignananapura	Horamavu	K.R. Puram	Mahadevpura	151	K.R. Puram
52.	K.R. Puram	K.R. Puram				
53.	Basavanapura					
54.	Hoodi	Hoodi	Mahadevpura		174	Mahadevpura
55.	Devasandra	K.R. Puram	K.R. Puram		151	K.R. Puram
56.	A. Narayanapura	HAL Airport				
57.	C.V. Raman Nagar	C.V. Raman Nagar	C.V.Raman nagar	East	161	C.V. Raman Nagar
58.	Hosa Thippasandra					
59.	Maruthiseva Nagar	Maruthiseva Nagar	Sarvagna Nagar		160	Sarvagna Nagar
60.	Sagayapuram	K.G. Halli	Pulakeshi Nagar		159	Pulakeshi Nagar
61.	S.K. Garden	Pulakeshi Nagar				

62.	Ramaswamy Palya	Vasantha Nagar	Shivaji Nagar		162	Shivaji Nagar
63.	Jayamahal					
64.	Rajamahal Guttahalli	Malleshwaram	Malleshwaram	West	157	Malleshwaram
65.	Kadu Malleshwaram					
66.	Subramanya Nagar					
67.	Nagapura	Nagapura	Mahalakshmi Layout	Mahalakshmi Layout	156	Mahalakshmi Layout
68.	Mahalakshmipuram	Mahalakshmi Layout				
69.	Laggere	Laggere	Rajarajeswari Nagar	Rajarajeswari Nagar	154	Rajarajeswari Nagar
70.	Rajagopala Nagar	Hegganahalli	Hegganahalli	Dasarahalli	155	Dasarahalli
71.	Heggenahalli					
72.	Herohalli	Herohalli	Kengeri	Rajarajeswari Nagar	153	Yeshwanthpur
73.	Kottegepalya	Laggere	Rajarajeswari Nagar		154	Rajarajeswari Nagar
74.	Shakti Ganapathiinagar	Mahalakshmi Layout	Mahalakshmi Layout	West	156	Mahalakshmi Layout
75.	Shankaramatha	Nagapura				
76.	Gayathrinagar	Malleshwaram	Malleshwaram			Malleshwaram
77.	Dattatreya Temple	Gandhi Nagar	Gandhi Nagar		164	Gandhi Nagar
78.	Pulakeshi Nagar	Pulakeshi Nagar	Pulakeshi Nagar	East	159	Pulakeshi Nagar
79.	Sarvagna Nagar	C.V. Raman Nagar	C.V. Raman Nagar		161	C.V. Raman Nagar
80.	Hoysalanagar	Jeevanbhima Nagar				
81.	Vignanannagar	HAL Airport	K.R.Puram	Mahadevpura	151	K.R.Puram
82.	Garudacharpalya	Hoodi	Mahadevpura		174	Mahadevpura
83.	Kadugodi	Whitefield				
84.	Hagadooru					
85.	Dodda Nekkundi	Hoodi				
86.	Marathhalli	Marathhalli				
87.	HAL Airport	HAL Airport	K.R. Puram		151	K.R. Puram
88.	Jeevanbhima Nagar	Jeevanbhimanagar	C.V. Raman Nagar	East	161	C.V. Raman Nagar
89.	Jogupalya	Domlur	Shanthi Nagar		163	Shanthi Nagar
90.	Halsur	Shivaji Nagar	Shivaji Nagar		162	Shivaji Nagar
91.	Bharathi Nagar					
92.	Shivaji Nagar					
93.	Vasantha Nagar	Vasantha Nagar				
94.	Gandhi Nagar	Gandhi Nagar	Gandhi Nagar	West	164	Gandhi Nagar

95.	Subhash Nagar					
96.	Okalipuram					
97.	Dayananda Nagar	Srirammandira				
98.	Prakash Nagar					
99.	Rajaji Nagar	Rajaji Nagar	Rajaji Nagar		165	Rajaji Nagar
100.	Basaveshwar Nagar					
101.	Kamakshipalya					
102.	Vrishabavathi Nagar	Nagapura	Mahalakshmi Layout	West	156	Mahalakshmi Layout
103.	Kaveripura	Govindaraja Nagar	Govindaraja Nagar	South	166	Govindarj Nagara
104.	Govindaraja Nagar					
105.	Agrahara Dasarahalli					
106.	Dr.Rajkumar Ward					
107.	Shiva Nagar	Rajaji Nagar	Rajaji Nagar	West	165	Rajaji Nagar
108.	Sri Rama Mandir	Sriram mandira				
109.	Chikpet	Chikpet	Gandhi Nagar		164	Gandhi Nagar
110.	Sampangirama Nagar	Vasantha Nagar	Shivaji Nagar	East	162	Shivaji Nagar
111.	Shantala Nagar	Shanthi Nagar	Shanthi Nagar		163	Shanthi Nagar
112.	Domlur	Domlur				
113.	Konena Agrahara	Jeevanbhima Nagar	C.V. Raman Nagar		161	C.V. Raman Nagar
114.	Agara	Domlur	Shanthi Nagar		163	Shanthi Nagar
115.	Vanarpete					
116.	Neelasandra	Shanthi Nagar				
117.	Shanthi Nagar					
118.	Sudhama Nagar	Kempegowda Nagar	Chikpet	South	169	Chikpet
119.	Dharmarayaswamy Temple					
120.	Cottonpet	Chikpet	Gandhi Nagar	West	164	Gandhi Nagar
121.	Binnypet					
122.	Kempapura Agrahara	Vijaya Nagar	Vijaya Nagar	South	167	Vijaya Nagar
123.	Vijaya Nagar					
124.	Hosahalli					
125.	Marenahalli	Govindaraja Nagar	Govindaraja Nagar		166	Govindarj Nagara
126.	Maruthi Mandira Ward	Chandra Layout				
127.	Moodalapalya					

128.	Nagarabhavi					
129.	Jnanabharathi	Rajarajeswari Nagar	Rajarajeswari Nagar	Rajarajeswari Nagar	154	Rajarajeswari Nagar
130.	Ullalu	Kengeri	Kengeri		153	Yeshwanthpur
131.	Nayandahalli	Chandra Layout	Govindarj Nagara	South	166	Govindarj Nagara
132.	Athiguppe	Gali Anjaneya Temple	Vijaya Nagar		167	Vijaya Nagar
133.	Hampi Nagar					
134.	Bapuji Nagar	Vijaya Nagar				
135.	Padarayanapura	Jagajeevanram Nagar	Chamrajpet	West	168	Chamrajpet
136.	Jagajeevanram Nagar					
137.	Rayapuram					
138.	Balavadhinagar					
139.	K.R. Market	Chamrajpet				
140.	Chamrajpet					
141.	Azadnagar					
142.	Sukenahalli	Kempegowda Nagar	Chikpet	South	169	Chikpet
143.	Vishveshwarapuram					
144.	Siddapura	Hombegowda Nagar				
145.	Hombegowda Nagar					
146.	Lakkasandra	B.T.M Layout	B.T.M Layout		172	B.T.M Layout
147.	Adugodi	Koramangala				
148.	Ejipura					
149.	Varthur	Whitefield	Mahadevpura	Mahadevpura	174	Mahadevpura
150.	Bellandur	Marathalli				
151.	Koramangala	Koramangala	B.T.M Layout	South	172	B.T.M Layout
152.	Sudduguntepalya	B.T.M Layout				
153.	Jaya Nagar	Hombegowda nagar	Hombegowda nagar		169	Chikpet
154.	Basavanagudi	Basavanagudi	Basavanagudi		170	Basavanagudi
155.	Hanumantha Nagar					
156.	Sriinagar	Giri Nagar				
157.	Gali Anjaneya Temple	Gali Anjaneya Temple	Vijaya Nagar		167	Vijaya Nagar
158.	Deepanjali Nagar					
159.	Kengeri	Kengeri	Kengeri	Rajarajeswari Nagar	153	Yeshwanthpur
160.	Rajarajeshwari Nagar	Rajarajeswari Nagar	Rajarajeswari Nagar		154	Rajarajeswari Nagar

161.	Hosakerehalli	Padmanabha Nagar	Padmanabha Nagar	South	171	Padmanabha Nagar
162.	Giri Nagar	Giri Nagar	Basavanagudi		170	Basavanagudi
163.	Kathriguppe					
164.	Vidyapeeta Ward	Basavanagudi				
165.	Ganesha Temple Ward	Banashankari	Padmanabha Nagar		171	Padmanabha Nagar
166.	Karisandra					
167.	Yediyur					
168.	Patttabiraman Nagar	Jaya Nagar	Jaya Nagar		173	Jaya Nagar
169.	Byrasandra			South		
170.	Jaya Nagar East					
171.	Gurappanapalya					
172.	Madivala	B.T.M Layout	B.T.M Layout		172	B.T.M Layout
173.	Jakkasandra	Koramangala				
174.	H.S.R.Layout	H.S.R.Layout	Bommanahalli	Bommanahalli	175	Bommanahalli
175.	Bommanahalli	Bommanahalli				
176.	B.T.M Layout	B.T.M Layout	B.T.M Layout	South	172	B.T.M Layout
177.	J.P. Nagar	J.P. Nagar	Jaya Nagar		173	Jaya Nagar
178.	Sarakki					
179.	Shakambari Nagar					
180.	Banashankari Temple Ward	Banashankari	Padmanabha Nagar		171	Padmanabha Nagar
181.	Kumaraswamy Layout	Padmanabha Nagar				
182.	Padmanabha Nagar					
183.	Chikkalasandra					
184.	Uttarahalli	Uttarahalli	Uttarahalli	Bommanahalli	176	Bengaluru south
185.	Yelachenahalli	Yelachenahalli				
186.	Jaraganahalli	Arakere	Bommanahalli		175	Bommanahalli
187.	Puttenahalli					
188.	Bilekahalli	Bommanahalli				
189.	Hongasandra					
190.	Mangamanapalya	H.S.R. Layout				
191.	Singasandra	Begur	Anjanapura		176	Bengaluru south
192.	Begur					
193.	Arakere	Arakere	Bommanahalli		175	Bommanahalli

194.	Gottigere	Anjanapura	Anjanapura		176	Bengaluru south
195.	Konanakunte	Yelachenahalli	Uttarahalli			
196.	Anjanapura	Anjanapura	Anjanapura			
197.	Vasanthapura	Uttarahalli	Uttarahalli			
198.	Hemigepura	Kengeri	Kengeri	Rajarajeswari Nagar	153	Yeshwanthpur

Table-3.2. List of villages in the study area (BMA)

S.No.	Village Name
Bengaluru North Taluk	
Bengaluru Kasaba Hobli	
1.	Agrahara Thimmasandra
2.	Akkithimmanahalli
3.	Annipura
4.	Arekempanahalli
5.	Bengaluru Old City
6.	Bengaluru City Railway Station
7.	Bariga Mudinahalli
8.	Bhogenahalli
9.	Bhupasandra
10.	Bilekalli
11.	Binnamangala
12.	Byadarahalli
13.	Byadarahalli Railway
14.	Byataguttapalya
15.	Byatrayanapura
16.	Chikkamaranahalli
17.	Cholanayakanahalli
18.	Civil Station
19.	Devara Jeevanahalli
20.	Dondu Upparahalli
21.	Dokkanahalli
22.	Dodda Bailakhana
23.	Dodkunte
24.	Dodkunte Railway

S.No.	Village Name
25.	Dodkunte Ruthrabhoomi
26.	Domluru
27.	Dyavasandra
28.	Forest Research Institute
29.	Gangenahalli
30.	Gavipura
31.	Geddalahalli
32.	Gerihalli
33.	Guddadahalli
34.	Gurihodeyo Maidana
35.	Guttehalli
36.	Hanumanthapura
37.	Hebbal
38.	Hebbal Amanikere
39.	Hennur
40.	Jakasandra
41.	Jedihalli
42.	Kacharakanahalli
43.	Kadagondanahalli
44.	Karithimmanahalli
45.	Kavala Byrasandra
46.	Kempambudhi Kere
47.	Kempapura Agrahara
48.	Kupsandra
49.	Lingarajapura
50.	Lottegollahalli

S.No.	Village Name
51.	Malenahalli
52.	Mattadahalli
53.	Mattikere
54.	Mavalli
55.	Nagashettyhalli
56.	Nagawara
57.	Nillsandra
58.	Purnapura
59.	Rajamahal
60.	Ranganathapura
61.	Sampigehalli
62.	Savarline
63.	Shamapura
64.	Siddapur
65.	Sonnenahalli
66.	Sunkanahalli
67.	Tata Research Institute
68.	Ulsoor
69.	Upparahalli
70.	Valyalikaval
71.	Vishwanthnagenahalli
72.	Water Works
Yeshwanthpura Hobli	
73.	Abbigere
74.	Agarahara Dasarahalli
75.	Bagalakunte

S.No.	Village Name
76.	Chikka Banavara
77.	Chikkasandra
78.	Chokkasandra
79.	Dasarahalli
80.	Doddabidrakallu
81.	Gangondanahalli
82.	Ganigarahalli
83.	Gidadhakonehalli
84.	Guladahalli
85.	Handrahalli
86.	Hegganahalli
87.	Herohalli
88.	Hosahalli Golarapalya
89.	Jalahalli
90.	Kammagondanahalli
91.	Kannehalli
92.	Karivobanahalli
93.	Kasaba Yeshwanthpura
94.	Kethamaranahalli
95.	Kodagehalli
96.	Laggere
97.	Lakshmipura
98.	Lingadeeranahalli
99.	Malegulu
100.	Malegulu SF
101.	Mallasandra
102.	Mallathahalli
103.	Manganahalli

S.No.	Village Name
104.	Myadharahalli
105.	Myakalachinnahalli
106.	Nagarbhavi
107.	Nagasandra
108.	Nallakadirenahalli
109.	Peenya
110.	Peenya Plantation
111.	Sajje Palya
112.	Sane Guruvanahalli
113.	Seegahalli
114.	Settyhalli
115.	Sidedanahalli
116.	Sivanahalli
117.	Srigandhadakavalu
118.	Soma Shettyhalli
119.	Thanniranahalli
120.	Thirumalapura
121.	Ullalu
Yelahanka Hobli	
122.	Agarahara
123.	Allalsandra
124.	Amruthahalli
125.	Ananthapura
126.	Attur
127.	Avalahalli
128.	Bellahalli
129.	Byatarayanapura
130.	Chikkabettahalli

S.No.	Village Name
131.	Chikkabommasandra
132.	Chokkanahalli
133.	Doddabettahalli
134.	Doddabommasandra
135.	Gantiganahalli
136.	Ghastikempanahalli
137.	Govindapura (Gollahalli)
138.	Harohalli
139.	Honnenahalli
140.	Jakkuru
141.	Jakkuru Plantation
142.	Jarakbande Kaval (Part-2 & 3)
142.	Jarakabande Kaval (T4)
143.	Jarakbande Kaval S.P
144.	Kasaba Yelahanka
145.	Kempanahalli
146.	Kempapura
147.	Kenchanahalli
148.	Kadigehalli
149.	Kodigehalli Plantation
150.	Kogilu
151.	Kothi Hosahalli
152.	Krishnasagara
153.	Lakshmisagara
154.	Manchenahalli
155.	Mandalakunte
156.	Medi Agrahara
157.	Muddanahalli

S.No.	Village Name
158.	Nagadasanahalli
159.	Narisapura
160.	Puttenahalli
161.	Ramachandrapura
162.	Ramagondanahalli
163.	Sampigehalli
164.	Shamarajapura
165.	Shinganayakanahalli
166.	Shinganayakanahalli Amanikere
167.	Singapura
168.	Shivanahalli
169.	Srinivasapura
170.	Srirampura
171.	Thindlu
172.	Thindlu Plantation
173.	Thirumalenahalli
174.	Vaderahalli
175.	Vaderapura
176.	Vasudevapura
177.	Veerasagara
178.	Venkatala
179.	Venkateshpura
180.	Yelahanka Amanikere
Jala Hobli	
181.	Bagaluru Majare
182.	Bettahalsuru
183.	Chagalatti
184.	Dasanayakanahalli
185.	Hunasemaranahalli
186.	Kattigenahalli
187.	Marenahalli
188.	Nellukunte Thimmanahalli
189.	Sathanuru
190.	Sonnappanahalli
191.	Sugatta
192.	Thimmasandra
Hesaraghatta Hobli	
193.	Adiganahalli
194.	Bilijaji
195.	Byala (Doddad Bylakere)
196.	Guniagrahara
197.	Huralichikkanahalli
198.	Iavalukandapura
199.	Ittagalipura
200.	Kalathammanahalli
201.	Kalenhalli
202.	Kasaghattapura
203.	Kempapura
204.	Kodagi Thirumalapura
205.	Kondashettyhalli
206.	Krishnarajapura
207.	Kumberahalli
208.	Linganahalli
209.	Lingarajapura
210.	Lingarajasagara
211.	Madappanahalli
212.	Maddagirihalli
213.	Mavalipura
214.	Muttugadahalli
215.	Myalappanahalli
216.	Rajanakunte
217.	Sasaveghatta
218.	Shivakote
219.	Soladevanahalli
220.	Tharabanahalli
221.	Thimmarasanahalli
Dasanapura Hobli	
222.	Adikemaranahalli
223.	Alur
224.	Bayandahalli
225.	Bylakonenahalli
226.	Chikkabidrakallu
227.	Dasanapura
228.	Dombarahalli
229.	Gangondanahalli
230.	Gavipalya
231.	Hanumanthasagara
232.	Harokyathanahalli
233.	Heggadadevanapura
234.	Kachohalli
235.	Kadaranahalli
236.	Kuduregere
237.	Lakkenahalli (K.G.Lakkenahalli)
238.	Lakshmipura

S.No.	Village Name
239.	Machohalli
240.	Makli
241.	Madhanayakanahalli
242.	Madhavara
243.	Muniyanapalya
244.	Narasipura
245.	Narayappanapalya
246.	Shrikantapura-1
247.	Shrikantapura-2
248.	Siddanahoshalli
249.	Thammenahalli
250.	Thorenagasandra
251.	Thotadhaguddadhahalli
252.	Vadddarahalli
Bengaluru East	
Varthuru Hobli	
253.	Ambalipura
254.	Balagere
255.	Bellandur
256.	Bellandur Amanikere
257.	Belur
258.	Belur Nagasandra
259.	Bhoganahalli
260.	Challaghatta
261.	Chikkabelandur
262.	Chikkakanneli
263.	Chikkanayakanahalli
264.	Devarabeesanahalli

S.No.	Village Name
265.	Doddakannenahalli
266.	Gunjuru
267.	Halanayakanahalli
268.	Haralur
269.	Junnasandra
270.	Kachamaranahalli
271.	Kadabeesanahalli
272.	Kaikondanahalli
273.	Kariyammana Agrahara
274.	Kasavanahalli
275.	Kempapura
276.	Khane Kandaya
277.	Kodathi
278.	Kodihalli
279.	Konena Agrahara
280.	Mallur (Mulluru)
281.	Marathahalli (Marutthahalli)
282.	Munnikolala
283.	Panathur
284.	Ramagondanahalli
285.	Hado Siddapura
286.	Siddapura
287.	Sorahunase
288.	Sulikunte (Sulakunte)
289.	Thumbrahalli
290.	Valepura
291.	Varthur
292.	Yamalur

S.No.	Village Name
Krishnarajapuram (KR Puram) Hobli	
293.	Amani Byrathikhane
294.	Banaswadi
295.	Basavanapura
296.	Bendiganahalli
297.	Binnamangala Manavarthikaval
298.	Byappanahalli
299.	Byatarayanapura Narayanapura
300.	Byrasandra
301.	Chellakere
302.	Channasandra
303.	Chinnappanahalli
304.	Dasarahalli
305.	Devasandra
306.	Doddanekkudi
307.	Geddalahalli
308.	Hagaduru
309.	Hoarumavu Agara
310.	Hoodi
311.	Horamavu
312.	Kaggadasapura
313.	Kalakere
314.	Kowdenahalli (Kavudenahalli)
315.	Kodigehalli
316.	Kottanur
317.	Kottanur Narayanapura
318.	Krishnarajapura (Kasaba)
319.	Kundarahalli

S.No.	Village Name
320.	Kyalasanahalli
321.	Mahadevapura
322.	Nagaresewara Nagenahalli
323.	Nagondanahalli
324.	Nallurahalli
325.	Pattandur Agrahara
326.	Ramagondanahalli Narayanapura
327.	Rachenahalli
328.	Sadara Mangala
329.	Seegehalli
330.	Sonnathammanahalli
331.	Sonnenahalli
332.	Srinivasapura
333.	Tannisandra
334.	Thippasandra
335.	Thippasandra Kavalu
336.	Vibhuthipura
337.	Vimanapura
338.	Vijanapura
339.	Whitefield
Bidarahalli Hobli	
340.	Adur
341.	Angalapura
342.	Avalahalli
343.	Bandapura
344.	Belathur
345.	Bhattrahalli

S.No.	Village Name
346.	Bidarahalli
347.	Bidarena Agarahara
348.	Billishivale
349.	Bande Bommasandra
350.	Byappanahalli
351.	Byrathi
352.	Channasandra
353.	Cheemasandra
354.	Chikkabanahalli
355.	Chikkagubbi
356.	Doddabanahalli
357.	Doddagubbi (Srigubbi)
358.	Doddenahalli
359.	Dommasandra
360.	Goravikere
361.	Halehalli
362.	Hirandahalli
363.	Huvina Ane
364.	Kada Agrahara
365.	Kada Sonappanahalli
366.	Kadugodi
367.	Kadugodi Plantation
368.	Kajisonnenahalli
369.	Kannamangala
370.	Kannur
371.	Katamanallur
372.	Kithiganur
373.	Konadasapura

S.No.	Village Name
374.	Kumbena Agrahara
375.	Kuruda Sonnenahalli
376.	Maragondanahalli
377.	Medihalli
378.	Mittaganahalli
379.	Nadagowda Gollahalli
380.	Nimbekayapura
381.	Rampura
382.	Sheegehalli
383.	Vodarahalli
384.	Varanasi
385.	Veerenahalli
386.	Yerappanahalli
Anekal Taluk	
Sarjapura Hobli	
387.	Avalahalli
388.	Chikkanagamangala
389.	Chikkanekkunde
390.	Chikkavaderapura
391.	Chokkasandra
392.	Chudasandra
393.	Dommasandra
394.	Gattihalli
395.	Gottemaranahalli
396.	Gulimanagala
397.	Halasahalli Thippasandra
398.	Harohalli
399.	Heggondahalli

S.No.	Village Name
400.	Hosahalli
401.	Huskuru
402.	Kada Agrahara
403.	Kaggalipura
404.	Kammasandra (Komasandra)
405.	Kathriguppe
406.	Kudlu
407.	Madivala
408.	Nekkundi Dommasandra
409.	Ramanayakanahalli
410.	Rayasandra
411.	Singena Agrahara
412.	Srirampura
413.	Thigala Choudenahalli
Attebele Hobli	
414.	Gollahalli
415.	Hebbagodi
416.	Veerasandra
Jigani Hobli	
417.	Amanikere Bhujangadasana
418.	Bannerughatta
419.	Bannerughatta Kaval
420.	Begihalli
421.	Bhuthanahalli
422.	Bilvardallai
423.	Bingipura
424.	Byrappanahalli
425.	Gollahalli

S.No.	Village Name
426.	Halesampigehalli
427.	Hulimangala
428.	Hullahalli
429.	Hullukasavanahalli
430.	Kallukere (Kalakere)
431.	Kannaikana Agrahara
432.	Lakshmipura
433.	Mantapa
434.	Maragondanahalli
435.	Nallasandra
436.	Nanjapura
437.	Ramasandra
438.	Sakalavara
439.	Thirupalya
440.	Vabasandra
441.	Vaderahalli
Bengaluru South	
Tavarekere Hobli	
442.	Channenahalli
443.	Chikkelluru
444.	Chikkelluru Ramapura
445.	Chikkelluru Venkatapura
446.	Kethohalli
447.	Kethohalli Narasimhapura
448.	Kethohalli Rampura
449.	Koluru
450.	Koluru Gururayanapura
451.	Koluru Nanjundapura

S.No.	Village Name
452.	Sheshagiripura
453.	Yelachaguppe
454.	Yelachaguppe Rampura
Kengeri Hobli	
455.	Agara
456.	Badamanavarthakaval
457.	Bhimanakuppe
458.	Bhimanakuppe Ramsagara
459.	Challaghatta
460.	Chinnakurchi
461.	Chowdenapura
462.	Deevatige Ramanahalli
463.	Devagere
464.	Doddabele
465.	Gangasandra
466.	Gollahalli (Kengeri Gollahalli)
467.	Gudimavu
468.	Gunakallu
469.	Halagevaderahalli
470.	Hemmigepura
471.	Kambipura
472.	Kommaghatta Krishnasagara
473.	Kaniminikere
474.	Kenchanahalli
475.	Kenchanapura
476.	Kengeri
477.	Kommaghatta
478.	Kumbalagodu

S.No.	Village Name
479.	Kumbalagodu Gollahalli
480.	Lingadheeranahalli
481.	Maragondanahalli Krishnasagara
482.	Maligondanahalli
483.	Mallasandra (Mylasandra)
484.	Maragondanahalli
485.	Nagadevanahalli
486.	Nayandanahalli
487.	Pantharapalya
488.	Pattanagere
489.	Rajanamadavu
490.	Ramasandra
491.	Ramohalli
492.	Sompura
493.	Sonnenahalli
494.	Sulikere
495.	Thagachakuppe
496.	Valagerahalli
497.	Varahasandra
498.	Vasanthanahalli
499.	Venkatapura
Uttarahalli Hobli	
500.	Alahalli
501.	Anjanapura
502.	Arehalli
503.	Avalahalli
504.	Bikasipura
505.	Byrasandra

S.No.	Village Name
506.	Channasandra
507.	Chikkalasandra
508.	Chunchaghatta
509.	Dasarahalli
510.	Doddakalasandra
511.	Gollahalli
512.	Gopinayakanahalli
513.	Gottigere
514.	Gubbalalu
515.	Hosahalli
516.	Hosakerehalli
517.	Ittamadu
518.	Jaraganahalli
519.	Kadirenahalli
520.	Karisandra (Kare Sandra)
521.	Kathiriguppe
522.	Kembathanahalli
523.	Konanakunte
524.	Kottunur
525.	Mallasandra
526.	Marasandra (Subramanyapura)
527.	Marenahalli
528.	Pilaganahalli
529.	Puttenahalli
530.	Ragavanapalya
531.	Raghuvanahalli
532.	Sarakki
533.	Sarakki Kere

S.No.	Village Name
534.	Talaghattapura
535.	Tayappanahalli
536.	Thippasandra
537.	Thurahalli
538.	Uttarahalli
539.	Uttarahalli Manavarte Kaval
540.	Vaddarapalya
541.	Vajarahalli
542.	Vasanthpura
543.	Vobichudahalli (Obichudanahali)
544.	Yediyuru
545.	Yediyuru Nagasandra
546.	Yelachenahalli
Begur Hobli	
547.	Adugodi
548.	Agara
549.	Arekere
550.	Basapura
551.	Basavanapura (F)
552.	Begur
553.	Beratana Agrahara
554.	Bettadasanapura
555.	Bilekahalli
556.	Bommanahalli
557.	Chandrashekarapura
558.	Chikkathoguru
559.	Devara Chikkanahalli
560.	Dodda Thoguru

S.No.	Village Name
561.	Doddanagamangala
562.	Ejipura
563.	Haralakunte
564.	Hommadevanahalli
565.	Hongasandra
566.	Hulimavu
567.	Ibbalur
568.	Jakkasandra
569.	Kalena Agrahara
570.	Kammanahalli
571.	Kodi Chikkanahalli
572.	Konappana Agrahara
573.	Koramangala
574.	Lakkasandra
575.	Madiwala
576.	Mallasandra (Mylasandra)
577.	Naganathapura

S.No.	Village Name
578.	Nyanappanahalli
579.	Nyanappanashetty Palya
580.	Parappana Agrahara
581.	Rupena Agrahara
582.	Sarakki Agrahara
583.	Shinivagilu
584.	Shinivagilu Kere
585.	Singasandra
586.	Tavarekere
587.	Venkojirao Kere
588.	Vittasandra
589.	Yelakunte
590.	Yelanahalli

BBMP Area

Grama Panchayat

Table-3.3. List of villages in BMICAPA area located in BDA area

S.No.	Village	Survey No.	Hobli	Taluk
1.	Bytarayanapura	5,6,40,41	Kasaba	Bengaluru North
2.	Handrahalli	87 - 92, 97 - 102	Yeswanthpura	
3.	Harorahalli	67,75, 170,176,178 - 181		
4.	Hosahalli Golarapalya	13 - 20, 22 - 29,31 - 33, 36 - 41		
5.	Kodigehalli	30-34, 36-38,73-76,83-93, 95-104, 112-119, 121-134		
6.	Lingaderanahalli	37,41,38,39		
7.	Manganahalli	30-45,47,48, 50-62, 66-73		
8.	Tirumalapura	10,13-16,19-35,39,43-45		
9.	Ullalu	29,30,186-188, 194-196,199,		
10.	Bilakonenahalli	24	Dasanapura	
11.	Gangondanahalli	16-21, 41-44,98-101,105,111,112		
12.	Kachohalli	14-16,19,27		
13.	Lakshmipura	15		
14.	Madhavara	3-15,17,24- 62,66-68		
15.	Madnayakanahalli	Full Village		
16.	Srikantapura-1	4,5,9-20,25-27		
17.	Srikanthapura-II	33-38		
18.	Tothadagudadhahalli	Full Village		
19.	Badhamanavarthakaval	Full Village	Kengeri	Bengaluru South
20.	Chinnakurchi	Full Village		
21.	Choodenapura	15-19		
22.	Devatige Ramanahalli	5-9		
23.	Doddabele	8		
24.	Gangasandra	Full Village		
25.	Gunakallu	4-12		
26.	Hemmigepura	1-8,51,53-55,57-59, 61,73-77, 86, 107, 114, 116 and Majara		
27.	Kengeri	94,112,118-128,137-155, 164-169, 202,204, 205,212,237,241-255		
28.	Kengeri Gollahalli	Full Village		
29.	Kommaghatta	1-27, 30, 38, 94, 96,97-99,112-114, 125-141,159-167,170-208 and gramatanas		
30.	Kumbalagodu Gollahalli	Full Village		
31.	Panthrapalya	9-23,26-74		
32.	Rachanamadu	Full Village		

33.	Ramsandra	4-10, 13,16-19,33,38-49, 51-60, 62 (P), 65-80, 168,169 and Majare		
34.	Sompura	Full Village		
35.	Varahasandra	Full Village		
36.	Vasanthahalli	Full Village		
37.	Anjanapura	13-15,16,22-28, 49, 78-81,93, 95-97, 100-107, 109-114, 121, 122	Uttarahalli	Bengaluru South
38.	Arehalli	24-27, 28(P), 41		
39.	Avalahalli	17,27,30		
40.	Channasandra	1,8,9,16,17,18,19,28,29,30, 31,32,13(p),33,34,2,15,27 and gramatanas		
41.	Gollahalli	35-38, 40-46, 57,58,66,67		
42.	Gottigere	10, 63-71, 97-104,112-124, 133,134		
43.	Hosakerehalli	7(P),9-15, 25-42,69-82, 83,87,124, 126-128		
44.	Kembathanahalli	1-13,23-50,53-56, 101		
45.	Mallasandra	7,19,22-24,26-35		
46.	Pillaganahalli	1-30 and gramatanas		
47.	Talaghattapura	24,25,27-29,32-39,41		
48.	Uttarahalli	88		
49.	Uttarahalli Manavarti kaval	8-22,24,27-38		
50.	Vaddarapalya	7-13,32-39		
51.	Basapura	28, 29, 34-42, 44-48	Beguru	
52.	Basavanapura	8, 40-46		
53.	Beguru	31-34, 39-51, 63, 64,79-83, 85-90, 94(P), 95,96, 107, 108, 110-129, 143 and Majare		
54.	Beratenaagarhara	40-48		
55.	Chikka Thoguru	1-23, 28-35,46-52, 55 -66 and gramatanas		
56.	Dodda Nagamagala	18,24,27,28		
57.	Dodda Thoguru	1-39, 112-116, 122-125,130-132,136-144, 146-148		
58.	Elenahalli	38-43,45, 47-49, 61,62, 64,66,		
59.	Kammanahalli	20(P), 37, 38, 42-47, 54-57, 71-74, 82(P), 83-85, 88(P), 89, 90		
60.	Konappanaagarhara	1,47,49,50-53,55,57,60-92,95		
61.	Koluru	Full Village	Tavarekere	

Table-3.4. Decadal growth in the Bengaluru City

Census Year	Population	% of Growth
1901	1,59,046	-
1911	1,89,485	19.1
1921	2,37,495	25.3
1931	3,06,470	29.0
1941	4,06,760	32.7
1951	7,78,977	91.5
1961	11,99,937	54.0
1971	16,53,779	37.8
1981	29,13,537	76.2
1991	33,02,296	30.04
2001	43,13,248	30.61
2011	84,25,970	65.2%
2016	1,15,56,907*	-

Source: Census of India, 2011

* http://www.indiaonlinepages.com/population/bangalore-population.html

CHAPTER

4

STATUS OF WATER BODIES

Chapter-4: Status of Water bodies

4.1. Introduction:

The status of the water bodies is an indirect reflection of the water quality of water body and it mostly depend on the morphometric characteristics of the water body. Morphometry refers to the quantitative analysis of lake forms and its elements. Morphometric data has the fundamental importance in limnological and hydrological studies, and as a matter of fact, they are the preparatory stage for many investigations. The study of the lake basin features is also known as 'lake morphology' and it is used to predict the condition of water body and also the adverse effects caused to the water levels by the human induced events. The morphometric characteristics of each and every water body are unique and the surrounding area of the water body has been used to forecast the changes in water quality with the amount of algae, and/or aquatic plants growing in the water, fish species and its abundance, and water clarity. It can even play a role in determining the types of birds and wildlife that are attracted to a water body. The information is helpful in anticipating changes and predicting the affecting factors of water body inhabitants by increasing the chances of mitigating with carefully planned management techniques (Mark Hoyer, 2006). Morphometric characteristics play a critical role in the dynamics of a lake system and provide a solid base to compare with the other water bodies, as well as an invaluable tool for developing a lake management plan. It also helps to appreciate water bodies to manage them with more realistic expectations.

4.2. Methodology:

The status of the water bodies are documented by following the systematic methods (Figure-4.1). The water bodies have been inventorised from different sources of maps such as the SSLR village map, taluk map, Toposheets, MI tank map, BDA lakes map, etc. After the identification of water bodies in the maps, the location of water bodies has been identified through the help of Google imageries (Google Earth Pro-7.1.5.1557) and then verified physically through the field visits using GPS instruments. The water bodies in the Bengaluru Metropolitan Area (BMA) are inventorised by following the Marcia (1999) approach that follows a four step process as follows:

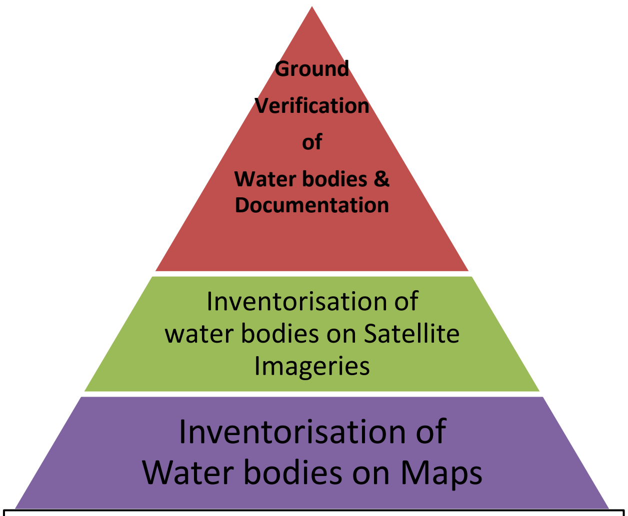


Figure-4.1. Pyramid for inventorisation of water bodies

4.2.1. Preparation of Base Map:

As the preliminary deskwork, before initiating the inventorisation of the water bodies, the four taluk maps and the village maps of the Bengaluru urban district are collected from the SSLR. Available digitized village map also downloaded from the Karnataka Land Records website (http://landrecords.karnataka.gov.in/service3/). Similarly, the BDA jurisdiction map and BBMP jurisdiction map are also collected from the respective Authorities with the details of the water bodies under their custodian. The BDA jurisdiction has been delineated on the taluk maps of Bengaluru urban district to list out the villages in the BMA.

4.2.2. Inventorisation of Water bodies on Village Map:

In each and every village of BMA, the water bodies have been identified with the survey numbers and recorded. The identified water bodies with the survey numbers has been verified with the RTC, which are available in the Bhoomi (http://bhoomi.karnataka.gov.in/) website. Apart from the village map, the water bodies are also inventorised in the 57G/8, 57G/12, 57H/5 and 57G/9 toposheets (1:50,000) and Minor Irrigation tank maps. The list of water bodies in the BMA with the verified survey number has been prepared and used for the inventorisation of water bodies on the satellite imageries. Additionally, the surveyed lake maps available in the Karnataka land records website (http://landrecords.karnataka.gov.in/service3/lakesurvey.aspx) was also downloaded for the verification.

4.2.3. Inventorisation of Water bodies on Satellite Imageries:

The water bodies, which are identified in the BMA village maps, are subjected to the verification on Google satellite imageries available in the open source Google Earth Pro-7.1.5. The imageries used for the study period is between the year of 2014 and 2016. The draft GPS location and the elevation of the water bodies are noted from the Google imageries and the same has been uploaded in the GPS instrument for the physical verification. Additionally, the available KMLZ (Keyhole Markup Language Zipped) files for BMR village maps and the digitised lake maps available in the Karnataka revenue maps online land records website (http://landrecords.karnataka.gov.in/service3/Lakeencroachment.aspx) are also downloaded and overlaid on the satellite imageries for the verification.

4.2.4. Ground Verification of Water bodies:

The identified water bodies from the village maps are verified in the satellite imageries have been confirmed by the ground-truth. Physical verification of water bodies have been done by the group of the CLC team members through the field visits with the help of GPS instruments such as GPS map 76CSx, Oregon 550 and Montana 650 (Garmin, Made in Taiwan). The methodology for confirmation of the water bodies' location has been done distinctly for the existing, newly created and disused water bodies as follows:

a) Inventorisation of Existing water bodies:

The existing water bodies are identified (**Annexure-1**) based on the Google imageries' geographical location. Access for the water bodies have been identified by interaction with the local villagers and the exact single point of GPS location has been recorded for the water bodies' database.

b) Inventorisation of Newly Created Water bodies:

The water bodies, which are not mentioned in the source maps such as village maps, toposheets, BDA and MI tank maps, etc. are inventorised only through the satellite imageries with the help of Google Earth Pro Ver. 7.1. The satellite imagery inventorised water bodies are verified physically on the ground with the interaction of local villagers, particularly for the survey number of water bodies. Survey number of the water body has been identified in the village map and the RTC has been verified for newly created water bodies.

c) Inventorisation of Disused Water bodies:

Disused or non-existing or landuse changed water bodies, which are inventorised (**Annexure-2**) in the village maps are physically verified on the ground based on the survey number in the village maps. The RTC of the disused water bodies have been verified to obtain the conversion of water bodies' landuse. The present landuse of the water bodies are identified in the satellite imageries using the "Time slider tool" on Google Earth Pro and the ground reality is recorded as photographs with the GPS location and surrounding area. Mostly, the historically important water bodies are presently disused, so additionally, the details of these water bodies are collected from the historical books etc., senior citizens and also from library (MHS, 2013).

4.2.5. Plotting of water bodies on Satellite Imagery:

The GPS reading of the water bodies location, which were recorded in the field have been transferred to the GIS platform. The verified GPS readings are plotted as .shape file using ArcGIS (Ver.10.3.1) software under geographic co-ordinating system with World Geodetic System (WGS84) datum. GPS readings of BMA water bodies were also plotted with administrative boundary thematic layer. General and morphometric characteristics of the water bodies were attached to the field attributes (Table-4.1) of the water bodies location shape file for quick access of the data on water bodies. During plotting, coloured dots were used to differentiate between the existing and disused water bodies, i.e. Blue and red colour dots were used for the existing and disused water bodies respectively.

4.2.6. Morphometric characteristics of Water bodies:

Morphometric characteristics of each and every water bodies, whether the water body is existing or disused (non-existing) are recorded in the field with the help of photographs using the camera Coolpix S-9700 and AW-120 (Nikon, Made in Indonesia) as the evidence. Characteristics of each and every water body have been recorded as follows;

a. **Custodian**: The information on the custodian of each and every water body has been collected from the Agencies/ Authorities. Information from field also collected from the display board, particularly for the rejuvenated lakes has been recorded and the custodian of the water body has been confirmed through the interaction with the local village people.
b. **Location**: GPS location such as the Longitude and Latitude of the water bodies has been recorded in the field by standing on the bund as one point. If it is a disused water body, then one point has been taken near the water body based on the accessibility. GPS locations have been recorded in degrees, minutes and seconds with the Lat. in North direction and Long. in the East direction.
c. **Elevation for the water body location**: While recording the GPS location, the elevations or the altitudes for the water bodies have also been recorded in the field with the help of the GPS instrument. The unit for the elevation is in metres above the mean sea level (amsl).
d. **Extent of Water body**: The extent of the water bodies have been collected from the RTC from the Land Survey Department, SSLR lake survey sketch, Authorities, etc. and recorded. Extents of non-documented *Kunte* were estimated with the help of GIS.
e. **Survey number and Created year:** Location of the water bodies in the survey numbers of the specific village has been noted from the village map and verified with the SSLR and RTC data. The water body creation year has been considered by default as the village map generated year. Whereas, the newly created water bodies establishment year has been approximately identified by using the 'time slider tool' in the Google Earth Pro.
f. **Type of water body**: The documented water bodies have been broadly classified as the perennial, seasonal and the non-existing or disused. During the field visit, the water bodies are physically verified and classified under appropriate type.

g. **Depth of the water body**: Maximum depth of each and every water body is measured using the pre-measured weight tied to a rope from the bund in the field (APHA, 2012). The rope with weight is put into the lake until it reaches the benthic of the lake and the average maximum depth of the lake in meters is noted.

h. **Islands**: Mostly the islands are artificially created in the rejuvenated water bodies, particularly in the lakes for encouraging bird migration. Therefore the number and size of the islands are based on the size of the water bodies. Numbers of the islands are recorded in the field by physical verification.

i. **Inlet Drains, Waste-weir, Sluice gate, Culvert and Check Dam**: Number of inlet drains, waste-weir or outlet drain, sluice gate, culvert and check dam of each and every water body has been recorded by visual encounter method in the field by walking around the water bodies. GPS location of drains, sluice gate, culvert and check dam are also noted for future reference.

j. **Surrounding Area**: The surrounding area of each and every water body has been physically verified in the field and also in the current google imageries. The surrounding area for the disused water bodies have also been recorded for the landmark.

k. **Type of Fence**: As a preservation measure, the lakes are completely fenced during the rejuvenation by the custodian. Apart from the Authorities, the water bodies are also partially fenced by the nearby property holders such as farmers, NICEL (Nandi Infrastructure Corridor Enterprises Ltd.), local people, etc. Accordingly, the types of fence are segregated into mesh type, thorn-weir type, walls and bio-fences. The types of fence of the water bodies have been recorded in the field by visual method during physical verification.

l. **Present Status**: Present status of the existing water bodies are recorded in the field by the visual method through the physical verification and classified into dried water bodies, clear water, muddy water and polluted water. Whereas, the present status of the disused water bodies have been recorded in the field through the photographs with the present landuse of the disused water bodies. In the field, the details such as the water bodies converted usage and converted persons/ Authorities are collected from the display board if there is one or by interaction with the local villagers.

m. **Water usage**: The various uses of water in the water bodies have been recorded in the field by interaction with the local people.

4.2.7. Classification of Water bodies:

All the inventorised water bodies are categorised into *Kunte* (Below one Acre), *Katte* (between 1 and 3 Acres) and *Kere* (Above 3 Acres) based on the size of the water bodies irrespective to existing and disused. The classification has been done by following the published reports by Rittu Kakkar *et al*., (2013 and 2016) and Sreenivas *et al*., 2016.

4.2.7.1. Coding of Water bodies:

Each and every water body in the study area is coded on the basis of its location of taluk, hobli and village by following the hydrologic unit code (Paul *et al.*, 1994). The invented coding system is named as "EMPRI Coding System". Bengaluru Urban district has been coded as BU and the four taluks viz… Bengaluru North, Bengaluru East, Anekal and Bengaluru South are coded as BN, BE, AK and BS respectively. Correspondingly, the two letter code is used to code the hoblis' within the study area i.e. YW for Yeswanthapura hobli. Both the taluk and hobli are coded using ISO 3166-1 alpha-2 coding system and 590 villages are coded using ISO 3166-1 alpha-3 coding system. All the water bodies (existing and disused) in the study area are coded on the basis of ISO 3166-1 numeric coding system (Figure-4.2). Two types of numerical coding used are (a) On the basis of water bodies in specific village (b) On the basis of total water bodies in the study area. The EMPRI coding system was followed and published by Shankar Hosmani and Mruthunjaya (2013) and Sreenivas *et al*. 2016.

Eg. Lalbhagh Lake: BUBNBKuph_kr1-76

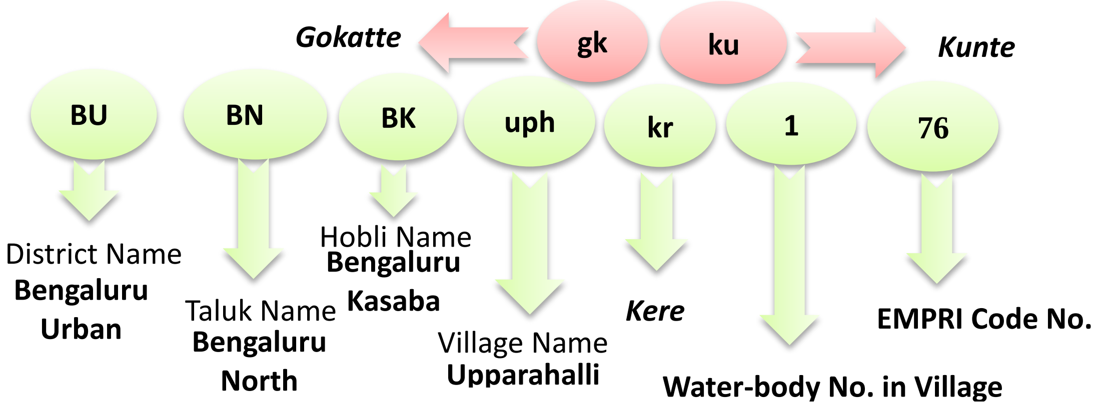


Figure-4.2. Description of EMPRI Coding System for Lalbhagh Lake

4.3. Status of Water bodies:

There are 590 villages in the Bengaluru Metropolitan Area (BMA), out of which there are 1521 water bodies in 512 villages and there is no surface water body in 78 villages. The number of villages in the BBMP and BDA areas is tabulated in the Table-4.2. Most of the BMA region has been covered in the Bengaluru North taluk (Figure-4.3). In taluk-wise, there are 503; 409; 201 and 408 water bodies in the Bengaluru North; Bengaluru East; Anekal and Bengaluru South respectively. The extent of 1521 water bodies are ≈72.61Km^2, which was 5.54% of the total study area (BMA). Types of water bodies in the BMA area have been plotted as pie chart in Figure-4.4. Within the 1521 water bodies, the maximum numbers of water bodies are *Kunte* (55%) then *Kere* (32%) and only 13% are *Gokatte*. There are 684 existing and 837 disused water bodies in the BMA area that are tabulated in the Table-4.3.

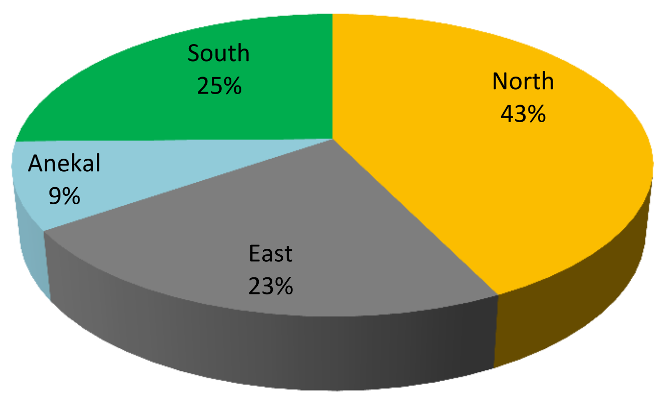


Figure-4.3. Percentage of BMA in Bengaluru Urban District

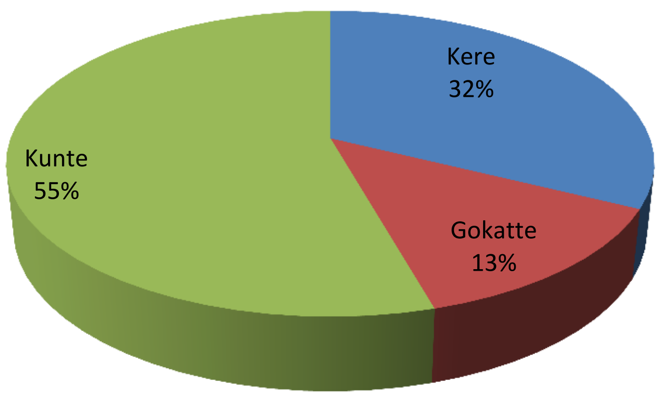


Figure-4.4. Pie chart for the types of total water bodies in BMA in Bengaluru Urban district

But the present scenarios of the existing water bodies are different. There is only 44.80% of existing water bodies, which is spread over ≈64.52Km^2 and contribute 4.94% of the BMA. The present scenario based on the existing water bodies are plotted in Figure-4.5, which exhibited that the 57% of the existing water bodies are lakes (*Kere*), 30% of the existing water bodies are *Kunte* and there are no changes in the percentage of existing *Gokatte* (13%).

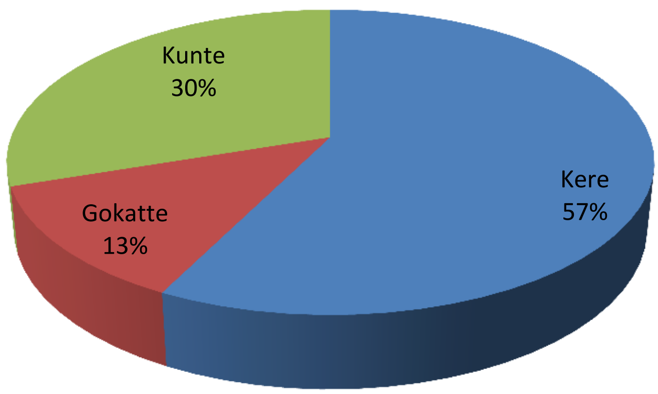


Figure-4.5. Pie chart for the existing water bodies in BMA area in Bengaluru Urban district

Within the 1521 water bodies, 28 water bodies are not mentioned in the village maps, as these maps were drawn during the pre-independence of India. The list of these 28 water bodies are tabulated in Table-4.4 and most of the water bodies are in the Bengaluru North taluk (17). Five water bodies were created during post-independence in the Kannalli village of Yeshwanthpura hobli, Bengaluru North taluk. Kannalli Govt. lake and KR Puram *Kere*-2 are disused due to the urbanization.

The lakes or *Kere* (above 3 acres) have once again been further classified into two groups based on the sizes i.e. bigger (extent above 40-100 acres) and biggest (extent above 100 acres). There are 60 bigger (Table-4.5) and 26 biggest lakes (Table-4.6 and **Annexure-3**) in the BMR within that six bigger and two biggest (Figure-4.6) lakes were disused respectively. Bellandur Amanikere lake (Figure-4.7) in the Varthur hobli of Bengaluru East taluk is the very biggest lake in the BMA with its extent of 919.38 A-G.

Figure-4.6. Biggest disused Sunnakall Kere in BMA area

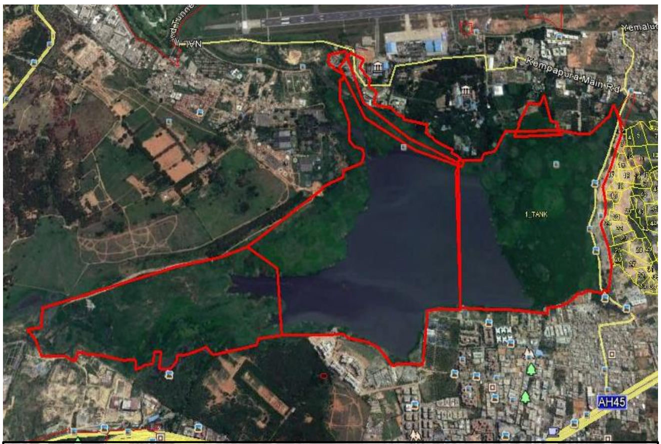


Figure-4.7. Biggest existing Bellandur Amanikere lake in BMA area

Sankey Tank (Figure-4.8) is one of the renowned existing artificial tanks located in the middle of Vyalikaval, Malleshwaram and Sadashivanagar of Bengaluru City. The tank was constructed by Col. Richard Hieram Sankey of the Madras Sappers Regiment in the year 1882 to meet the water supply demands (https://en.wikipedia.org/wiki/Sankeytank-citenote-Patrao-DH-4). The tank was built to safeguard the water shortages based on the experience of Great Famine of 1876-78. Sankey tank augmented the Miller's and Dharmambudhi tanks for water supply to the cantonment and municipality respectively. The tank was also known as *Gandhadhakoti Kere*, because of the Government Sandalwood Depot located near the lake. In the year 1888, Lord Connemara (Governor of Madras) found that the water quality was not good due to inflow of sewage. Now it is being used for aesthetic and recreational activities like boating.

Figure-4.8. Existing Sankey Tank

4.3.1. Coding of Water bodies:

All the inventorised water bodies in the BMA area included in the existing and disused have been coded based on its localities and listed in the database (Refer Volume-II). Coding of each and every water body has become important because of the existing Tank Reg. no. of MI and also the list maintained by BBMP has not represented the location of water body (Reg. no. for water bodies are numerical serial no.). Meanwhile, the registration number assigned for the tank by the Departments like MI does not tally with the other Departments tank registration number. Therefore the standard coding system has been followed for coding the BMA area water bodies, which also represents the location of water bodies.

4.4. Disused Water bodies:

Water bodies, which lost its characteristics to hold the water is called as the disused or abandoned or non-existing water bodies. The water bodies have lost their characteristics when the landuse and landcover pattern have been changed. The definition on the disused water bodies states that these water bodies are no longer being used for the purpose for which it was created. The reasons for the water bodies become disused in urban area are developmental activities, urban amenities and encroachment.

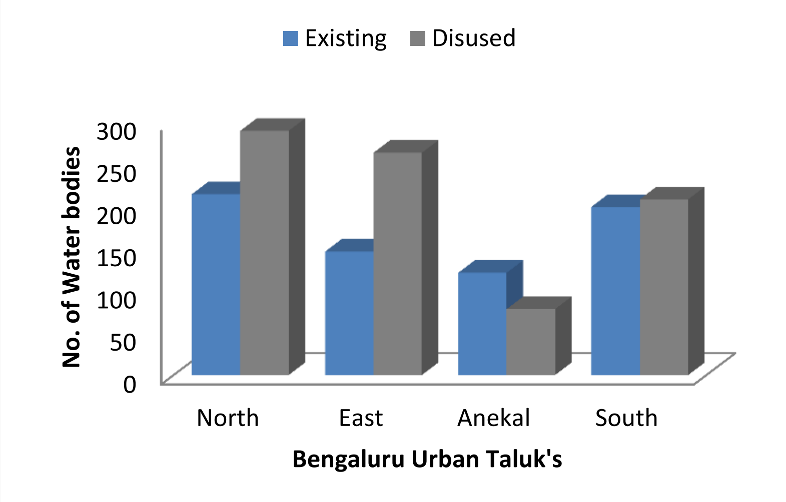


Figure-4.9. Comparative graph between existing and disused water bodies in BMA area

Details of the disused water bodies in the BMA area has been compared with the number of existing water bodies between the four talukas are plotted in Figure-4.9. Within the 1521 water bodies, 837 (55.20%) number of water bodies were disused in the BMA area and most of the water bodies were disused in the Bengaluru North and East talukas. One of the examples for the disused water body is *Kere* in Makli village (Figure-4.10) with extent of 3.31A-G located in the TGR (Tippa Gondanahalli Reservoir) catchment area of Hesaraghatta hobli, Bengaluru North taluk. Even, the G.O. on preservation of the TGR catchment area can't prevent the landuse change of Makali *Kere*. Further, the numbers of disused water bodies are greater than the present existing water bodies.

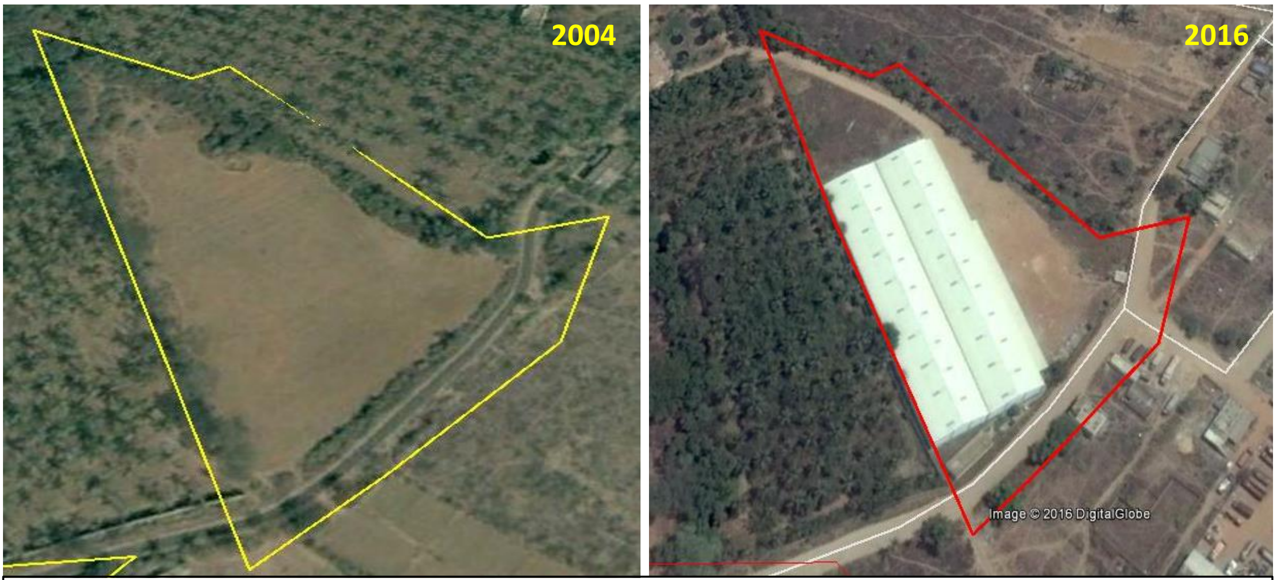


Figure-4.10. Comparative Landuse in Makli *Kere* between the year 2004 and 2016

4.4.1. Status of the Disused Water bodies:

Water bodies are mostly disused to provide the urban amenities to the Bengaluru City people **(Annexure-4)**. Most of the water bodies landuse have been changed to schools, roads, parks, graveyards, playgrounds, worship places, BDA layouts, public service offices such as BBMP office, BESCOM office, KSPCB lab, Mysore Sales International Ltd. (MSIL) office, KSRTC and BMTC Depo, etc. Apart from the Bengaluru local governing Authorities, the Central Government Departments such as the Indian Space Research Organization (ISRO), railways, National Institute of Unani Medicine (NIUM), Central Reserve Police Force (CRPF), Defence, Air force, Hindustan Aeronautics Limited (HAL), National Aerospace Laboratories (NAL), Hindustan Machine Tools Ltd. (HMT), etc. were also disused the water bodies. Apart from the Government Authorities, the local people also involved to convert the landuse of the water bodies for agriculture, plantation and to construct the superstructures such as the residential houses, apartments, layouts, hospitals, educational institutes, commercial shops, warehouses, etc. Due to the landuse, most of the water bodies had lost its characteristics i.e. become the vacant lands.

Further, the water bodies converted for other landuses have been evicted by the Authorities are also maintained as the vacant lands. About 230 water bodies (27.44% of the total disused water bodies) are completely and partially converted as the vacant lands. Within the 837 disused water bodies, 102 water bodies were *Kere*, 115 water bodies were *Gokatte* and 620 water bodies were *Kunte*. The details on the types of disused water bodies were plotted in the Figure-4.11. The details of 102 disused lakes were tabulated in the

Table-4.7, which show that most of the lakes were disused in the Kasaba hobli of the Bengaluru North taluk. Two renowned disused lakes have been discussed below:

i. **Dharmambudhi Tank**: The tank was commissioned by Kempe Gowda in the year 1537 (Figure-4.12). The tank was also called as "Jeeva *Kere*" since it was the primary source of drinking water for the inhabitants of old Petta and this continued for over 300 years till the late 19th century. The tank was named after the Dharmarayana temple and Ambudi (Kannada) means a place where the water collects. According to historical records, water from the lake was led through channels in the streets and collected by the people from square troughs of basins called 'Karanjis' which were located at junction points. In 1877 when famine struck Mysore Kingdom, the Government had initiated the lake desilting, repaired the channels, cleared the debris and evicted the encroachment as part of the employment programme. Within a few years, the lake regained its lost glory and it began supplying water to the Petta. The open ground adjacent to the lake was converted as a park and named as 'Chika Lalbagh'. In 1878, Nadaswaram and English band music were conducted on every Sunday and Wednesday evening to entertain the people. Prince Albert Victor son of Queen Victoria had visited Bengaluru in 1889, he noticed that the royal train was alighted near the Dharmambudhi lake. The city administration had organised a Bharatanatya performance in the middle of the lake on a theppa (platform made on boats) to welcome him. Every year, when the lake filled up, local citizens organised the theppotsava (boat festival).

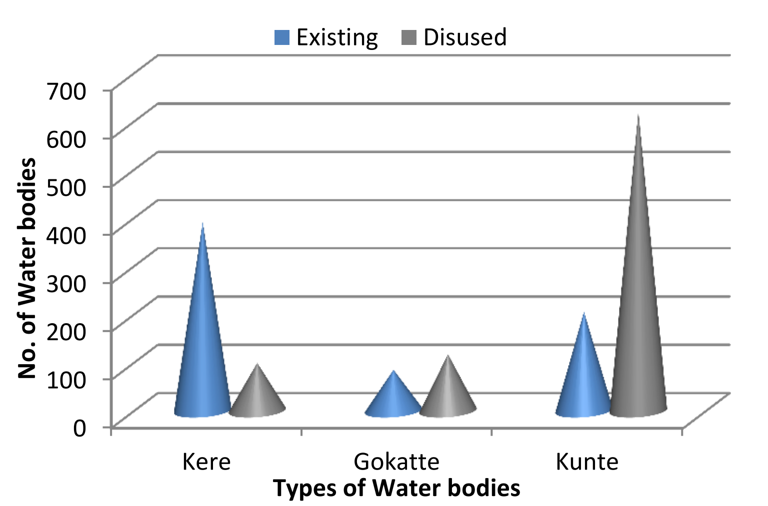


Figure-4.11. Comparative graph for the disused water bodies

Figure-4.12. Dharmambudi Tank

When monsoons failed in Bengaluru during the year 1892-93, the government pumped the water from Jakkarayana and Hebbal tank to Dharmambudi tank. Then the piped water supply system was introduced in 1896 from the Hesaraghatta reservoir. By then, the Dharmambudi tank became completely dry. The Mysore Government planned to convert the Dharmambudi tank into a children's park in 1905 but the municipality decided to sink wells in the dry bed of Dharmambudi to supply water to Balepet and Manavarthpet areas. By the early 1930s, there was little water towards Chikalalbagh, which was losing its hygiene due to the increased migration of people, Majestic area commercialization and the open defecation in tank channels. In the year 1931, the water of the tank was drained for holding public meeting addressed by Sri. Jawaharlal Nehru to hoist the tricolour flag. The dry tank bed was called as "Gandhi Sagara", which led to the beginning of Gandhinagara area. Later, the lake dry bed was named as Subash Nagar and to honour Sri. Subash Chandra Bose (http://www.deccanherald.com/content/440446/dharmambudhi-water-tank-bus-station.html).

After independence, the dry lake bed began to be used as an exhibition ground as Congress Exhibition and for temporary amusements like circuses. In 1960's, a part of the dry lake became the bus terminal for the state road transport corporation. In 1963, the Government handed the Dharmambudi tank land to KSRTC to construct a bus stand. In 1980's, the iconic semi-circular city bus terminal was built on the remaining portion of the lake bed and named as Kempegowda Bus Station but remembered as Majestic after the oldest and closest film theatre. The bus stand stood for nearly 30 years and was modernised with the Namma Metro project.

ii. Millers Tank:

Just like Dharmambudhi tank, Millers tank was constructed by Sir L B Bowring (Commissioner of Bangalore) in the year 1873 to supply the unfiltered water to Cantonment people. The unfiltered water was supplied to the Cantonment area until the year 1895.

Among the disused water bodies, 74.10% of them were *Kunte* because there were no Government records on the *Kunte'* and the landuse can be easily converted by the public as well as the Government Authorities due its size. The number of the disused water body was greater than the existing water bodies but actually the area of the disused water bodies were less than the existing water bodies. Pertaining to the water body area, only 11.17% area of water bodies extent have been disused, which is plotted in the Figure-4.13. Therefore, the existing water body area is 64.37Km^2 and the disused water body area is 8.09Km^2. Chellaghatta *Kere* (Figure-4.14) in Varthuru hobli with extents of 124.09 A-G and

Sunnakall lake (Figure-4.15) in Begur hobli with extents of 116.18 A-G are the two biggest lakes that have been disused for the development of golf business park and Government Bus Transport Depot (Shanti Nagar Bus Stand) respectively.

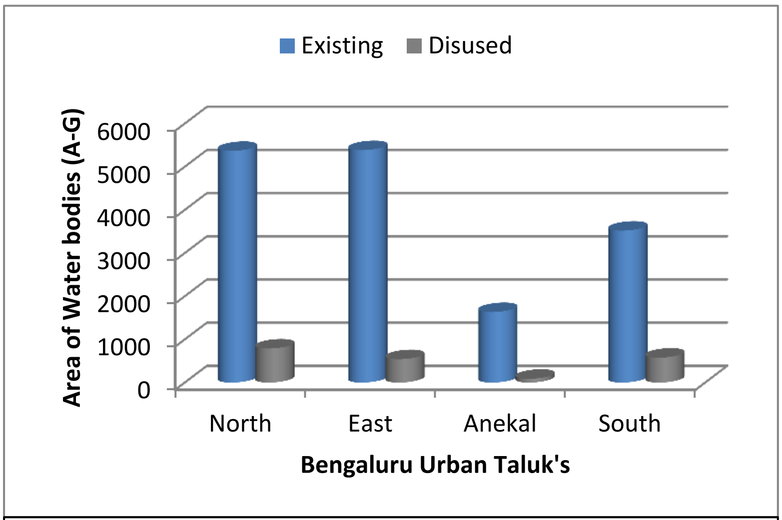


Figure-4.13. Comparative graph for the area of existing and disused water bodies in BMA

Figure-4.14. Disused Chellaghatta *Kere* as golf business park

Figure-4.15. Disused Sunnakall lake as Shanti Nagar Bus Depot

4.5. Water bodies Map for BMA:

Spatial data of water bodies' location and respective field information is attached as a spatial attribute data to each BMA water body point file. Each point file graphic indicates the location of the water body as per the base map (Cadastral map) and the field visits. Size symbology indicates the extent of water bodies into three categories such as <40 acres; between 40 – 100 acres (blue circular dots with green outline) and > 100 acres (blue circular dots with beige outline). Location of 1521 water bodies in the BMA jurisdiction map is shown in Figure-4.16. Further, each water body location is symbolized as point geometry with respective attributive information and the digitized map in the KML format has been plotted on the google imagery is illustrated in the Figure-4.17. Selecting any point file of the water body in the digital map will display several attribute information along with photos for selected water bodies. Maps reveal spatial relations and patterns, and offer the user insight into the distribution of particular phenomena.

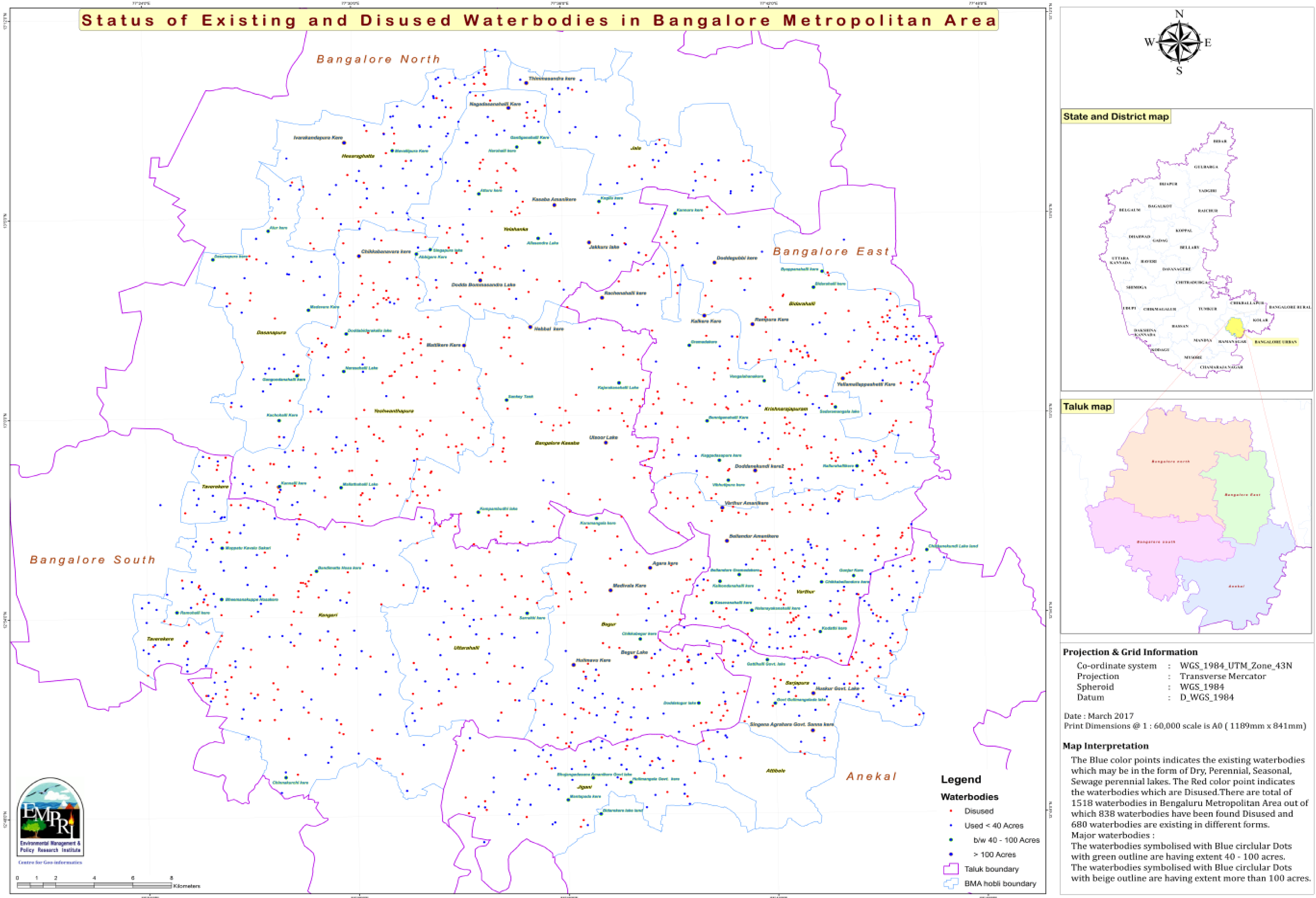
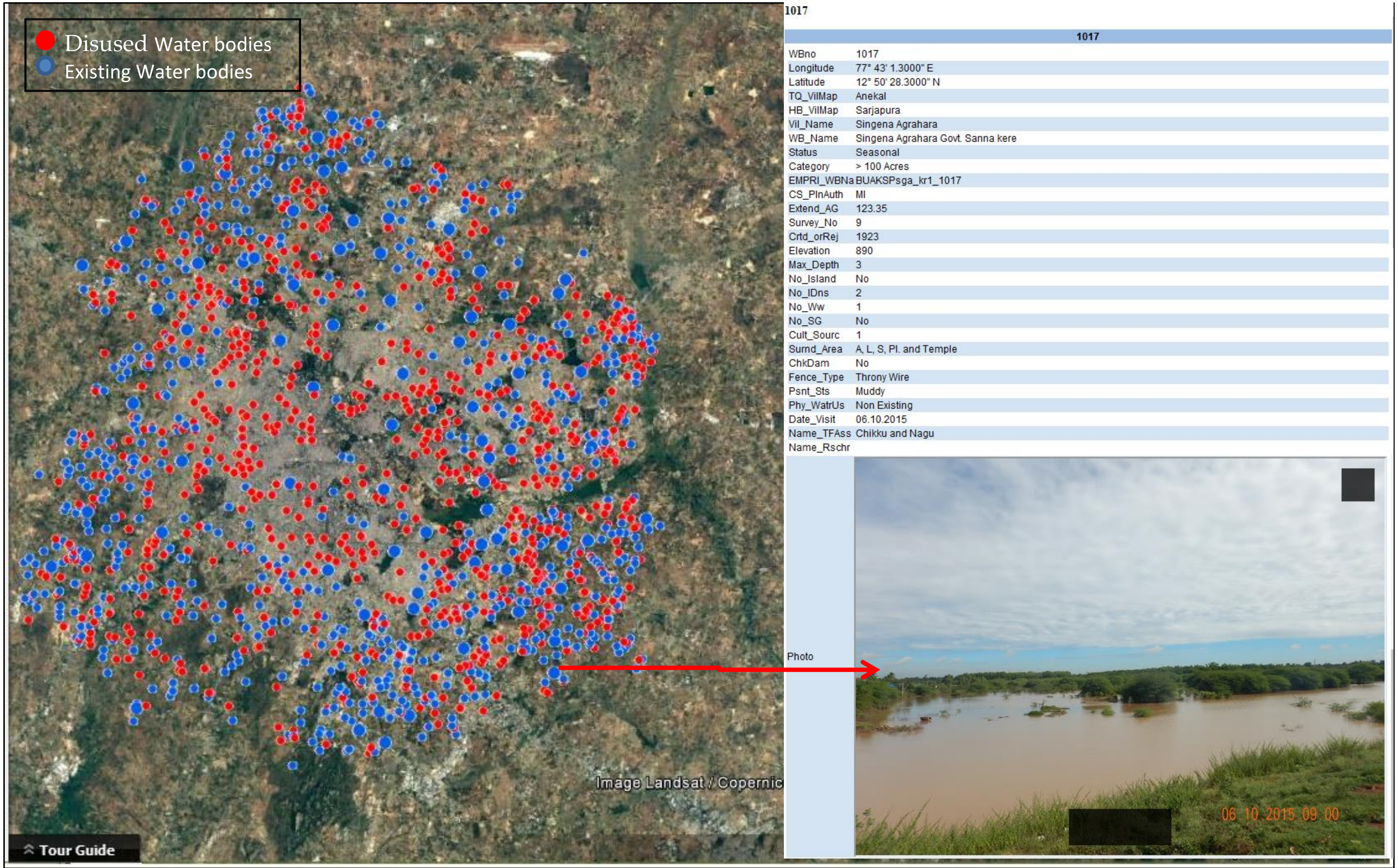


Figure-4.16. Inventorised water bodies location map in the BMA



1017

1017	
WBno	1017
Longitude	77° 43' 1.3000" E
Latitude	12° 50' 28.3000" N
TQ_VilMap	Anekal
HB_VilMap	Sarjapura
Vil_Name	Singena Agrahara
WB_Name	Singena Agrahara Govt. Sanna kere
Status	Seasonal
Category	> 100 Acres
EMPRI_WBNa	BUAKSPsga_kr1_1017
CS_PlnAuth	MI
Extend_AG	123.35
Survey_No	9
Crtd_orRej	1923
Elevation	890
Max_Depth	3
No_Island	No
No_IDns	2
No_Ww	1
No_SG	No
Cult_Sourc	1
Surnd_Area	A, L, S, Pl. and Temple
ChkDam	No
Fence_Type	Throny Wire
Psnt_Sts	Muddy
Phy_WatrUs	Non Existing
Date_Visit	06.10.2015
Name_TFAss	Chikku and Nagu
Name_Rschr	
Photo	

Figure-4.17. GIS map with attributes was superimposed on Google imagery

4.6. Morphometric Characteristics of Water bodies

Each and every water body has different morphometric characteristics based on its location, purpose of creation and flow of runoff water. So, the morphometric characteristics of each and every water body has been recorded and included in the BMA water bodies database. Taluk –wise water body database has been expounded in the Volume-II of this report. The cumulative result of the morphometric characteristics of the BMA water bodies are follows:

4.6.1. Year of Creation:

In Bengaluru, all the water bodies are man-made and the evolution of the tank system in Bengaluru City had the history from the 16th Century. Most of the renowned tanks in Bengaluru were created in the pre-colonial period. Kempambuddhi tank, Dharmambudhi tank, Sampangie tank, Siddikatte (Kalasipalayam) were constructed in the year of 1537 onwards during Kempe Gowda period for the purpose of irrigation and domestic needs. In 18th Century, Haider Ali and Tipu Sultan have created the Lalbagh tank for the maintenance of park and also as the recreational space in the year 1759. The Gokatte and Kunte also largely created by local village community people for the cattle feeding and for the community uses respectively in the 18th Century. But in the 19th century, the British colonial period had created few renowned tanks in the Bengaluru for supply of unfiltered drinking water to the growing population such as Millers tank (1873) and Sankey tank (1882). By knowing the importance of the tanks in Bengaluru, the royal British Government was also involved in creation of new channels, lake rejuvenation and created the documents for tanks by survey for the pre-colonial tanks.

In 20th century, every water body created during the post-colonial period was documented in generated village map. Accordingly, 20th century was considered as the 'Centuries for Tank Creation' or the golden era for the creation of water bodies. Whereas, the 21st century is named as the 'Centuries of Tank Rejuvenation and Maintenance', because most of the lakes have been rejuvenated and are planned to be rejuvenated under the preservation of water bodies. Importance of the water bodies in context of climate change also necessitates the Government to conserve the water bodies for future. The study revealed that the 116 water bodies have been created in the 19th century and also pre-independence period. Whereas, 1370 water bodies were created in the 20th century, particularly during the colonial and pre-independence period of India and only 16 water bodies were created till in 21st century. The newly created water bodies, which were not mentioned in the village maps are tabulated in the Table-4.4 and the list of oldest lakes in the BMA hoblis are listed in the Table-4.8.

The 480 years old and existing water body in BMA is the Sampangi tank as a *Kunte* (Figure-4.18), which was created in the year of 1537 for domestic needs. Whereas, the Mavalipura Kere-2 (Figure-4.19) in Hesaraghatta hobli of Bengaluru North taluk is newly created water body in the year of ≈2006 for rainwater harvesting.

Figure-4.18. Shrunken Sampangie tank

Figure-4.19. Newly created Mavalipura Kere-2

4.6.2. Altitude of the Water bodies:

Even Bengaluru Urban district itself is elevated, the location of water bodies plays an important role in movement of water. Generally due to the elevation of Northern Bengaluru than the Southern Bengaluru, the water flows from the Northern to Southern Bengaluru water bodies and that it mingles with Vrishabhavathi river, a tributary of Cauvery in the Southern direction of Bengaluru. The low-lying water bodies, which is located in the low elevation than its catchment area will collect more runoff water. The hobli-wise location of high and low elevated water bodies are tabulated in the Table-4.9. On an average, the high altitude of the water bodies range between the 852 and 958 masl (meter above sea level) and the low altitude water bodies range from 742-903 masl. Both the high and low altitude water bodies are located in the Bengaluru South taluk. In the present BMA, the Doddatogur *Kunte*-1 (Figure-4.20) of Begur hobli is located in the high elevation of 958 masl and the Gangasandra *Kunte* (Figure-4.21) of Kengeri hobli is located in the low elevation of 742 masl. The location of the high and low elevated water bodies are shown in the Figure-4.22.

4.6.3. Custodian of the Water bodies:

According to the KLCDA Act, 2014, all the water bodies in the BMA are under the custody of KLCDA. There are 395 existing lakes in the BMA, within that only 211 lakes (Table-4.10) are under the custodian of the KLCDA, BBMP, BDA and Karnataka Forest Department (KFD) as the 4, 109, 92 and 6 lakes respectively. Most of the water bodies in the

BBMP area (Figure-4.23) are under the custodian of the BBMP and very few lakes are under the custodian of BDA for the rejuvenation process. But the remaining 184 lakes in the BDA and BMICAPA area have been mostly under the custodian of the Zilla Panchayat.

Figure-4.20. Disused Doddatogur *Kunte*-1 as IT Park

Figure-4.21. Disused Gangasandra *Kunte*

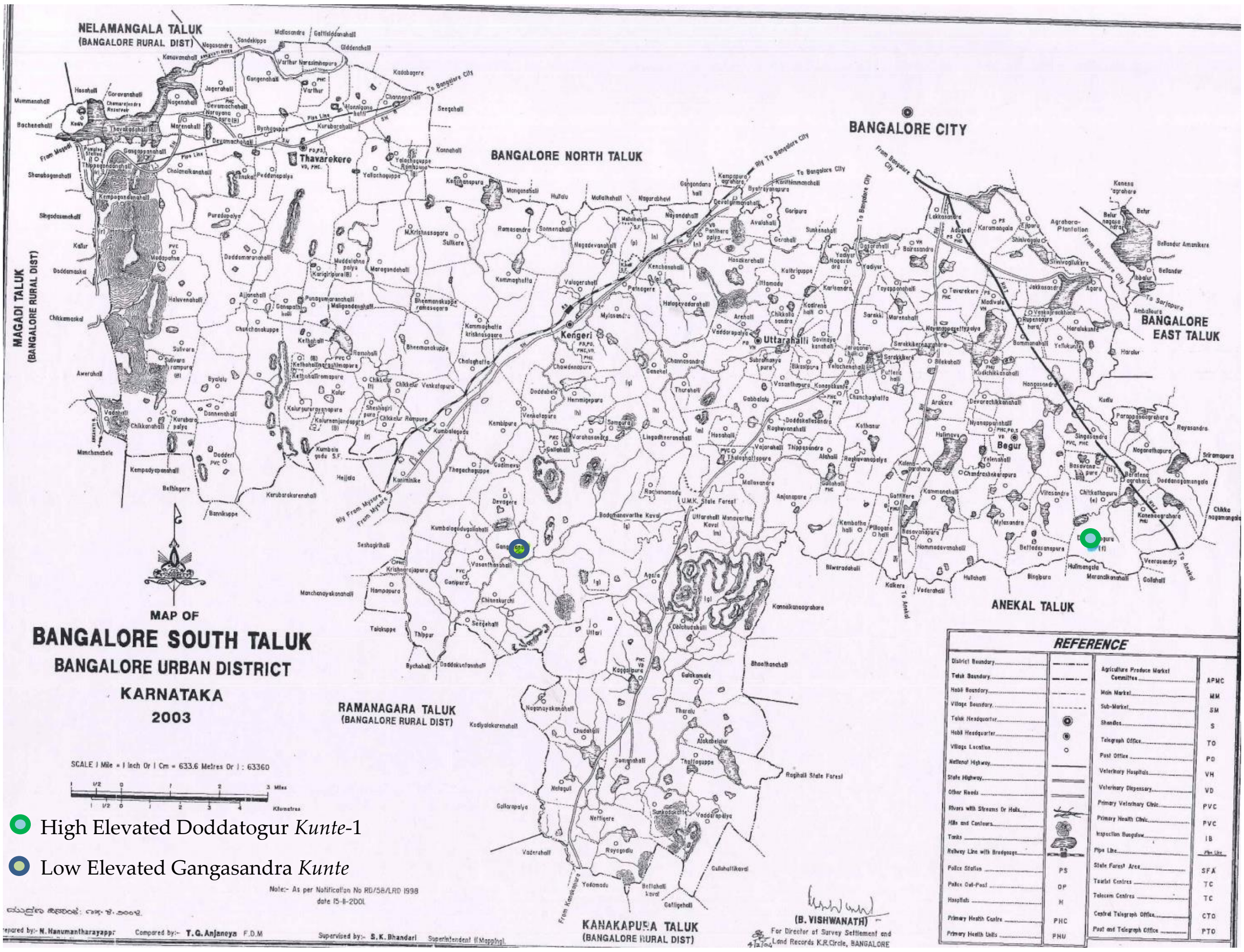


Figure-4.22. Location of high and low elevated water bodies in BMA

The histories of the lakes custodian are tabulated in the Table-4.11, which showed that the KFD was the custodian of 115 lakes in the year 1988. After that, the BBMP and BDA became the nodal Agency for the rejuvenation of the lakes in BMA. The present custodian of the BMA lakes are perplexing, particularly between the BBMP and BDA. Further, the BDA document mentioned that the specific lakes are hand-over to BBMP, but BBMP data showed that they have not taken the charge of these specific lakes. The custodian of the lakes has been changed time to time, based on the need i.e. BDA custodian lakes have been rejuvenated and handed over to the BBMP for maintenance. Therefore the Government Order is the only document that will show the custodian of the water bodies in the BMA.

Figure-4.23. Rejuvenated Yediyuru lake under the custody of BBMP

Further, the most of the lakes are maintained by these four Authorities and few lakes are maintained by the NGO (Non-Government Organization), Residential Welfare Association (RWA), etc. Lakes maintained by the NGO and associations are tabulated in the Table-4.12. Apart from these, Nagawara lake (Figure-4.24) is leased to the M/s Lumbini Gardens Ltd. under the PPP (Public-Private Partnership) scheme by KLCDA. The water bodies such as *Gokatte* and *Kunte* are under the custodian of the village panchayat's.

Figure-4.24. Rejuvenated Nagavara lake under custody of KLCDA has leased to M/s Lumbini Gardens Ltd.

Disused lakes in the BBMP area are under the management of BBMP such as the playground, stadium, offices, roads, schools, graveyard and park. Further, the disused lakes are under the KSRTC and BMTC as bus depot like Dharmambudy tank and Sunnakall lake (Table-4.7). Even parts of the lakes are converted as BDA sites and sold out like Binnamangala *Kere*-2 and Haralakunte.

Bring Back the Lakes-2016

The KLCDA (Karnataka Lake Conservation and Development Authority) had conducted the workshop on “Bring Back the Lakes” in the Capitol hotel on 13th June’2016, which was inaugurated by the Hon’ble Minister for Forest, Ecology and Environment. The workshop was conducted with collaboration with the Confederation of Indian Industry (CII) and EMPRI also involved as member of the organizing Committee as per G.O. No. APG 107 ENV 2016, dated 17.05.2016. The objective of the workshop is to bring the corporate volunteers, Residential Welfare Association and donors in the Bengaluru City to develop the lakes under the Corporate Social Responsibility (CSR). Construction of wetland, sewage drain and wastewater diversion, walkway, silt trap, idol immersion tank, fencing and STP; strengthening of bund; desilting, afforestation, electrification and environmental education are the types of works listed in the lake developments during workshop. The approximate cost for the development of the lakes have been estimated by the lake custodian based on the 2016-2017 schedule rates of the Karnataka Public Works Development (KPWD), Minor Irrigation (MI) Department, Bangalore Water Supply and Sewerage Board (BWSSB) and Karnataka Urban Water Supply & Sewage Board (KUWS&SB). Approximately, 20-25 lakhs/ acre of lake area have been estimated by the KLCDA for the development of lakes and the activities such as the commercial, advertisement and charging for entry have been prohibited. Some of the lakes taken up by the Corporates for the development are listed in the following table.

S.No.	Name of Lake	Hobli	Name of Corporates
1.	Hebbagodi lake	Athibele	Biocon Ltd.
2.	Bommasandra lake	Athibele	
3.	Kammasandra lake	Athibele	
4.	Mahadevapura lake	KR Puram	Mphasis India
5.	Maragondanahalli lake	Jigani	Wipro Ltd.
6.	Kyalsanayakanahalli lake	Jigani	Sansera Engineering
7.	Doddathoguru Kere	Begur	Infosys Foundation
8.	Chikkathoguru Kere	Begur	

Whereas, the Chikkamaranahalli (Figure-4.25) and Kodihalli lakes were converted for superstructures erection by ISRO and Saneguruvanahalli Lake-1 (Figure-4.26) was converted as environmental laboratory by KSPCB. Kempapura lake (Figure-4.27) and Halagevaderahalli *Kere*-1 (Figure-4.28) were converted and maintained by HAL and BEML respectively. Apart from the lakes, disused *Gokatte* and *Kunte* were maintained by NICE for roads under the custodian of KIADB and as training ground by CRPF and Indian Defence.

Figure-4.25. Disused Chikkamaranahalli lake converted for ISRO

Figure-4.26. Disused Saneguruvanahalli Lake-1 converted for KSPCB lab and playground

Figure-4.27. Disused Kempapura lake converted for HAL

Figure-4.28. Disused Halagevaderahalli *Kere*-1 converted as BEML layout

4.6.4. Types of the Water bodies:

There are four types of the water bodies are segregated in to four categories based upon its water holding capability such as the perennial, seasonal, dry and disused. There are 837 disused water bodies and within the remaining 684 water bodies, 97 water bodies are perennial and 587 water bodies are seasonal (Figure-4.29). Whereas, most of the water bodies are perennial in the Bengaluru City are due to sewage inflow i.e. Yellamallapa Shetty *Kere* (Figure-4.30).

Figure-4.29. Dried Nimbeyakipura *Kere* as Seasonal lake

Figure-4.30. Perennial Yellamallapa Shetty Kere is due to the sewage inflow

4.6.5. Depths of the Water body:

It is important to determine the water holding capacity of water bodies, which are related to the size of the water bodies. Except the rejuvenated lakes, the bathymetries of all the water bodies are not uniform due to the illegal soil excavation. Further, the depth of the water bodies have plays an important role in the recharge of groundwater and building of the aquatic biodiversity based on light transparency. There are 85 and 203 existing *Gokatte* and *Kunte* in the BMA, which have the average depth of below one meter. The average depth of the lakes has been ranged from the 0.5 to 9 meters. Sankey tank (Figure-4.31) has the maximum average depth of 9 m. Yelahanka lake is also one of the water bodies, which has an average depth of 6m (Figure-4.32).

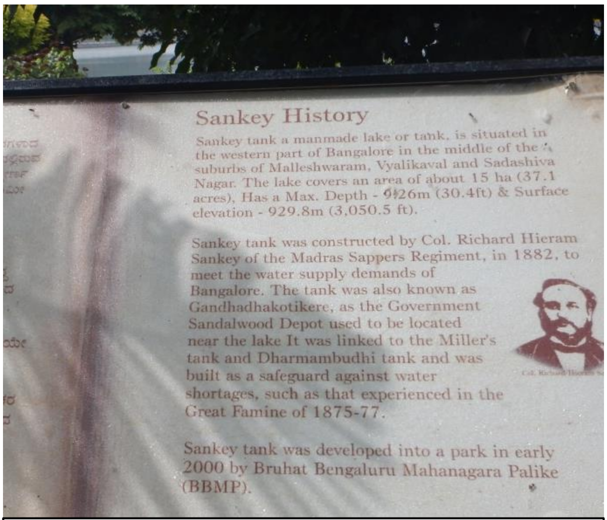


Figure-4.31. Display board shown that Sankey tank has 9m average depth

Figure-4.32. Yelahanka lake has 6m average depth

4.6.6. Holms (Islands in Water bodies):

A land surrounded by water is called an 'Island' and if it is located within an inland water body, then it is also called as 'Holm'. The uses of holm in Bengaluru water bodies are to attract the birds during migration for roosting and nesting, and also it helps in maintaining the water bodies' biodiversity. In Bengaluru, the holms are mostly created as a part of lake rejuvenation and the number of holm is based upon the size of the water body. Holms are recorded in 66 lakes and a maximum of six holms are recorded in three lakes viz… Ulsoor lake (Figure-4.33), Gangondanahalli *Kere* and Sonnenahalli *Kere*. Holms are recorded in the 41 rejuvenated lakes and a minimum of one holm (Figure-4.34) is recorded in the 35 lakes in the BMA.

Figure-4.33. Rejuvenated Ulsoor lake have six islands

Figure-4.34. Islands in rejuvenated Lalbagh Tank

4.6.7. Drains of the Water bodies:

Drain is the channel made naturally or created artificially, which is connected to lentic water bodies for the purpose of conveying the surplus water on land, particularly rainfall runoff. Britishers built *Raja Kaluves* during the year 1883 to feed water for irrigation and to keep the tanks alive in those regions. Drains of the small water bodies or feeder tanks (*Kunte* and *Gokatte*) have been connected to the major tanks. Generally, the drains are located in the upstream of water bodies. In Bengaluru City most of the drains are used to carry the sewage to water bodies due to the negligence or the drains are blocked by siltation and weeds. During rejuvenation, the drains are well constructed by incorporating the components of silt trap, sewage diversion, etc. The presence of inlet drains in the water bodies are ranged from one to 14 are shown in the bar diagram in Figure-4.35.

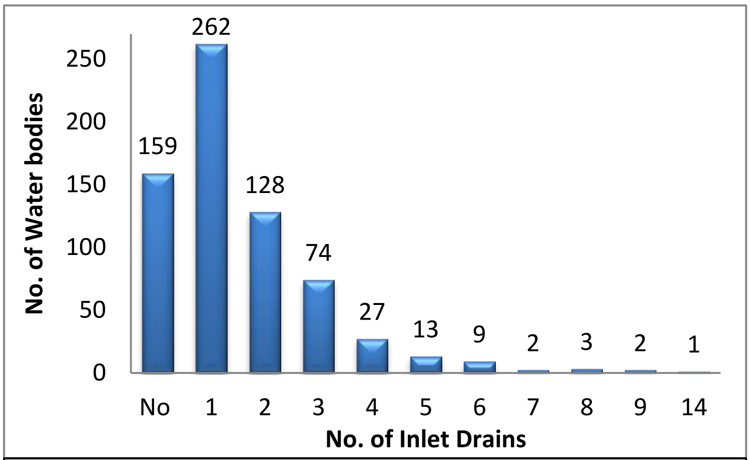


Figure-4.35. Ranges of inlet drains in BMA water bodies

Byappanahalli lake in Bidarahalli hobli of Bengaluru East taluk (Figure-4.36) has a maximum of 14 inlet drains and the rejuvenated Sankey tank (Figure-4.37) has seven inlet drains. There was no inlet drain for the 159 water bodies, which are rain-fed *Kunte* and 262 water bodies have the minimum of one inlet drain.

Figure-4.36. Byappanahalli lake has 14 inlet drains

Figure-4.37. Rejuvenated Sankey tank has seven inlet drains

4.6.8. Waste-weirs of the Water bodies:

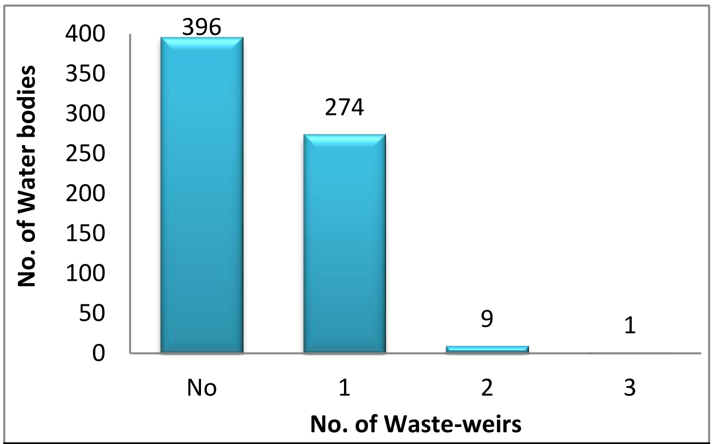


Figure-4.38. Ranges of waste-weirs (outlets) in BMA water bodies

An artificially constructed channel or weir that allows the surplus water from a water body is called as waste-weir. Generally, the waste-weir is located in the downstream of one water body and becomes the drain for another water body. Waste-weirs range from one to three numbers in the water bodies based on its extent and they are graphically represented in the Figure-4.38. Kasaba Amanikere lake (Figure-4.39) in Yelahanka hobli of Bengaluru North taluk has maximum of three waste-weirs and 274 water bodies have a minimum of one waste-weir. To minimize the super flow of water, check dams will also be constructed on the waste-weirs. During the field work, the check dams have been recorded near the three water bodies viz… Alur Thimmagowdana *Kere* (Figure-4.40) in Dasanapura hobli of the Bengaluru North taluk; Bilwaradahalli *Kunte* in Jigani hobli of Anekal taluk and Yelachaguppe Rampura Sakaari *Katte* in Tavarekere hobli of Bengaluru South taluk. There was no waste-weir for the 396 water bodies and most of them are *Kunte* and *Gokatte* because the purpose of these small water bodies is to store water during the rainy season. But even though there were no waste-weirs for these small water bodies, the excess water has been spilled out and reaches the downstream water bodies through slope.

Figure-4.39. Waste-weir of Yelahanka Kasaba Amanikere lake

Figure-4.40. Dasanapura lake waste-weir with check dam

4.6.9. Sluice Gates in the Water bodies:

An artificial channel constructed to control the flow of water with a valve or gate is called as "Sluice Gate", which is mainly used for irrigation purposes. There are no sluice gates for the 510 water bodies, which are mostly the *Kunte* and *Gokatte*. The 170 water bodies have one or more sluice gates; within that, two sluice gates (Figure-4.41 & 4.42) in a water body have been observed in 18 lakes and 152 water bodies have only one sluice gate. The hobli-wise water bodies having the sluice gate are tabulated in the Table-4.13 and revealed that the water bodies in the Kasaba hobli of the Bengaluru North taluk have no sluice gates because all the lakes were constructed as the drinking water source for people.

Figure-4.41. Sluice gates in Bheemanakuppe Hosakere

Figure-4.42. Sluice gates in Vaderahalli lake in

4.6.10. Culverts in the Water bodies:

Culvert is a closed conduit structure, used to convey water from one area to another, usually from one side of a road to the other side under a road. Most of the Bengaluru water bodies have culverts, which are constructed with the round precast concrete pipes and concrete blocks (Figure-4.43). Two lakes namely Kodigehalli lake in Yeshwanthapura hobli of Bengaluru North taluk and Doddanekundi *Kere*-2 in KR Puram hobli of Bengaluru East taluk have the maximum of five culverts to convey the water to the lakes. There is no culvert in 528 water bodies and as minimum one culvert has been recorded from the 98 water bodies. Only 153 water bodies in BMA have the culverts, which are shown in the Table-4.13. Apart from these water bodies, 10; 11 and 32 water bodies have the number of 4; 3 and 2 culverts respectively. Whereas most of the Gokatte and Kunte have no culvert and most of the rejuvenated lakes have the culverts in the BMA. The main disadvantage of culvert construction is the lack of slope. Most of the culverts in BMA are *Stream-crossing culvert* (Figure-4.44), which is a roadway constructed to cross stream channel, collect road runoff and allow water to pass downstream.

Figure-4.43. Round precast concreted culvert pipe in Byappanahalli lake

Figure-4.44. Box concreted culvert in Kithaganur lake

4.6.11. Fences of the Water bodies:

Within the 684 existing water bodies in BMA, only 419 (62%) water bodies are partially or completely fenced for the preservation. The types of fence, which are recorded in the BMA water bodies are tabulated in the Table-4.14. There are three types of fences, which are used to preserve the water bodies in BMA by the Authorities as well as by water body neighborhoods to protect their property. The types of fences recorded are follows;

i. *Mesh fence* is mainly done in the rejuvenated lakes (Figure-4.45) and most of the water bodies in the BBMP area (36%) by using the coated steel wires, which is also called as 'Chain-link fence'. In some places, People have damaged the back-shore fences for their routine activities.

Figure-4.45. Chain-link mesh fence in Kempabhudi lake

ii. *Wired fence* is constructed with sharp edge wires at a regular interval along the strands, which is also called as 'Barbed' or 'Barb-wire' fence (Figure-4.46) and it is mainly used by the farmers. As a precautionary measure and in order to protect their lands, land owners have constructed the low cost wired fence. Wired fences for 31% of the water bodies are partially fenced, because the farmers have fenced only on their side of the land.

iii. *Wall* is constructed by the neighboring stakeholder in order to restrict the access to their property. As the construction of wall is one of the expensive fences, only 16% of the fenced water bodies are fenced with wall. Based on the materials used for the construction of walls, there are two types viz… bricks (red bricks & hollow-blocks) wall and stone wall. Wall fences or compound walls are mainly constructed by NICE Limited by using hollow bricks in Gollahalli *Kere* (Figure-4.47), Ramasandra *Kere*, Manganahalli *Kere*, Gangondanahalli *Kere*, etc. In few places, wall is constructed using the stones by the neighbourhood farmers (Figure-4.48).

Figure-4.46. Partial barb-wire fence in Chikkagubbi lake

Figure-4.47. Compound wall using hollow bricks by NICE Ltd. in Gollahalli Kere

Apart from these three types of walls, there are water bodies with fences that are a combination between the wall, thorn-wire and chain-link mesh fences to partially fence the water bodies. Three lakes in the BMA namely Gollahalli lake in Jigani hobli of Anekal taluk; Ramasandra and Valagerahalli *Kere* in Kengeri hobli of Bengaluru South taluk have been preserved by use of all the three types of fences such as wall, thorn wire and chain-link mesh. The three combination fences such as wall and thorn-wire fence; wall and mesh fence (Figure-4.49); and mesh and thorn-wire fence have been used in 24; 42 and 6 BMA water bodies respectively.

4.6.12. Status of Water in the Water bodies:

During the study, the five types of water status have been observed in the water bodies on the basis of physical quality and quantity of water. The present status of the water in the BMA water bodies is tabulated in the Table-4.15. The following are the five status of the water in the water bodies;

Figure-4.48. Stone wall in Kumbalagodu Cheluvekere

Figure-4.49. Begur Subbedarana *Kere* has been partially fenced with wall and chain-link mesh

a. Clean/ Clear Water: Water is free from pollutants or high dilution rate of pollutants in a water body according to the aesthetic appearance is considered as the clean or clear water. Within the 684 existing water bodies, only 21.62% of (149) water bodies are good (refer database) and most of them are rejuvenated water bodies (Figure-4.50).

b. Muddy Water: Colour of the water is brown due to the soil type of runoff flow and high turbidity. Mostly, the muddy water is observed in the water bodies after the rain (Figure.4.51). So the muddy water is the temporary status in the water bodies, which will disappear after the settlement of the silt. Muddy water in puddle is found in 31.74% of water bodies and is still used by mammals (animal) and for irrigation.

Figure-4.50. Clean water in Lalbagh Kere

Figure-4.51. Muddy water in Ganigarahalli Kere

c. *Puddle of Water:* It is the occurrence of stagnant water in the water body area as small patches during the non-rainy or summer season. This puddle type of water is recorded in the deeper places of water bodies (Figure.4.52) and particularly in places where soil has been excavated. Like muddy water, the puddle of water in the water bodies is also the temporary status which may disappear after the rain. During study period, 216 water bodies have puddle type water and which are also having muddy water used by domestic animals.

d. Greenish Water: Impurities in the water may reflect in the colour of the water and accordingly, the presence of bio-impurities such as the algae, duck weed plant in the water appears as the greenish colour water. There are also possibilities of copper metal presence in the water, which will also reflect as greenish colour water. Greenish colour water has been observed in the nine BMA water bodies (Figure-4.53).

Figure-4.52. Puddle of water in Mavalipura *Kere*

Figure-4.53. Greenish water in Byrasandra *Kere*

e. Polluted Water: Water colour also gets changed due to the presence of pollutants or low dilution rate of pollutants particularly sewage inflow in Bengaluru water bodies (Figure-4.54). The colour of the water will be brownish to black. Totally 34.75% of (202) water bodies are polluted, even the rejuvenated lakes water is also polluted.

e. Dry: It is the absence of water in water body due to encroachment on nallah or catchment degradation. During the study period, 107 (15.73%) water bodies were found to be dry and these types of water bodies are vulnerable to the encroachment by the local people. Further, the water body become dry (Figure-4.55) during summer season and the same water body filled with water during the monsoon season are based upon the seasonal variation.

4.6.13. Present Usage of Water bodies:

Within the 684 existing water bodies, 107 water bodies are dry and the remaining 577 water bodies water is still being used by people for various activities. The usage of water in the water bodies differ from one water body to another water body. The seven different usage recorded are tabulated in the Table-4.16. The present usage of BMA water bodies are as follows:

Figure-4.54. Polluted water in Sadaramangala *Kere*

Figure-4.55. Dried Dyavasandra *Kere*

i. *Fishing*: As fish is a good source of protein and it has good economic value in the market, the fishing in the BMA lakes is through the contract or leasing of water bodies for fishing. The lakes pertained for the fishing activity will be tendered by the Karnataka Fisheries Department, who encourage inland fishermen by providing the subsidy for fish seeds. Fishing in the leased lakes have been done by using the gill net and coracle (Figure-4.56). The cast net and rod-liner worm bait fishing (Figure-4.57) are also used by the local people for fishing in the non-leased BMA lakes. During the study period, the fishing activities have been recorded in the 69 BMA lakes (Table-4.16).

Figure-4.56. Fishing in Dasanapura *Kere* leased by Department of Fisheries

Figure-4.57. Fishing in Kothanur *Kere* by local village people

ii. *Irrigation*: Most of the water bodies are created in the outskirts of the Bengaluru City to improve the irrigation process. But due to rapid sprawl of urbanization and by the boom of real estate, agriculture has rapidly decreased in Bengaluru urban district. But still 148 water bodies in the BMA (Table-4.16) have been used for the micro-irrigation for the cultivation of vegetables. The water from the lakes (Figure-4.58 & 4.59) have been pumped to agriculture land for irrigation. Ramachandra (2008) observed that the local residents depend on Varthur lake for irrigation, fodder, etc., through the socio-economic analysis. The common crop in the study area is mainly paddy and the water used for cultivation of paddy crop (until harvest) is not fully dependent on water bodies. Farmers mostly depend on the groundwater and they use the water from the lake for part of paddy cultivation.

Figure-4.58. Water in the Siddapura *Kere* has been used for irrigation through pumping

Figure-4.59. Water in the Varanasi *Kere* has been used for irrigation through pumping

iii. *Washing*: Four types of washing activities have been observed in the 49 BMA water bodies (Table-4.16) such as the vehicle washing, animal washing, laundry activity and bathing.

a. *Vehicles washing* by hand are usually observed in BMA water bodies, but vehicles are washed in water bodies and mass washing of vehicles are observed during festival seasons. Two-wheelers (Motor-bike and Bicycle), three-wheelers (auto), cars (Figure-4.60), vans, lorries are the vehicles that are washed in the water bodies.

Figure-4.60. Car was washed in the Bheemanakupe Hosakere water

b. *Domestic animals washing* (Figure-4.61) are frequent in the water bodies; particularly mass washing has been observed during the festival season. Apart from washing, cattle and dogs are also found inside the marginal area of water bodies during summer season.

c. *Cloth washing* is a routine process. Thus, the washing is carried out by individuals as well as by washer-men at large scale (dhobi). Importance of the laundry in the olden days has made the villagers to construct the dhobi ghats, but in Bengaluru water bodies, huge stones or rock or stone anchored bund (Figure-4.62) in the water bodies are used. The washer-man also uses the bund of water bodies to dry the washed wet cloths.

Figure-4.61. Cow washed in the Nekkundi Dommasandra *Kere* water

d. *Bathing* in the BMA water bodies by the local people has been observed in the BDA area. In summer season, the people also use the water bodies for swimming (Figure-4.63).

Figure-4.62. Cloth washing in the Madiwala *Kere*

Figure-4.63. Bathing in Rayasandra *Kere*

iv. *Recreational Activities*: Due to open spaces decrease in the urbanised Bengaluru, the people do not have place for recreation except park and playgrounds. So the people use the 18 BMA water bodies (Table-4.16) for the recreational activities like boating (Figure-4.64), recreational fishing (Figure-4.65) and apart from that, the dried part of the water bodies are also used as playground by the youngsters during the summer season. The part of the lake land has been converted into park in most of the rejuvenated lakes and opened for the public recreational activities.

Figure-4.64. Boating in the rejuvenated Vengainakere

Figure-4.65. Recreational fishing activity by local people in Chokkasandra *Kere*

v. *Cattle Feeding*: Water bodies are used to manage the livestock through the fodder harvest and to quench the thirst of cattle. Apart from the cattle, domestic animals, such as dogs (pet & stray), also used to drink and dip in the water bodies during the summer season. *Gokatte* are created for meeting the needs of cattle and in BMA, about 269 water bodies are used for the cattle feeding (Table-4.16). Interestingly, a farmer of the Kannalli village has pumped the groundwater to Mande *Katte* water body as drinking water for the local cattle. The rejuvenated lakes have '*Kalyani*' to store water for the cattle. In the greenbelt zone, most of the cattle like cow (Figure-4.66) buffalo (Figure-4.67), ox, goat, sheep and even horses are found grazing on the plants, including the emergent aquatic plants in the water bodies.

Figure-4.66. Grazing cow in the Ramohalli *Kere*

Figure-4.67. Buffalo quench its thirst in Singapura *Kere*

vi. *Cultural Activities*: Activities, which are done as a part of tradition and by belief on religion, are classified as cultural activities. The activities include - idol immersion;

dispersal of puja materials and bathing in holy water are recorded in the BMA water bodies. The cultural activities that take place frequently are observed in 39 BMA lakes and the two major activities are as follows:

a. *Organic wastes disposal:* The wastes generated due to the cultural activities are mostly the organic wastes like flowers, fruits, coconuts, cloth, incense sticks, camphor, etc. These organic wastes have been dispersed in the water bodies as the part of the cultural activities (Figure-4.68). These organic degrading or degraded wastes results in nutrient enrichment, leading to eutrophication of water bodies.
b. *Idol Immersion*: The immersion of Ganesha and Gowri idols is common during the season of 'V*inayaka Chathurthi*' and '*Durga Puja*' respectively. For these activities, most of the rejuvenated lakes have the constructed 'Idol immersion tank' (Figure-4.69) or 'Kalyani', to stop the impact of idols all over the water bodies. Whereas the KSPCB and KLCDA are playing an important role in awareness of Bengaluru people about the 'idol made by Plaster of Paris' that won't dissolve in water. Apart from these, BBMP and BDA are implementing the CPCB guideline (2010) for the idol immersion in the lake. Paint in the idols have toxic metals like lead and chromium, which threaten the aquatic life by increasing the acid content and TDS.

Figure-4.68. Mass puja performing resulted in organic waste in the Ulsoor lake

Figure-4.69. Idols in the Idol immersion tank of rejuvenated Mallathalli lake

vii. *Other Activities*: The four lakes (Table-4.16) such as Kogilu *Kere* (Figure-4.70), Allalsandra *Kere*, Yelahanka AmaniKere, Hebbala lake, Mattikere, Sankey tank, etc. the water has been used for the park maintenance, construction activities like road and building construction.

BMA water bodies are used for multiple activities such as irrigation, fishing, cultural activities, washing (Figure-4.71), etc. Apart from water usage, the water bodies also play the critical role in socio-economic aspects as sewage dilution; biodiversity aspect as bird roosting and species richness; and climate change aspect as maintain the micro-climate.

Figure-4.70. Kogilu *Kere* water has been pumped for park maintenance

Figure-4.71. Washing of vehicles and cattle in Gangondanahalli *Kere*

4.7. Rejuvenated Water bodies:

Urban water bodies are prone to pollution and encroachments. So, in order to preserve these fragile water bodies using the modern technologies is very much essential. As per the NLCP guidelines (MoEF, 2008), the activities of lake rejuvenation were categorized into core and non-core works. De-silting, de-weeding, construction of wetland and island (Figure-4.72), strengthening of bund, wastewater diversion, silt-trap and screen barrier, improvement of storm-water drains and waste-weirs, construction of idol immersion tank are the core activities implemented under the rejuvenation activities. Whereas, the pathway construction, landscaping, fencing and electrification are the non-core activities considered during the rejuvenation activities. The major lakes in the BMA were rejuvenated (**Annexure-5**) by the Planning Authority (BDA) as well as by the Administrative Authority (BBMP). The lakes rejuvenated by BDA were handed over to BBMP for the maintenance. A few of the lakes rejuvenated by BBMP are maintained by the NGOs and Residential Welfare Associations. The list of the rejuvenated lakes, lakes under rejuvenation and lakes selected for rejuvenation are tabulated in the Table-4.17, Table-4.18 and Table-4.19 respectively. According to KLCDA (2016), 68 lakes were rejuvenated and 39 lakes are under the rejuvenation process (Figure-4.73). Whereas, the comprehensive result on the rejuvenated lakes in BMA shows that out of the 84 lakes rejuvenated (56 lakes by BBMP, 22 lakes by BDA, 4 lakes by KLCDA, one lake by KFD and one lake by Department of Horticulture), 21 lakes are under rejuvenation (16 lakes by BBMP and 5 lakes by BDA) and 39 lakes (22 lakes by BDA and 17 lakes by BBMP) are selected for rejuvenation on priority.

Figure-4.72. Recently rejuvenated Mahadevapura *Kere*

Figure-4.73. Kammagondanahalli *Kere* under rejuvenation process

As per the CAG (Comptroller and Auditor General of India) performance audit report (2015), most of the fund for the rejuvenation activities has been spent on the non-core activities. The report also revealed that there was lack of lake restoration work monitoring, inadequate sewage treatment and inflow of sewage into lakes resulting in high rate of lake pollution.

4.8. Conclusion:

Water bodies in the BMA have been inventorised based on the village map and verified by physical verification. There are 1521 water bodies in the 590 villages in the BMA, within that only 684 water bodies are existing. The inventorised water bodies are segregated into *Kere* (above 3 acres), *Gokatte* (between 1 and 3 acres) and *Kunte* (below 1 acre) based on its size and are uniquely coded using the ISO standards. Within the 837 disused water bodies, most of them were (620) *Kunte*. The status of the water bodies in the BMA has revealed the urgent need for preservation. The information on morphometric characteristics of the BMA water bodies such as the drains, waste-weirs, water status and present usage of the water bodies are useful for the preservation of water bodies on priority basis and for decision making. About 85 lakes have already been rejuvenated by its respective custodian.

Table-4.1. Details of variable field name codes used for attributes

Sl No.	Field Variables	Description	Source
1	WBno.	Water Body No.	-
2	Longitude	Longitude (E)	Field Visit
3	Latitude	Lattitude (N)	
4	TQ_VilMap	Taluk	Village Map
5	HB_VilMap	Hobli	
6	Vil_Name	Village Name	
7	WB_Name	Water Body Name	Authorities/ Local Residents
8	Status	Type	Field Visit
9	Category		-
10	EMPRI_WBNa	EMPRI Water Body Code	
11	CS_PlnAuth	Custodian/ Planning Authority	Custodian & Koliwad Committee Report
12	Extent_AG	Extent (A-G)	Bhoomi RTC
13	Survey_No	Survey No.	Village maps & RTC
14	Crtd_orRej	Created/ Rejuvenated Year	Village maps & Display Board
15	Elevation	Elevation(m)	Field Visit
16	Max_Depth	Max. Depth (m)	
17	No_Island	No. of Islands	
18	No_IDns	No. ofInlet Drains	
19	No_Ww	No. of Waste-Weirs	
20	No_SG	No. of Sluice Gate	
21	Cult_Sourc	Culvert	
22	Surnd_Area	Surrounding Area	
23	ChkDam	Check Dam	
24	Fence_Type	Type of Fence	
25	Psnt_Sts	Present Status	
26	Phy_WatrUs	Physical Water Usage	
27	Date_Visit	Date of Visit	
28	Name_TFAss	Name of Technical & Field Assistants Visited the Lakes	
29	Name_Rschr	Name of Researcher Verified the Lakes by Field Visits	-

Table-4.2. Details of the villages in the BBMP & BDA areas pertaining to Water bodies

Name of Taluk	Name of Hobli	No. of Villages								Total No. Villages
		Presence of Water bodies		No Water bodies		Sharing Water bodies		Total		
		BBMP	BDA	BBMP	BDA	BBMP	BDA	BBMP	BDA	
Bang. North	(Beng.) Kasaba	41	-	25	-	6	-	72	-	72
	Yeshwanthpur	35	6	3	-	5	-	43	06	49
	Yelahanka	29	13	8	3	5	1	42	17	59
	Jala	1	10	-	-	-	1	1	11	12
	Hesaraghatta	-	28	-	1	-	-	-	29	29
	Dasanapura	-	23	-	7	-	1	-	31	31
	Sub-Total	**106**	**80**	**36**	**11**	**16**	**3**	**158**	**94**	**252**
Bang. East	Varthuru	28	6	4	-	1	1	33	7	40
	K.R. Puram	40	-	4	-	3	-	47	-	47
	Bidarahalli	40	-	4	-	3	-	47	-	47
	Sub-Total	**108**	**6**	**12**	**-**	**7**	**1**	**127**	**7**	**134**
Anekal	Sarjapura	1	24	-	2	-	-	1	26	27
	Attebele	-	3	-	-	-	-	-	3	3
	Jigani	-	22	-	2	-	1	-	25	25
	Sub-Total	**1**	**49**	**-**	**4**	**-**	**1**	**1**	**54**	**55**
Bang. South	Tavarekere	-	10	-	2	-	1	-	13	13
	Kengeri	17	24	2	2	-	-	19	26	45
	Uttarahalli	41	2	3	-	1	-	45	2	47
	Begur	32	4	6	-	2	-	40	4	44
	Sub-Total	**90**	**40**	**11**	**4**	**3**	**1**	**104**	**45**	**149**
	Total	**305**	**175**	**59**	**19**	**26**	**6**	**390**	**200**	**590**

Table-4.3. Details of the water bodies in the BMA area

Name of Taluk	Name of Hobli	Kere (Above 3 Acres)			Katte (Between 1 & 3 Acres)			Kunte (Below 3 Acres)			Total Water bodies		
		E	D	Total	E	D	Total	E	D	Total	E	D	Total
Bang. North	(Bangal.) Kasaba	10	24	34	-	9	9	1	33	34	11	66	77
	Yeshwanthpur	31	14	45	5	20	25	7	80	87	43	114	157
	Yelahanka	32	1	33	10	9	19	5	40	45	47	50	97
	Jala	13	1	14	2	3	5	14	7	21	29	11	40
	Hesaraghatta	25	5	30	6	1	7	21	24	45	52	30	82
	Dasanapura	16	3	19	3	2	5	14	12	26	33	17	50
Sub-Total		**127**	**48**	**175**	**26**	**44**	**70**	**62**	**196**	**258**	**215**	**288**	**503**
Bang. East	Varthuru	27	8	35	4	12	16	24	76	100	55	96	151
	Krishnarajapuram	34	13	47	-	3	3	13	71	84	47	87	134
	Bidarahalli	21	4	25	7	15	22	16	61	77	44	80	124
Sub-Total		**82**	**25**	**107**	**11**	**30**	**41**	**53**	**208**	**261**	**146**	**263**	**409**
Anekal	Sarjapura	26	4	30	7	7	14	31	40	71	64	51	115
	Attebele	5	-	5	-	2	2	1	2	3	6	4	10
	Jigani	33	-	33	7	2	9	13	21	34	53	23	76
Sub-Total		**64**	**4**	**68**	**14**	**11**	**25**	**45**	**63**	**108**	**123**	**78**	**201**
Bang. South	Tavarekere	8	-	8	8	1	9	11	10	21	27	11	38
	Kengeri	48	4	52	12	14	26	23	63	86	83	81	164
	Uttarahalli	26	11	37	7	6	13	5	24	29	38	41	79
	Begur	40	10	50	7	9	16	5	56	61	52	75	127
Sub-Total		**122**	**25**	**147**	**34**	**30**	**64**	**44**	**153**	**197**	**200**	**208**	**408**
Total		**395**	**102**	**497**	**85**	**115**	**200**	**204**	**620**	**824**	**684**	**837**	**1521**

E – Existing as Water bodies;

D – Disused water bodies for other land use

Table-4.4. List of water bodies that are not mentioned in the village maps

S. No.	Water body Name	Year of Creation	Village Name	Hobli	Taluk
1.	Rajamahal Kere	≈1995	Rajamahal	Kasaba	Bengaluru North
2.	Ulsoor Lake	≈1900	Ulsoor		
3.	Herohalli kunte6	≈1998	Herohalli	Yeshwanthpura	
4.	Channabasappana katte	≈1960	Kannehalli		
5.	Kannalli Katte-1	≈1990			
6.	Mande Katte	≈1980			
7.	Kannalli Govt. lake*	≈2000			
8.	Kannalli Katte-2	≈2000			
9.	Krishnasagara Kunte	≈2000	Krishnasagara	Yelahanka	
10.	Bettahalsur Narayanapura kunte	≈2000	Bettahalsuru	Jala	
11.	Marenahalli Chokkanahalli kunte	≈1995	Marenahalli		
12.	Sathanoor kunte 6	≈ 2000	Sathanuru		
13.	Anurah katte	≈1995	Adiganahalli	Hesaraghatta	
14.	Hanuman kunte	≈ 2005	Ittagalipura		
15.	Mavalipura Kere 2	≈ 2006	Mavalipura		
16.	Kubaran Kunte	≈2000	Rajanakunte		
17.	Torenagasandra Urkunte	≈2004	Thorenagasandra	Dasanapura	
18.	Krishnaraja Puram kere-2*	≈1995	Krishnarajapuram	KR Puram	Bang. East
19.	Byatarayanadoddi Kere	≈1990	Bhuthanahalli	Jigani	Anekal
20.	Bilwaradahalli Hosakere	≈1990	Bilwaradahalli		
21.	Agarakere	≈2000	Badamanavartha kaval (P1)	Kengeri	Bengaluru South
22.	Hosakere-1	≈2000			
23.	Vaderahalli lake	≈2000	Badamanavartha kaval (P2)		
24.	Bheemanakuppe Hosakere	≈2000	Bhimanakuppe		
25.	Muppatu Kavalu Sakari	≈2000	Maragondanahalli		
26.	Hosa Katte	≈2000			
27.	Mudukappana Katte	≈2000			
28.	Kariyana Kunte	≈2000			

* Disused water body

Table-4.5. List of bigger (between 40 and100 Acres) lakes in BMA

S. No.	Water body Name	Extent (A-G)	Village Name	Hobli	Taluk
1.	Karanji Tank*	43.10	Dodda Bailakhana & Bengaluru Old City	Kasaba	Bengaluru North
2.	Cihkkamaranahalli Lake	43.08	Chikkamaranahalli, Geddalahalli & Nagashettyhalli		
3.	Hennur Lake*	76.24	Hennuru & Nagavara		
4.	Kajarakanahalli Lake	51.26	Kacharakanahalli		
5.	Kempambudhi lake	56.16	Kempambudhi Kere		
6.	Sankey Tank	46.19	Rajamahal		
7.	Abbigere Kere	47.13	Abbigere & Singapura	Yeshwanthpura	
8.	Doddabidarakallu lake	40.17	Doddabidarakallu & Nagasandra		
9.	Kannalli kere	68.09	Kannalli		
10.	Mallathahalli Lake	72.15	Mallathahalli & Gidadakonenhali		
11.	Narasahalli Lake	53.24	Karivabanahalli, Nelagadiranahlli & Doddabidarakallu		
12.	Allasandra Lake	41.23	Allasandra	Yelahanka	
13.	Atturu kere	90.04	Atturu, Kempanahalli, Ramgondanahalli & Ananthapura		
14.	Gantiganahalli Kere	85.05	Gantiganahalli & Nelakunte		
15.	Harohalli kere	74.32	Harohalli		
16.	Kogilu kere	78.28	Kogilu & Kattigenahalli		
17.	Singapura lake	66.18	Singapura		
18.	Mavallipura Karabu Kere 4	65.15	Mavallipura & Shivakote	Hesg.	
19.	Alur kere	76.20	Alur, Vaderahalli, Narsipura & Mathahalli	Dasanapura	
20.	Dasanapura kere	44.33	Dasanapura & Arashinakunte		
21.	Gangondanahalli kere	63.30	Gangondanahalli & Karihobanahalli		
22.	Kachohalli Kere-1	63.01	Kachohalli		
23.	Madavara Kere	71.30	Madavara, Thirumalapura, Chikkabidarakallu & Doddabidarakallu		
	Chikkabellanduru kere	75.21	Chikkabellanduru & Mulluru		

25.	Bellandure Gramadakere	61.37	Bellanduru, Kaikondanahalli & Doddakannelli	Varthuru	Bengaluru East
26.	Gunjur Kere-1	65.39	Gunjur & Kachamaranahalli		
27.	Halanayakanahalli kere1	79.25	Halanayakanahalli, Chikkakannelli & Chikkanayakanahalli		
28.	Kaikondanahalli kere	48.23	Kaikondanahalli & Kasavanahalli		
29.	Kasavanahalli kere	55.08	Kasavanahalli & Haralur		
30.	Kodathi kere	78.01	Kodathi & Solikunte		
31.	Banaswadi Kere2*	47.38	Banaswadi	KR Puram	
32.	Benniganahalli Kere	45.39	Benniganahalli		
33.	Gramadakere	51.34	Horamavu Agara		
34.	Kaggadasapura kere	50.18	Kaggadasapura, Byrasandra & Benniganahall		
35.	Vengaiahanakere	64.35	K.R.Puram & Sannathammanahalli		
36.	Nallurahallikere	54.29	Nallurahalli & Pattaduru Agrahara		
37.	Sadaramangala lake	52.21	Sadaramangala & Kodigehalli		
38.	Vibhutipura kere	45.18	Vibhutipura		
39.	Bidarahalli kere	96.26	Byappanahalli & Bidarahalli	Bidar.	
40.	Byappanahalli kere	43.33	Byappanahalli & Manduru		
41.	Kannuru kere2	63.28	Kannur		
42.	Chikkanagamangala Govt. Gulimangalada lake	46.19	Chikkanagamangala	Sarjapura	Anekal
43.	Chikkanekundi Lake land	43.11	Chikkanekundi & Nekkundi Dommasandra		
44.	Gattihalli Govt. lake	72.39	Gattihalli & Rayasandra		
45.	Bhujangadasana Amanikere Govt lake	54.02	Bhujang.Amanikere, Hullahalli & Sakalavara	Jigani	
46.	Hulimangala Govt. kere	67.07	Hulimangala		
47.	Mantapada kere	42.14	Mantapa & Nallasandra		
48.	Bidarekere lake land	85.25	Ramasandra, Nallasandra & Begihalli		
49.	Bheemanakuppe Hosakere	84.19	Bhimmanakuppe & Ramohalli		
50.	Chinnakurchi kere-1	69.31	Chinnakurchi		
51.	Halagevaderahalli kere-1*	46.34	J.I.Halagevaderahalli		

52.	Muppatu Kavalu Sakari	46.31	Maragondanahalli & Marg. Krishnasagar	Kengeri	Bengaluru South
53.	Ramohalli kere	64.22	Ramohalli	Kengeri	Bengaluru South
54.	Bandimatta Hosa kere	54.14	Valagerahalli	Kengeri	Bengaluru South
55.	Sarrakki kere	82.24	Jaraganahalli, Sarrakki Kere & Puttenahalli	Utta.	Bengaluru South
56.	Bellekanahalli Kere*	56.37	Bellekanahalli	Begur	Bengaluru South
57.	Chikkabegur kere	42.16	Begur & Singasandra	Begur	Bengaluru South
58.	Doddatogur lake	52.22	Doddatogur, Konappana Agrahara & Beratena Agrahara	Begur	Bengaluru South
59.	Koramangala kere2	99.02	Koramangala & Nilasandra (Kasaba Bengaluru North)	Begur	Bengaluru South
60.	Sinivagilu Govt. Lake*	49.11	Shinivagilu Kere	Begur	Bengaluru South

* Disused lake

Table-4.6. List of biggest lakes (Above 100 Acres) in BMA

S. No.	Water body Name	Extent (A-G)	Village Name	Hobli	Taluk
1.	Hebbal kere	192.19	Hebbal & Kodigihalli (Yelahanka)	Kasaba	Bengaluru North
2.	Mattikere Kere	131.31	Mattikere, Jalahalli, Yeshwantpur & Tanniranahalli		
3.	Ulsoor Lake	100.23	Ulsoor		
4.	Chikkabanavara kere	105.15	Chikkabanavara, Keregulladahalli, Somashettihalli & Ganigarahalli	Yeshwp.	
5.	Dodda Bommasandra Lake	124.19	DoddaBommasandra, Kodigehalli & Tindlu	Yelahanka	
6.	Jakkuru lake	164.07	Jakkuru, Yalahanka Amanikere, Agrahara & Sampigehalli		
7.	Yelahanka Kasaba Amanikere	310.08	Kasaba Yelahanka, Vengatala, Kenchanahalli, Manchenahalli & Puttenahalli		
8.	Nagadasanahalli Kere	288.28	Nagadasanahalli, Singanay Amanikere, Thimmasandra, Honnenahalli, Adegenahalli & Singanayakanahalli		
9.	Thimmasandra kere	102.14	Thimmasandra & Tharahunse	Jala	
10.	Ivarakandapura Kere	141.16	Ivarakandapura & Shivakote	Hesr.	
11.	Bellandur Amanikere	919.38	Agara, Bellandur, Beluru Amanikere, Ibbalur, Yamaluru & Kempapura	Varthuru	Bengaluru East
12.	Varthur Amanikere	445.14	Bellandur Amanikere (P2)		
13.	Chellaghatta kere*	124.09	Chellaghatta & Kodihalli		
14.	Doddanekundi kere2	135.30	Doddanekundi, Vibhutipura & Kaggadasapura	KR Puram	
15.	Kalkere Kere	194.06	Bhairathi, Horamavu Agara, Kalkere, Kyalasanahalli & Bilashiwale		
16.	Rachenahalli kere	131.06	Dasarahalli, Jakkur (Yelahanka) & Racenahalli		
17.	Doddagubbi kere	132.12	Doddagubbi, Chikkagubbi & Nadagowdagollahalli		

18.	Rampura Kere	187.31	Huvinane, Rampura, Kallkere & Maragondanahalli	Bidarahalli	East
19.	Yellamallappashetti Kere	490.15	Avalahalli, Medahalli, Kurudusonnenhalli, Hirandahalli & Veeranahalli		
20.	Huskur Govt. Lake	122.28	Huskur, Harohalli & Avalahalli	Sarjapura	Anekal
21.	Singena Agrahara Govt. Sanna kere	123.35	Singena Agrahara, Narayanaghatta & Gottammanahalli		
22.	Begur Lake1	137.24	Begur	Begur	Bengaluru South
23.	Sunnakall kere*	116.18	Adugodi, Annipura (Kasaba) & (Kasaba) Arekempanahalli		
24.	Hulimavu Kere	130.17	Hulimavu & Kammanahalli		
25.	Madivala Kere	276.28	Madivala, Belekannahalli, Kodichikkanahalli & Rupena Agrahara		
26.	Agara kere	142.29	Venkojiraokere & Agara		

* Disused lake

Table-4.7. Details of the disused lakes in BMA

S.No.	Water body Name	Extent (A-G)	Converted to	Hobli
1.	Akkithimmanahalli kere	9.29	Hockey Stadium, Road & Divya Shree Teck Park	Kasaba
2.	Dharmambudy Lake	28.16	Majestic Kempegowda BMTC Bus Terminal	
3.	Karanji Tank	43.10	National College Ground, Buildings, Mahila Seva Samaja school, Kempegowda Hospital & College, Road & Basavanagudi Aquatic center (BBMP Eejukola)	
4.	City Railway Kere	5.37	Vacant land, Slum, Sree Rajashree Food Pvt. Ltd. & Road	
5.	Bilekalli kere	≈10.00	Bengaluru Cantonment Quarters	
6.	Binnamangala kere1	32.02	Open Ground & Buildings	
7.	Binnamangala kere2	9.20	Road, BDA Houses, Masjid-E-Ummul Hasnain, Pristine Public School, Vasanth Enterprises LPG Gas, & Hamsadhwani School for Hearing and Speech Impaired	
8.	Byadarahalli kere	7.25	Slum Area Buildings, Road & School	
9.	Byataguttapalya Lake	5.39	Park, Playground & buildings	
10.	Chikkamaranahalli Lake	43.08	Buildings & ISRO	
11.	Devara Jeevanahalli Lake	14.13	Govt. Urdu model Primary Girls School Playground & Buildings	
12.	Dandu Upparahalli Kere	13.02	Mount Carmel Collage Playground, Buildings, Temple & Road	
13.	Domluru Kere	38.33	ISRO Housing Colony & Defence Colony	
14.	Geddalahalloi Lake	21.18	Buildings & Graveyard	
15.	Hanumanthapura Kere	18.35	Slum Area, Metro Railway Area, Buildings & Temple	
16.	Hennur Lake	76.24	Forest Ranger Officer Office with trees, Road & Houses	
17.	Jedihalli Lake	6.13	Commercial & Residential buildings - Choultries, Industries, Houses & WOC Road	
18.	Kalagondanahalli Lake	25.00	Dr B R Ambedkar Medical college	
19.	Karethimmanahalli Lake	3.16	Park, Houses, Godowns, Road, BBMP building & vacant land	
20.	Kempapura Agrahara Kere	5.09	Temple, Buildings, Vacant land & Road	
21.	Lingarajapura Lake-1	15.20	Buildings, playground, road & Vacant land	
22.	Neelasandra kere	17.32	Housing Colony, Park, Commercial Shops & Road	
23.	Siddapur Kere	17.26	Slum Area & Buildings	
24.	Agrahara Kere	9.25	Dr. Ambedkar Playground	Yeshwanthpura
25.	Bagalakunte Kere1	11.04	Vacant land, Graveyard, Building & road	
26.	Doddabidarakallu kunte2	3.30	Buildings & Vacant land	
27.	Kasaba Yeshwantpur kere	3.02	RNS Motors	
28.	Kethamaranahalli kere-1	8.30	Kempegowda Stadium, Park & Road	
29.	Kethamaranahalli kere-2	21.37	Gayatri devi park/ Mariyappanapalya park,	

S.No.	Water body Name	Extent (A-G)	Converted to	Hobli
			road, houses	
30.	Kethamaranahalli kere-4	6.26	Kala Kesari Udayakumar Park	Yeshwanthpura
31.	Gongadipura kere	12.21	Agriculture	
32.	Laggeri Katte	4.11	Park, Playground & Building	
33.	Laggeri Govt. Katte	6.22	Vacant land	
34.	Saneguruvanahalli Lake-1	12.24	Park, Playground & KSPCB Lab building (Nisarga Bhavana)	
35.	Saneguruvanahalli Lake-2	6.21	Kempegowda Playground	
36.	Ayyana Kere	8.33	Houses	
37.	Ullalu lake-1	6.03	Park & building	
38.	Byatarayapura Lake	5.01	Agriculture	Yelah.
39.	Sathanuru kunte 7	6.07	Eucalyptus Plantation	Jala
40.	Guniagrahara Kere 2	11.13	Mango Plantation	Hesaraghatta
41.	Kasagattapura Kere 1	4.22	Agriculture & Eucalyptus Plantation	
42.	Kodagithirumalpura Kere	3.24	Agriculture & Road	
43.	Kumbarahalli kere 2	3.02	Eucalyptus Plantation & Agriculture	
44.	Madappanahalli kere 2	5.07	Plantation	
45.	Heggadadevanapura kere-2	4.01	Godown	Dasana pura
46.	Heggadadevanapura kere -3	6.04	Layout	
47.	Makali Kere	3.31	Godown	
48.	Balagere kunte1	3.01	Vacant land	Varthuru
49.	Chellaghatta kere	124.09	Golf Business park	
50.	Chudasandra kere	4.06	Eucalyptus Plantation	
51.	Kempapura kere	13.32	HAL Airport	
52.	Bandekere	10.00	BMTC Bus Depo	
53.	Sheshayyanakere	4.39	Agriculture	
54.	Kodihalli kere	25.24	ISRO (Department of space liquid propulsion systems center)	
55.	Konena agrahara kere	20.37	Houses & Sir M V College	
56.	Bhairathikhane kere	5.29	Sewage Drain & Vacant land	KR Puram
57.	Banasavadi Kere-1	19.17	Houses, New Horizon College, Mini Forest	
58.	Banaswadi Kere2	47.38	Houses & Vacant land	
59.	Byappanahalli kere	8.09	Houses	
60.	Byatarayanapura kunte1	3.02	Park	
61.	Chinnappanahalli kere1	11.10	Coconut plantation	
62.	Doddanekundi kere1	12.28	Coconut Plantation	
63.	Kalkere kunte2	3.01	Vacant land	
64.	Kothnur kunte1	4.03	Vacant land	
65.	Krishnaraja puram kere-2	8.05	Dr Ambedhkar Stadium	
66.	K.G Thippasandra kere	15.26	Houses	Pur

S.No.	Water body Name	Extent (A-G)	Converted to	Hobli
67.	Vijinapura kere	29.15	Houses	
68.	White field kunte4	3.09	Post Office & Houses	
69.	Doddabanahalli kere	21.19	Agricultural land	Bidarahalli
70.	Kadusonnappanahalli kere	14.35	Houses, layout & Agriculture	Bidarahalli
71.	Kannuru kere1	3.13	Layout	Bidarahalli
72.	Medihalli kere	3.11	Vacant land	Bidarahalli
73.	Chikkanagamangala Kere	5.18	Vacant land & layout	Sarjapura
74.	Chikkavaderapura Govt. Karabu Kere land	3.21	Eucalyptus Plantation	Sarjapura
75.	Kommasandra Kere-1	14.20	Agricultural land	Sarjapura
76.	Nekkundi Dommasandra Sarkari Karabu Kere	22.23	Settlement, Eucalyptus Plantation, layout & Vacant land	Sarjapura
77.	Badamanavarthakaval Kere	5.09	Agriculture & vacant land	Kengeri
78.	Halagevaderahalli kere-1	46.34	BEML layout	Kengeri
79.	Kumbalagodu Kere	3.18	Vacant land	Kengeri
80.	Maragondanahalli Krishnasagara Lake	5.25	Agricultural land	Kengeri
81.	Chikkakallasandra Kere	12.26	Buildings, Vacant land & BMTC bus stand	Uttarahalli
82.	Govt. Vodanakunte	7.18	Layout	Uttarahalli
83.	Dasanakatte-1	4.15	Layout with few buildings	Uttarahalli
84.	Dasanakatte-2	4.11	Sapota plantation	Uttarahalli
85.	Ittamadu kere	10.23	Vacant land & Settlement	Uttarahalli
86.	Channamanakere	9.07	Govt. Training college, Samudhaya Bhavan, Bank & Houses	Uttarahalli
87.	Marenahalli Kere	21.22	Park, BMTC bus stop & Buildings	Uttarahalli
88.	Thalagattapura Kere	5.21	Anjanapura Layout & Houses	Uttarahalli
89.	Vaddarapalya Lake	4.08	Coconut plantation, Godown & NICE Road	Uttarahalli
90.	Cannammakere	33.01	Playground, BBMP office, Hospital & houses	Uttarahalli
91.	Jaraganahalli kere	5.26	Playground, buildings & Lorry stand	Uttarahalli
92.	Sunnakall kere	116.18	BMTC & KSRTC Bus Depot, Road, Southern Roadways, Buildings	Begur
93.	Bellekanahalli Kunte1	7.17	Buildings	Begur
94.	Bellekanahalli Kunte 2	7.24	Apollo Hospital	Begur
95.	Bellekanahalli Kere	56.37	Dollars Colony	Begur
96.	Haralakunte	17.12	BDA houses	Begur
97.	Koramangala kere1	6.27	Buildings	Begur
98.	Nynappanashettypalya kere	3.25	Buildings	Begur
99.	Sinivagilu Govt. Lake	49.11	Buildings	Begur
100.	Yellakunte Kere-1	15.11	Buildings	Begur
101.	Yellakunte Kere-2	9.26	Buildings	Begur

Table-4.8. Details of the oldest water bodies in BMA

Taluk	Hobli	Year	Water body Name
Bengaluru North	Kasaba	≈1537	Dharmambudhi Tank
	Yeshwanthpura	≈1869	Srigandhakavalu Karabu Katte
	Yelahanka	≈1902	Amruthahalli Lake
	Jala	≈1919	Bettahalsur kere
	Hesaraghatta	≈1873	Mylappanahalli Kere 2
	Dasanapura	≈1871	Kuduregere kere
Bengaluru East	Varthuru	≈1874	Kaikondanahalli kere
	KR Puram	≈1889	Mahadevapura kere
	Bidarahalli	≈1882	Kannuru kere2
Anekal	Sarjapura	≈1864	Chikkanekundi Lake land
	Athibele	≈1923	Hebbagodi/ Uramundinakere
	Jigani	≈1887	Bilwaradahalli kere
Bengaluru South	Tavarekere	≈1904	Chanenahalli kunte 1
	Kengeri	≈1890	Kambhipura Govt. Karabu kere-1
	Uttarahalli	≈1856	Chikkakallasandra Kere
	Begur	≈1819	Koramangala kunte

Table-4.9. Details of the high and low altitude water bodies location in BMA

Taluk	Hobli	Highest Altitude		Lowest Altitude	
		Elevation (masl)	Water body Name	Elevation (masl)	Water body Name
Bengaluru North	Kasaba	944	Dandu Upparahalli *Kere*/ Millers Tank	853	Jakkasandra *Kunte*
	Yeshwanthpura	940	Peenya *Kunte*	836	Ullalu *Kere*
	Yelahanka	945	Shinganayakanahalli	887	Kogilu *Kere*
	Jala	948	Bettahalsuru	890	Thimmasandra
	Hesaraghatta	932	Rajanakunte *kunte*	856	Kodagi Thirumalapura *Kere*
	Dasanapura	895	Dasanapura *Kunte*-1	841	Bayandahalli *Kere*
Bengaluru East	Varthuru	917	Kodihalli *Kunte*-1	833	Ambalipura *Kere*/ Melinakere
	KR Puram	927	Banasavadi *Kunte*-2	864	Bhairathikhane *Kere*
	Bidarahalli	931	Kannuru *Kere*-1	785	Varanasi *Kunte*-2
Anekal	Sarjapura	940	Chikkanagamangala *Kunte*-3	820	Gulimangala *Kunte*-1
	Athibele	936	Veerasandra Govt. *Kunte*-2	903	Veerasandra Govt. *Kunte*-1
	Jigani	948	Byrappanahalli *Kunte*-1	821	Byatarayanadoddi kere
Bengaluru South	Tavarekere	874	Chanenahalli *Kunte*-3	784	Chikkelluru Venkatapura *Kunte*
	Kengeri	852	Konashetty *Kere*	742	Gangasandra *Kunte*
	Uttarahalli	953	Kembathahali *Kere*	756	O.B. Chudahalli *Kunte*-2
	Begur	958	Doddatogur *Kunte*-1	871	Koramangala *Kere*-2

Water body located in the highest altitude in BMA

Water body located in the lowest altitude in BMA

Table-4.10. Details of the lakes custodian in BMA

S.No.	Name of Authority	No. of Tanks under custody
1.	KLCDA	4
2.	BBMP	109
3.	BDA	92
4.	KFD	6
	Total	**211**

Source: KLCDA, 2016

Table-4.11 . History of lakes Custodian in the BMA

Date of Order	No. of lakes with Authorities				Details
	KFD	BBMP	BDA	LDA	
1986	105	1	2	-	Order No. PWD 82 IMB 85 dt. 26.07.1985 (N. Lakshman Rau Report)
11.02.1988	115	-	-	-	115 lakes handed to KFD for the development by PWD according to G.O. order No. PWD 82 IMB 85
28.03.2008	100	23	-	4	23 ZP, MI and KFD lakes handed to BBMP according to APG/172/ ECO/2007
20.09.2008	100	42	-	4	19 MI lakes handed to BBMP according to MI88/2008
19.04.2010	6	136	-	4	94 KFD lakes handed to BBMP according to G.O.No. FEE 139 ECO 2008
06.08.2010	6	107	29	4	29 BBMP lakes handover to BDA for rejuvenation according to G.O. NAE 291 MNY 2010
26.02.2011	6	129	44	11	N.K.Patil High Court Committee Report vide its order dated 26.11.2010 in WP.No. 817/2008 (Additionally, Ministry of Defence have 2 lakes; ZP have 11 lakes and MI have 18 lakes)
03.05.2011	6	127	46	11	2 BBMP lakes handover to BDA according to G.O. NAE 865 MNY 2010
05.07.2011	6	126	47	11	1 BBMP lake handover to BDA according to NAE 690 MNY 2010
25.01.2012	6	48	125	7	78 BBMP lakes handover to BDA according to NAE 441 MNY 2011
04.08.2012	6	54	122	4	3 LDA lakes and 3 developed BDA lakes are transferred to according to BBMP NAE 305 MNY 2012
30.11.2013	6	54	122	4	BDA Document
13.06.2016	6	109	92	4	Bring back the lakes workshop by KLCDA

Table-4.12. Lakes maintained by NGO and Associations in BBMP area

S.No.	Name of Lake	Hobli	Maintained by
1.	Sankey Tank	Kasaba	Total Environment Building System (TEBS)
2.	Jakkur Lake	Yelahanka	Satya Foundation and JaLaPoshan Trust
3.	Kaigondanahalli lake	Varthur	Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti (MAPSAS) & United way (sponsored by Wellfargo)
4.	Sowlkere		Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti (MAPSAS) & United way (sponsored by GENPACT)
5.	Amblipura Kelaginakere		Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti (MAPSAS)
6.	Haralur Lake		Mahadevpura Parisara Samrakshane Mattu Abhivrudhi Samiti (MAPSAS)
7.	Doddakanneli Lake		Swami Vivekananda Seva Abhivruddhi Samsthe
8.	Munnekolalu Lake		Munnekolalu Lake Trust & United way (sponsored by Northern Trust)
9.	Chinnappanahalli Kere	KR Puram	Chinnappanahalli Lake Development Trust (CLDT) & TCS
10.	Sheelvantana Kere		NUSA DUA Owners Welfare Association & VDB Property Ventures
11.	Kavdenahalli Lake		United way (sponsored by Wellfargo)
12.	Devasandra Lake		United way (sponsored by Wellfargo)
13.	Puttenahalli Lake	Uttarahalli	Puttenahalli Neighborhood Lake Improvement Trust (PNLIT)

Table-4.13. List of sluice gate and culverts in the BMA

S.No.	Hobli Name	No. of Water bodies	
		Sluice gate	Culvert
1.	Kasaba	-	4
2.	Yeshwanthpura	19	14
3.	Yelahanka	8	9
4.	Jala	6	2
5.	Hesaraghatta	18	7
6.	Dasanapura	8	9
7.	Varthuru	10	12
8.	KR Puram	11	24
9.	Bidarahalli	15	12
10.	Sarjapura	13	12
11.	Athibele	-	3
12.	Jigani	15	7
13.	Tavarekere	7	3
14.	Kengeri	18	16
15.	Uttarahalli	3	11
16.	Begur	19	8
	Total	**170**	**153**

Table-4.14. Types of fence used to preserve the water bodies in the BMA

Name of Hobli	Type of fences recorded in water bodies					
	Mesh	Thorn-wire	Wall	Mesh & Thorn-Wire	Mesh & Wall	Thorn-Wire & Wall
Kasaba	8	1	-	-	-	-
Yeshwanthpura	20	2	4	2	-	-
Yelahanka	21	8	1	-	2	-
Jala	3	4	2	-	-	1
Hesaraghatta	1	17	6	-	-	1
Dasanapura	-	10	10	-	-	1
Varthuru	19	4	2	-	2	1
KR Puram	19	2	3	-	12	-
Bidarahalli	5	8	8	-	1	3
Sarjapura	2	24	6	-	1	3
Athibele	-	1	2	-	-	2
Jigani	-	14	11	1	1	8
Tavarekere	2	8	1	-	1	1
Kengeri	11	15	8	1	11	3
Uttarahalli	19	1	3	-	3	-
Begur	19	9	3	2	8	-
Total	**149**	**128**	**70**	**6**	**42**	**24**

Table-4.15. Present status of water in the water bodies of BMA

Name of Hobli	Water Status in water bodies				
	Dry	Polluted (Sewage)	Muddy & Puddle	Clear	Greenish
Kasaba	2	4	-	5	-
Yeshwanthpura	4	24	11	4	-
Yelahanka	8	16	17	5	1
Jala	5	5	19	-	-
Hesaraghatta	20	5	26	-	-
Dasanapura	7	3	17	4	2
Varthuru	9	13	21	11	1
KR Puram	5	27	3	10	2
Bidarahalli	7	9	17	9	2
Sarjapura	8	11	40	5	-
Athibele	-	6	-	-	-
Jigani	4	9	18	22	-
Tavarekere	6	-	8	13	-
Kengeri	14	18	15	35	1
Uttarahalli	5	24	2	7	-
Begur	3	28	2	19	-
Total	**107**	**202**	**216**	**149**	**9**

Table-4.16. Present water usage of the water bodies in the BMA

Name of Hobli	Usage						
	Fishing	Irrigation	Washing	Recreation Activity	Cattle feeding	Cultural activities	Others
Kasaba	1	-	-	2	-	9	-
Yeshwanthpura	3	4	2	3	15	9	1
Yelahanka	12	11	10	4	14	1	-
Jala	5	8	3	-	20	6	-
Hesaraghatta	1	47	1	-	5	-	-
Dasanapura	3	13	1	1	17	-	-
Varthuru	4	8	2	-	16	1	1
KR Puram	10	-	5	1	15	-	-
Bidarahalli	3	15	4	-	22	-	1
Sarjapura	1	21	4	1	40	-	1
Athibele	-	-	1	-	-	-	-
Jigani	3	6	3	3	22	1	-
Tavarekere	-	7	1	-	14	-	-
Kengeri	6	3	5	1	39	6	-
Uttarahalli	8	1	2	-	13	4	-
Begur	9	4	5	2	17	2	-
Total	**69**	**148**	**49**	**18**	**269**	**39**	**4**

Table-4.17. Rejuvenated lakes in the BMA

S. No.	Water body Name	Custody	Hobli	Taluk
1.	Nagavara lake	KLCDA	Bengaluru Kasaba	Bengaluru North
2.	Hebbal lake	KLCDA		
3.	Kempambudhi lake	BBMP		
4.	Sankey Tank	BBMP		
5.	Ulsoor lake	BBMP		
6.	Lalbagh Kere	Dept. Horticulture		
7.	Mallathahalli lake	BDA	Yeshwanthpura	
8.	Handrahalli lake	BBMP		
9.	Kodigehalli lake	BBMP		
10.	Ullala lake	BBMP		
11.	Mattikere	BBMP		
12.	Chokkasandra lake	BBMP		
13.	Kammagondanahalli kere	BBMP		
14.	Malagalu kere	BBMP		
15.	Manganahalli Kere	BDA		
16.	Lingadeeranahalli kere	BBMP		
17.	Herohalli kere	BBMP		
18.	Jakkur & Sampigehalli lake	BDA	Yelahanka	
19.	Venkateshpura lake	BDA		
20.	Thirumenahalli lake	BBMP		
21.	Agrahara lake	BBMP		
22.	Kogilu lake	BBMP		
23.	Yelahanka lake	BBMP		
24.	Veerasagara lake	BBMP		
25.	Attur lake	BBMP		
26.	Narasipura lake	BBMP		
27.	Chokkanahalli lake	BBMP		
28.	Ramagondanahalli lake	BBMP		
29.	Narasipura lake	BBMP		
30.	Allalasandra lake	BBMP		
31.	Doddbommasandra kere	BBMP		
32.	Kattigenahalli Kere	BBMP	Jala	
33.	Kattigenahalli lake	BBMP		
34.	Kattigenahalli karabhu kere	BDA		
35.	Gangondanahalli kere	BDA	Dasanapura	
36.	Madavara lake	BDA		
37.	Ambalipura Kelagina Kere	BBMP	Varthuru	Bengaluru East
38.	Kaigondanahalli lake	BBMP		

S. No.	Water body Name	Custody	Hobli	Taluk
39.	Ambalipura Melina Kere	BBMP		
40.	Doddakanenahalli lake	BBMP		
41.	Munnekolalu Kere	BBMP	Varthuru	Bengaluru East
42.	Kasavanahalli lake	BBMP		
43.	Haraluru Kere	BBMP		
44.	Sowl Kere	BBMP		
45.	Lake dew kere Haraluru	BBMP		
46.	Rachenahalli lake	BBMP	KR Puram	
47.	Vijanapura lake	BBMP		
48.	Sigehalli lake	BBMP		
49.	Devsandra lake	BBMP		
50.	Shilavanthana Kere	BBMP		
51.	Vengaiahana Kere	KLCDA		
52.	Chinnappanahalli lake	BBMP		
53.	Kowdenahalli lake	BBMP		
54.	B. Narayanapura kere	BDA		
55.	Doddanekundi kere	BDA		
56.	Gangashetti kere	BDA		
57.	Vibhuthipura kere	BDA		
58.	Kudlu Chikere	BBMP	Sarjapura	Anekal
59.	Kudlu Doddakere	BBMP		
60.	Hosahalli	BDA		
61.	Kethohalli Mogi kere	BDA	Tavarekere	Bengaluru South
62.	Kommaghatta lake	BDA	Kengeri	
63.	Ramasandra lake	BDA		
64.	Sompura lake	BDA		
65.	Halage Vaderahalli lake	BBMP		
66.	Chudenapura kere	BDA		
67.	Deepanjalinagara kere	BDA		
68.	Kasaba Kengeri kere	BBMP		
69.	Thalaghattapura lake	BDA	Uttarahalli	
70.	Kothanur lake	BDA		
71.	Yadiyur lake	BBMP		
72.	Byrasandra kere	BDA		
73.	Kothanuru Kere	BBMP		
74.	Puttenahalli Kere	BBMP		
75.	Bikasipura Devara Kere	BBMP		
76.	Uttarahalli Dore Kere	BBMP		
77.	Uttarahalli Mogi Kere	BBMP		

S. No.	Water body Name	Custody	Hobli	Taluk
78.	Agara lake	KLCDA	Begur	
79.	Singasandra lake	BBMP		Bengaluru South
80.	Parappana Agrahara Kere	BBMP		
81.	Madiwala tank	KFD		
82.	Jakkasandra kere	BBMP		
83.	Tavarekere kere	BBMP		
84.	Mylasandra Uramundinakere	BDA		

Table-4.18. List of lakes under rejuvenation in the BMA

S. No.	Water body Name	Custody	Hobli	Taluk
1.	Amruthahalli lake	BDA	Yelahanka	Bengaluru North
2.	Avalahalli lake	BBMP		
3.	Herohalli lake	BBMP		
4.	Devarabeesanahalli lake	BBMP	Varthuru	Bengaluru East
5.	Kalkere lake	BBMP	KR Puram	
6.	Challakere lake	BBMP		
7.	Mahadevapura lake	BBMP		
8.	Kaggadasapura lake	BBMP		
9.	Hoodi Kere	BBMP		
10.	H.Gollahalli Kere	BBMP	Kengeri	Bengaluru South
11.	Nayadahalli lake	BBMP		
12.	Nayanadanahalli kere	BDA		
13.	Dodda Kallasandra lake	BDA	Uttarahalli	
14.	Hosakerehalli kere	BDA		
15.	Arakere Kere	BDA	Begur	
16.	Kodige Singasandra lake	BBMP		
17.	Basapura lake-1	BBMP		
18.	Ibblur lake	BBMP		
19.	Kalena Agrahara lake	BBMP		
20.	Begur lake	BBMP		
21.	Yellukunte kere	BBMP		

Table-4.19. List of lakes selected for rejuvenation in the BMA

S. No.	Water body Name	Custody	Hobli	Taluk
1.	Srigandha Kaval lake	BDA	Yeshwanthpura	Bengaluru North
2.	Bagalgunte lake	BBMP		
3.	Nagarabhavi lake	BBMP		
4.	Vishwaneedum lake	BBMP		
5.	Singapura lake	BBMP	Yelahanka	
6.	Panathur lake	BDA	Varthuru	Bengaluru East
7.	Junnasandra lake	BDA		
8.	Gunjur Mouje lake	BDA		
9.	Gunjur Palya lake	BDA		
10.	Chikka Bellanduru lake	BDA		
11.	Siddapura lake	BBMP		
12.	Bhoganahalli lake	BBMP		
13.	Panathur lake	BBMP		
14.	Garudachrpalya lake	BDA	KR Puram	
15.	Mahadevapura lake	BDA		
16.	Nallurahalli lake	BDA		
17.	Horamavu lake	BDA		
18.	Sadaramangala lake	BBMP		
19.	Garuddacharpalya lake	BBMP		
20.	Chikkabasavanapura lake	BBMP		
21.	Hormavu Agara lake	BBMP		
22.	Channasandra lake	BDA	Bidarahalli	
23.	Bhattarahalli lake	BBMP		
24.	Lingdheeranahalli lake	BDA	Kengeri	Bengaluru South
25.	Chikkegowdana Palya lake	BDA		
26.	Bikasipura Devera Kere	BDA	Uttarahalli	
27.	Vasanthapura lake	BDA		
28.	Gowdanapalya lake	BDA		
29.	Alahalli lake	BDA		
30.	Gubbalalu lake	BDA		
31.	Gottigere	BBMP		
32.	Jaraganahalli lake	BBMP		
33.	Subramanyapura lake	BBMP		
34.	Yelchenahalli lake	BBMP		
35.	Begur Nyanappanahalli lake	BDA	Begur	
36.	Yelenahalli lake	BDA		
37.	Somasundarapalya lake	BDA		Bengaluru South
38.	Hulimavu lake	BDA		Bengaluru South
39.	Mangammana Palya Kere	BBMP		Bengaluru South

CHAPTER

5

WATER QUALITY

Chapter-5: Water Quality of Lakes

5.1. Introduction:

Water is the most important factor in shaping the land and regulating the climate. It is one of the most important compounds that profoundly influence life. The quality of water is usually described according to its physical, chemical and biological characteristics. Water quality plays a crucial role in human population as well as aquatic biota. Water quality is very vulnerable to changes. Rapid industrialization, indiscriminate use of chemical fertilizers and pesticides in agriculture, land use land cover changes and invasive species are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota. Due to use of contaminated water, human population suffers from various water borne diseases. It is therefore necessary to check the water quality at regular interval of time. The major causes for the water impaired by other pollutants are listed in Table-5.1.

> As per Article 48-A of constitution of India – "The State shall endeavor to protect and improve the environment and to safeguard the forests and wild life of the country". Article 51-A (g), says that "It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures." Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution and the maintaining or restoring of wholesomeness of water pollution and the maintaining or restoring of wholesomeness of water.

Table-5.1. Major impairment cause categories

Category	Examples
Cause Unknown – Impaired Biota	Impairment or degradation of the biological community (e.g. fish, Macro invertebrates) due to unknown/unidentified cause
Dioxins	Highly toxic, carcinogenic, petroleum-derived chemicals that are persistent in the environment and may be found in fish tissue, water column, or sediments
Flow Alterations	Changes in stream flow; includes water diversions for purposes
Habitat Alterations	Modifications to stream banks, fish habitat; barriers
Metals	Substances identified as "metals;" include, Mercury, selenium, lead, copper, arsenic, manganese, others
Nuisance Exotic Species	Non-native fish, animals, or plants such as cat fish, which choke out native species and alter the ecological balance of waters

Nutrients	Primarily nitrogen and phosphorus; in excess amounts, these nutrients over-stimulate the growth of weeds and algae and can lead to oxygen depletion
Organic Enrichment/ Oxygen Depletion	Low levels of dissolved oxygen; high levels of biochemical oxygen demanding substances (e.g., organic materials such asplant matter, food processing waste, sewage) that use up dissolved oxygen in water when they degrade
Pathogens	Bacteria and pathogen indicators *E.coli*, total coliforms, fecal coliforms, Enterococci; used as indicators of possible contamination by sewage, livestock runoff, and septic tanks
Polychlorinated biphenyls (PCBs)	A toxic mixture of chlorinated chemicals that are no longer used, but are persistent in the environment; used in industry and electrical equipment; primarily found in fish tissue or sediments. The 'Regulation of Polychlorinated Biphenyls Order, 2016' bans manufacture and import of PCBs and import of equipment containing PCBs. But Polychlorinated Biphenyls may be used, sold and imported in quantities as required for research and development activities in Central Universities, Council of Scientific and Industrial Research Laboratories, Government Institutions or Central Power Research Institute after the concurrence of the Ministry of Environment, Forest and Climate Change, Government of India.
Pesticides	Substances identified as "pesticides;" also, chlordane, atrazine, carbofuran, and others; many older pesticides are persistent in the environment
Sediment	Excess sediments, siltation; affects aquatic communities by altering and suffocating habitat and clogging fish gills
Toxic Organics	Chemicals identified only as "toxic organics;" also, priority organic compounds, non-priority organic compounds, polycyclic aromatic hydrocarbons (PAH), and others; often persistent in the environment

As on February 2018, in addition to organic and inorganic substances, chemical abstract Registry has: 67,527,398 sequences, 105,473,387 Single and multi-step reactions, and synthetic preparations, 387,863 inventoried/regulated substances (CAS, 2018).

Many of the chemicals/products enter market and subsequently to environment even before fully understanding its impact on health of humans and environment. Many chemicals/products like insect repellents, florescent lamps, leaded paints, non-biodegradable surfactants, lead-acid battery, used engine-oil make their way to environment directly or without being removed in sewage treatment plant.

Antibiotics are vital in the treatment of bacterial infectious diseases but when released into the environment they may impact non-target organisms that perform vital ecosystem services and enhance antimicrobial resistance development with significant consequences for human health. After the use of antibiotics, only about 30 percent of the antibiotics can be absorbed via the human or animal metabolism. Rest of the antibiotics drugs goes through excrement (or faeces) and discharge into the environment (Yu and Lu, 2015).

5.2. Methodology:

A onetime sampling was carried out as per the approval of Project Technical Advisory Committee held on 14.07.2016. Water analysis was carried out for approved 14 parameters for the lakes in the study area comprising BBMP and BDA region of Bengaluru.

Water sampling (**Annexure-6**) and analysis was carried out for lakes/*Kere's* with an area of 3 and above 3 acres during the year 2017-2018. The water bodies belonged to all the four taluks of Bengaluru district namely Bengaluru North, Bengaluru South, Anekal and Bengaluru East taluks, respectively. The collected samples were analysed in the established laboratory in EMPRI. Standard Operating Procedure (SOP) was prepared based on Bureau of Indian Standards (BIS-3025) to be followed during analysis in the laboratory.

Out of 395 existing lakes visited, 92 lakes were found to be dry and remaining 303 lakes were sampled (**Annexure-7**). The analysis for 14 parameters are based on Bureau of Indian Standards is tabulated in the Table-5.2.

5.2.1. Water Sample Collection:

Water samples are collected in two types of containers for bacteriological and physico-chemical analysis. The leak-proof glass (Non-actinic glass bottles) is used for collecting bacteriological samples. The photosensitive activities are reduced to a considerable extent. The plastic container (polyethylene cans) are used for collecting water samples. As per the BIS: 3025 (1):2003 the new containers and the glass containers are cleaned before collecting the samples. In the field, the sampling is carried out as per the BIS-3025 (1): 2003. General sampling techniques was followed. For lake studies, minimum two samples per lake are collected as discrete sampling. One sample each at inlet (to analyse the inflow water quality) and outlet drains or waste weir (to analyse the status of lake water quality) are collected.

Table-5.2. Protocols followed for water sample collection and analysis of 14 water quality parameters

Sl. No.	Parameters	Unit	Protocol	Methodology
1.	Sample Collection	-	BIS-3025 (1): 2003	Physico-chemical Analysis - Surface water sample collected in 2L plastic (Polyethylene) cans Bacteriological Analysis - Surface water sample collected in 100 ml pre-sterilized brown bottle
2.	Water Inflow	Cumecs	BIS-1192: 2001	Measured in the inlet drains of lake by Velocity-Area method using surface float (ball)
3.	Water Temperature	^{0}C	BIS-3025 (9):1984	Mercury glass thermometer used to measure temperature in the field
4.	pH	-	BIS-3025 (11):1996	Electrometric method by use of Eutech-ECPH TUTOR pH meter
5.	Light Transparency	m	-	20 cm width Secchi Disk with black and white colour and pre-measured rope was used
6.	Electric Conductivity (EC)	µS/cm	BIS-3025 (14): 2013	Wheatstone Bridge method using conductivity meter of Systronics MK-509
7.	Total Suspended Solids (TSS)	mg/l	BIS-3025 (17): 2012	Gravimetric method use of Whatman GF/C or equivalent
8.	Total Dissolved Solids (TDS)	mg/l	BIS- 3025 (16): 2012	Gravimetric method use of Whatman GF/C or equivalent
9.	Turbidity	NTU	BIS-3025 (10): 1996	Nephelometric method by use of Systronics-135 Turbidity meter
10.	Dissolved Oxygen (DO)	mg/l	BIS-3025 (38): 2003	Titrimetric method by Modified Winkler's with Azide modification
11.	Chemical Oxygen Demand (COD)	mg/l	BIS-3025(58):2006	Open reflux digestive method followed by titration
12.	Biochemical Oxygen Demand (BOD_3)	mg/l	BIS- 3025(44): 2003	Titrimetric method by 3 days Modified Winkler's method with sample dilution based on COD value
13.	Total Phosphates (P)	mg/l	BIS- 3025 (31): 2014	Stannous Chloride method
14.	Total Kjeldahl Nitrogen (TKN)	mg/l	BIS- 3025 (34): 2014	using Pelican KEL PLUS Kjeldahl Apparatus
15.	Total Coliform	MPN/ 100ml	BIS- 1622: 2014	Presumptive test under the Multiple Tube Dilution (MTD) Test

Sample Volume: One litre of water sample was collected for the physico-chemical water analysis in polyethylene container and 100 ml of water samples was collected for the bacteriological water samples in pre-sterilized brown glass bottle. Further 300 ml of water sample in the BOD bottle was filled and fixed in the field.

Labeling of Water Sample Containers: After the collection of water samples, the sample containers or bottles are carefully labeled to provide the information on place of sampling, time and date of sampling. Permanent marker or ball point pen are used for writing details on the labels which should be protected from wetting.

Sample Preservation: Chemicals in the water usually decomposes rapidly at room temperature therefore dissolved oxygen is fixed. Water sample collected in one liter polyethylene container for analysis of pH, Total Dissolved Solids (TDS), Turbidity, total phosphate and Total Kjeldahl Nitrogen in laboratory. The collected water samples are preserved according to BIS-3025: 2003 standard and stored in laboratory at 4 ^{0}C in the freezer.

Transportation of Samples: The individual components of water tend to decompose on keeping, which results in the change of composition at room temperature. Hence the samples are transported in an ice-box keeping the temperature around 4°C, jerking of the samples are avoided, samples are handled under aseptic conditions for bacteriological tests while placing in the ice box or removing from the ice box and immediately after reaching the destination, the samples are transferred to Deep or quick freezer or refrigerator.

5.3. Observations and Inferences:

The observations and inferences of the results for water samples of 303 water bodies for the entire study area are as follows:

5.3.1. Water temperature and Dissolved Oxygen:

The water temperature of water bodies in the study area during study period varied from 16.8°C to 31.8°C which is not abnormal considering the ambient temperature of Bangalore. The indication normal temperature reveals discharge of hot water from any of the industrial/ commercial/ residential activity.

The temperature range also confirms absence of incompatible hazardous waste dumping during sampling period which otherwise would have resulted in abnormal temperature due to exothermic reaction.

Establishment of Sophisticated Water Analysis Laboratory in EMPRI

Water analysis was usually done in the KSPCB, DMG (Department of Mines and Geology), PHI (Public Health Institute) water analysis laboratory as well as in the Environmental Science Department in the Bangalore University and University of Mysore for the research projects of EMPRI. The 11 physico-chemical parameters along with the coliform analysis are the water quality analysis components in the project, which is to mainly confirm whether the water quality of lakes in the BMA has been polluted or not. The first Project Advisory Committee meeting held on 30.09.2014, had found that the budget for the establishment of water quality analysis laboratory was economical compared to the outsourced laboratories **(Annexure-8)**.

As per the first Project Advisory Committee suggestion the EMPRI has taken up the initiative to establish the water analysis laboratory for the parameters viz… quantify the sewage inflow, temperature, pH, Total Dissolved Solid, Electrical Conductivity, Light Transparency, Turbidity, Dissolved Oxygen, Biochemical Oxygen Demand, Total Nitrogen (Kjeldahl), Total Phosphates and Total Coliform.

The 42nd GB Meeting of EMPRI held on 10th March'2015 had approved the establishment of water analysis laboratory in EMPRI based on the comparative cost analysis statement. Accordingly, the Technical Expert Committee **(Annexure-9)** was constituted comprising of the Director General and Directors of EMPRI; Representatives of CPCB South Regional Zone Laboratory, CEO of KSPCB, Chief Chemist of Public Health Institute (PHI) Laboratory and Chief Chemist of Department of Mines & Geology water analysis Laboratory is also being committed on the establishment of water analysis laboratory in EMPRI. The specifications of the instruments were approved by the Technical Committee on 22.09.2015 (Annexure-10) and the same had called-for through the e-tender. According to the Technical Expert Committee suggestion, the MoU had made with the Karnataka Rural Infrastructure and Development Limited (KRIDL) to provide the infra structures for the water analysis laboratory under the Karnataka Transparency in Public Procurements (KTPP) Act, 1999. The water analysis laboratory in EMPRI was established by following the MoEF and CPCB guidelines (2008) for the Environmental Laboratory, National Accreditation Board for Laboratory (NABL) guidelines for quality and OSHA (BIS-18001:2015) guidelines for safety.

A state-of-Art Sophisticated physico-chemical and microbiology water analysis laboratory was inaugurated by Hon'ble Forest Minister, Shri. B. Ramanath Rai, and Shri. T.M. Vijay Bhaskar, Additional Chief Secretary, Department of Forest, Ecology and Environment, Government of Karnataka on 25th April'2016. Except the water temperature, light transparency and quantify the sewage inflow into lakes, all other nine parameters have been analysis in the **EMPRI** water analysis laboratory.

Additionally, Total Suspended Solids and Chemical Oxygen Demand are the two water analysis parameters which are also included for water analysis and the same were approved in the **KLCDA EC** meeting held on 14.07.2016. **EMPRI** has also initiated the implementation process of the **ISO** 9001: 2015 for Quality Management System **(QMS)** and **BIS**-18001: 2007 for Occupation Health and Safety Management Systems **(OHSMS)**.

Dissolved oxygen in water depends in the temperature of water. More dissolved oxygen is present in water with a lower temperature compared to water with a higher temperature. The reason for this inverse relationship between dissolved oxygen and temperature is that the solubility of a gas in a liquid is an equilibrium phenomenon.

Dissolved oxygen at different temperature is shown in Figure.5.1. But dissolved oxygen does not depend only on oxygen. It depends on other interference in water. As pH decreases (i.e. the concentration of H^+ or the activity increases), the redox reaction is shifted to the right. Hydrogen ions and oxygen react with water, which results in a decrease of the DO. An increase of the pH value can shift the redox reaction to the left. Solubility of dissolved oxygen also decreases as salinity increases. Turbidity resulting from suspended solids in the water, including silts, clays, industrial wastes, sewage and plankton. Such particles absorb heat in the sunlight, thus raising water temperature, which in turn lowers dissolved oxygen levels. Too much of biodegradable organic matter like slaughter house waste dumped into lake would also deplete dissolved oxygen without giving clue to source of pollution.

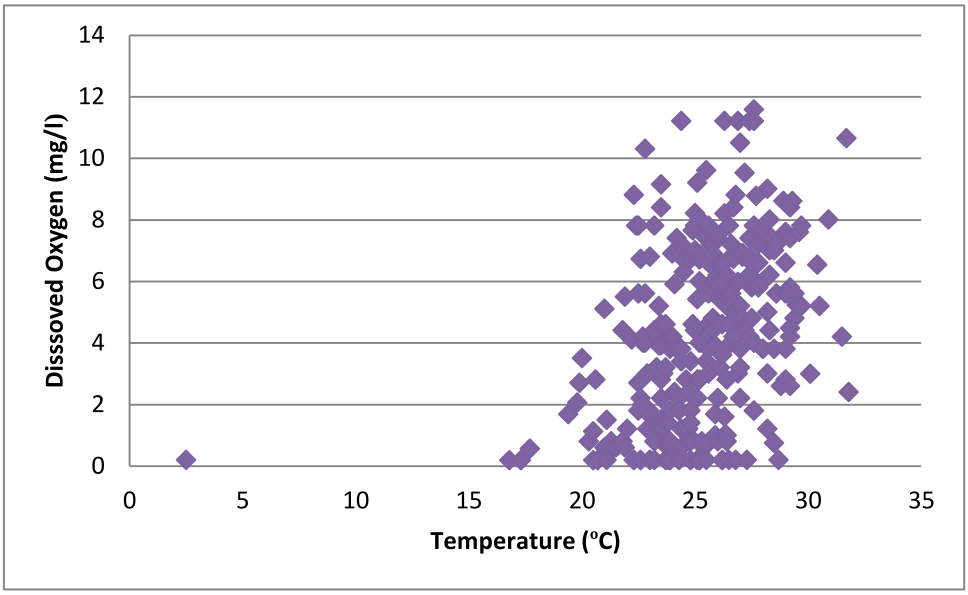


Figure-5.1. Dissolved Oxygen Vs Temperature

5.3.2. Light transparency, Turbidity and Suspended Solids:

The light transparency in the study area during study period varied from 1 to 58 cm which primarily depends on TSS and turbidity. The correlation between TSS and light transparency; turbidity Vs light transparency; and TSS and turbidity is shown in Figure-5.2, Figure-5.3 and Figure-5.4 respectively.

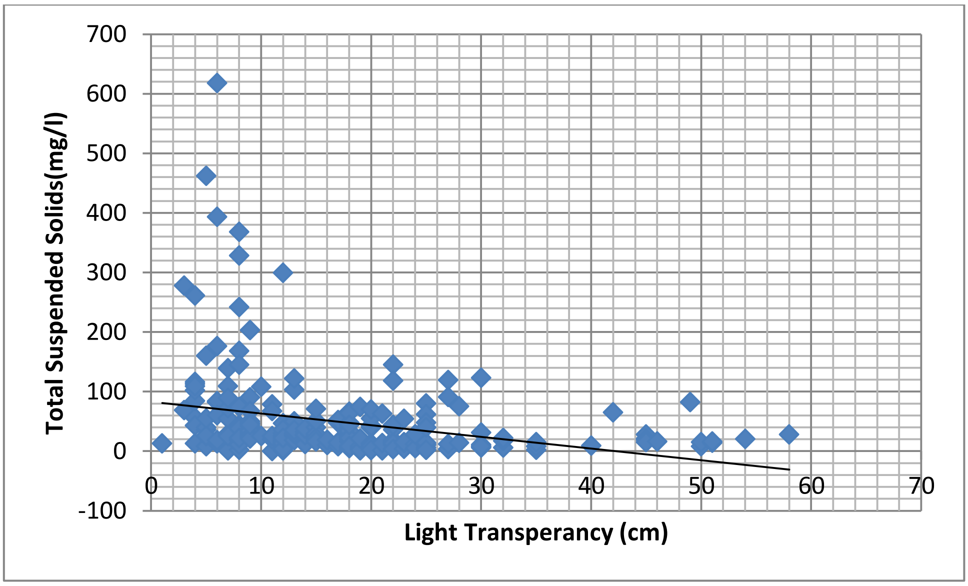


Figure-5.2. Total Suspended Solids Vs Light Transparency

The TSS in the study is during study period varied from 0 mg/l to 1045 mg/l whereas turbidity varied from 2.1 to 856 mg/l.

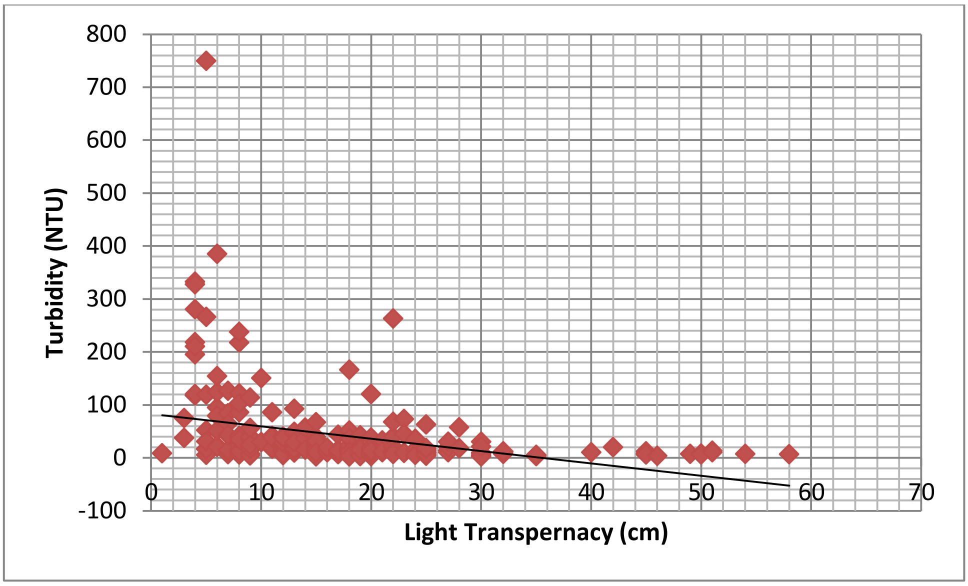


Figure-5.3. Turbidity Vs Transparency

It was observed that solids in sewage and soil particles mainly contributed for TSS, turbidity and hindrance to light transparency.

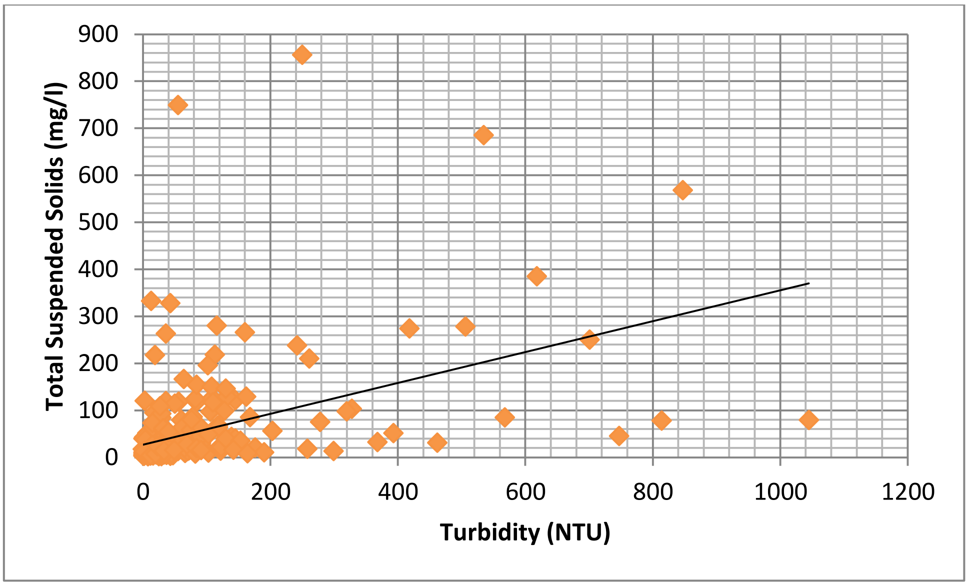


Figure-5.4. Total Suspended Solids Vs Turbidity

5.3.3. pH:

pH in the study area during study period ranged from 5.8 to 9.9 with 92.76% of the values lying between 6.5 to 8.5. Out of rest of the values 2.76 % was less than 6.5 inferring acidification due to microbial activity or acidic substance in sewage entering into lake and

4.48% was more than 8.5 inferring entry of alkaline substances into lake in the effluent or soil.

5.3.4. Electrical Conductivity and Total Dissolved Solids:

Electrical conductivity in the study area during study period varied from 57 to 3700 µS/cm and TDS varied from 35 mg/l to 1742 mg/l. Correlation between TDS and Electrical Conductivity is given in Figure-5.5.

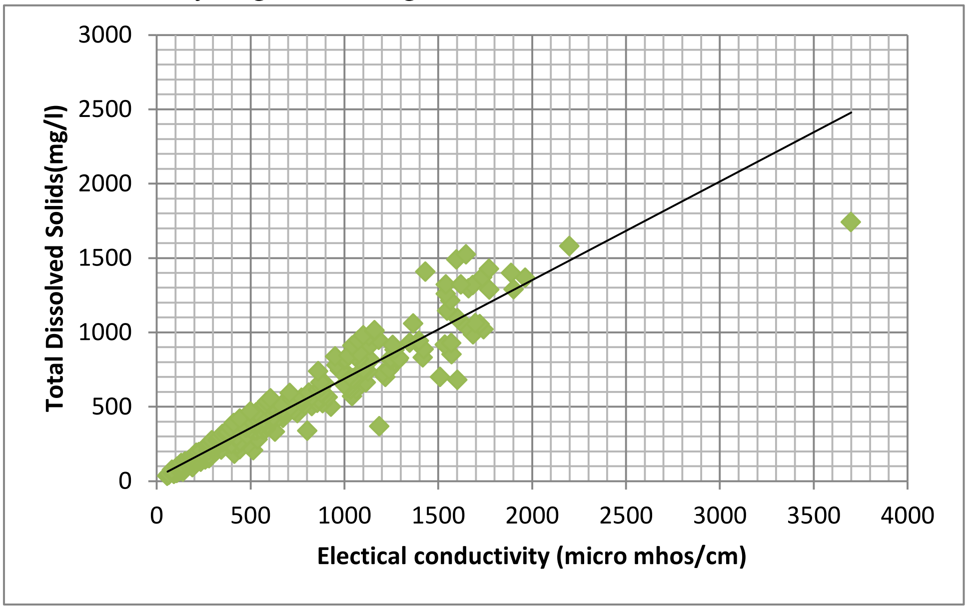


Figure-5.5. Total Dissolved Solids Vs Electrical Conductivity

5.3.5. Chemical Oxygen Demand and Biochemical Oxygen Demand

If ***the BOD/COD ratio*** is more than 0.7, biological processes would be a cheaper option. If the ***BOD/COD ratio*** is less than 0.4, then physico-chemical treatment would be essential as living things cannot remove refractory substances (Chandrappa and Das, 2014).

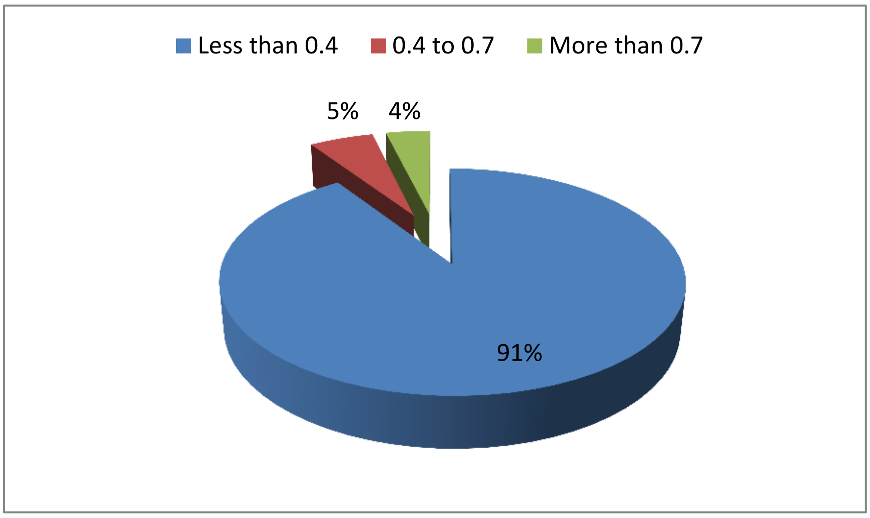


Figure-5.6. BOD/COD Ratio

Analysis result of the lake water revealed 91% of the lake water has BOD/COD ration less 0.4 which demanding physic chemical treatment. The possible reason could be accumulation of non-biodegradable substance over past few decades.

5.3.6. Total Phosphate and Total Kjeldal Nitrogen:

Lakes and reservoirs can be classified according to the extent of their eutrophication (or nutrients enrichment) into four main classes: oligotrophic, mesotrophic, eutrophic and hyper-eutrophic (Table-5.3). This classification results from extensive examination of eutrophication in countries within the Organization for Economic Cooperation and Development (OECD) in the 1970s and early 1980s. It is based on concentrations of phosphorus, nitrogen and chlorophyll-a (the green plant pigment needed in photosynthesis). Chlorophyll a roughly indicates the concentration of plant biomass (on average 1% of algae biomass is chlorophyll a).

Table-5.3. Classification of lakes according to the extent of their eutrophication

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Average total phosphorous (mg/l)	8.0	26.7	84.4	>200
Average total nitrogen (mg/l)	661	753	1875	High
Average Chlorophyll a (mg/l)	1.7	4.7	14.3	100-200
Chlorophyll-a, peak concentration (mg/l)	4.2	16.1	42.6	>500

5.3.6a. Factors that limit Eutrophication:

The average composition of freshwater plants on a wet basis (when they are not dried) is shown in Table-5.4. The plants require all listed components in the approximate percentages indicated. Generally, nitrogen (0.7%) and/or phosphorus (0.09%) are usually the first components depleted when plants form following photosynthesis. These two nutrients are less abundant in water than other elements needed, relative to their composition in plants. About eight times more nitrogen is required than phosphorus. Phosphorus thus limits eutrophication if nitrogen is more than eight times as abundant as phosphorus, while nitrogen limits eutrophication if its concentration is less than eight times as abundant as phosphorus (UNEP- IETC and IELEC, 2001).

Total phosphate of all the samples collected in study area revealed total phosphate value from Not Detectable (ND) limit to 4.6 mg/l and TKN value form 0-87 mg/l making lakes oligotrophic (nutrient deficient). The observation of lakes also revealed non-greenish colour of water reinforcing the observations of analysis.

Table-5.4. Average freshwater plant composition on a wet basis

Element	Plant content (%)
Oxygen	80.5
Hydrogen	9.7
Carbon	6.5
Silicon	1.3
Nitrogen	0.7
Calcium	0.4
Potassium	0.3
Phosphorous	0.09
Magnesium	0.07
Sulphur	0.06
Chlorine	0.06
Sodium	0.04
Iron	0.02
Boron	0.001
Manganese	0.0007
Zinc	0.0003
Copper	0.0001
Molebdenum	0.00005
Cobalt	0.000002

5.3.7. Total Coliform:

Total coliform in the lake water varied from 2 to > 1600 indicating contamination of water bodies by feces of warm-blooded animals and humans.

5.4. Advise on Critical Issues:

The major critical issues observed during water quality issue in study area are climate change and accountability. The issues are briefly discussed in subsequent paragraphs.

5.4.1. Changing Climate:

Changing climate is affecting and will continue to affect lakes. The effect of climate change on lakes is tabulated in the Table-5.5.

Table-5.5. Effect of Climate Change on lakes

Climate-related Issues in the region	Likely Environmental Impacts
Warmer air temperatures (especially warmer nights; warmer winters)	• Less oxygen distribution in the lakes • More lake evaporation year-round (trending to lower lake levels) • More favorable conditions for algae and bacteria • Loss of habitat and/or increased stress for cool and cold-water fish • Increased likelihood of heat waves and urban heat-island effects; • More warm weather pests, including invasive species • Loss of valued ecosystem services (flood buffers, water filtration, erosion stabilization, coastal habitat including nesting/nursery areas), damage to streamside habitat; loss of important populations
More precipitation and more extreme precipitation events	• Increased polluted runoff • Sediment and nutrient "flushes; " rapid increased loading in lakes watersheds and the lakes themselves • Algal blooms oxygen depletion, dead zones, cyanobacteria
More extreme swings between periods of drought and drench	• Loss of valued ecosystem services (flood buffers, water filtration, erosion stabilization, coastal habitat including nesting/nursery areas), damage to streamside habitat; loss of important populations
Increasing variability in lake levels	• Loss of valued ecosystem services (flood buffers, water filtration, erosion stabilization, coastal habitat including nesting/nursery areas) from coastal erosion, damage to streamside habitat; loss of important populations.
Changes in vitality and distribution of cold-climate dependent species—both aquatic and terrestrial	• Changes in species range and relative abundance, especially for cool and cold-water fish • Likely range expansion for warm-weather invasive species
Nutrient and invasive species challenges exacerbated	• Polluted runoff from extreme storms enriches nutrient and bacteria loadings into nearshore waters • Sunlight penetration and warmer air temperatures warm the waters faster, deeper, and to higher temperatures;

	• Sunlight and warm water supports growth of algae and other phytoplankton • With plenty of nutrients, warm water and sunlight, algae growth “explodes” • Massive blooms die off and use up dissolved oxygen = dead zones
Changes in seasonal wind directional (vector) patterns Negative synergies from multiple effects	• Polluted runoff from extreme storms enriches nutrient and bacterial loadings into near shore waters • Sunlight penetration and warmer air temperatures warm the waters faster, deeper, and to higher temperatures • Sunlight and warm water support growth of algae and other phytoplankton • With plenty of nutrients, warm water and sunlight, algae growth “explodes” • Massive blooms die off and use up dissolved oxygen = dead zones

5.5. Conclusion:

The high impact on lakes due to absence of accountability to Article 48 A and Article 51-A (g) of constitution of India cannot be overruled considering direct effect of following issues.

a. Migration
b. Poor urban planning
c. Failure of execution of existing laws
    i. Pollutants
    ii. Nutrients
    iii. Solid Waste
d. Non-Commitment from manufacturers and service providers to curb pollution due to product and service rendered by them

The city was not ready to accept mammoth migration. Migrants hardly had any plans to evaluate and mitigate impact on lakes due to their migration and hence continued to generate waste without assessing capacity of city to accept the waste. As a result waste and pollution made their ways to lakes. Poor urban planning resulted in encroachment of lakes as well as natural drainage. Pollutants, nutrient and solid waste from product (toilet cleaners, surfactants, fast moving consumer products etc.) and services (Vehicle service station, construction and demolition etc.) also resulted in detrimental effect of lakes.

Hence following suggestion are made to safeguard lakes

1. Make corporate accountable to curb pollution due to product they sell and service they provide; and
2. Ban products highly detrimental to environment (Corrosive; May contain ingredients with potential for respiratory effects; acute aquatic toxicity; chronic aquatic toxicity, non-bio-degradable surfactants).
3. People's participation –involving people in the neighbourhood to safeguard the lakes would give them a sense of ownership and they themselves would prevent pollution.
4. Make sure that STPs are located near the lakes to ensure that sewage does not enter the lakes and all the STPs should be in working condition.

Degradation of biodegradable substance over the years has led to accumulation of refractory substance in lakes. There is no accountability to comply with existing laws.

Sankey Tank

CHAPTER

6

BIOTA

Chapter-6: Biota of Water bodies

6.1. Introduction:

India is one of the 12 mega biodiversity areas in the world with over 45,000 wild species of plants and 77,000 wild species of animals. These together comprise about 6.5% of the world's known wildlife; India's biological heritage is impressive, not only in its sheer diversity, but also in its uniqueness. The range of domesticated biodiversity in the country is also quite impressive. Atleast 166 species of crops and 320 species of wild relatives of crops are known to have originated in India. The diversity of varieties within each of these species is very high. Biota is the total living organisms in the particular local region during the specific period. Concerted efforts are needed to preserve, conserve and augment the domesticated biota both at species and varietal/generic levels. Wetlands have played a very important role in the life of living beings since time immemorial. Wetlands are characterized by their fragile ecosystems that are susceptible to changes. They are productive and biologically rich but endangered ecosystems act as interface between land and water systems. They filter the sediments and nutrients from the surface water and support all forms of life through extensive food webs. Wetlands also provide multiple benefits such as fish, recreation, flood control system, groundwater recharge and storm water collection.

Aquatic biota and the riparian vegetation of the water bodies are inter-related in the aquatic ecosystem. As the advancement in the monitoring of the water body, aquatic biota has been assessed based on the characteristics as water quality indicator, water pollution indicator, eutrophication indicator, health indicator, etc. Universities and academic institutions have assessed the biodiversity and water quality in few BMA water bodies using bio-indicators and published as research articles.

6.2. Methodology:

About eight major biota of the water bodies such as floral vegetation, insects, fish, herpetofauna, avifauna and visiting mammals are recorded in and around the 50m vicinity of BMA water bodies during the study period. Coolpix P-600 (Nikon, Made in Indonesia) camera was used to document the water bodies biota as still photographs. Biota of the water bodies were recorded by following the simple methods as following;

i. ***Vegetation*** comprises of trees, shrubs and herbs along the banks and also around 30 m vicinity of the water bodies are recorded by following different methodology.

a) **Trees, *Shrubs and Herbs*** in and around the 30m vicinity of water bodies are recorded with the help of still photographs and identified up to the generic level (Williams, 2006).

b) ***Macrophytes*** are the vegetation present in the littoral offshore zone including emergent, submerged, rooted floating and free floating plants. The macrophytes in the water bodies are recorded using the still camera and the same has been identified with the help of subject experts.

ii. ***Insects*** found in and around the 30m vicinity of water bodies are recorded by following the different methodologies for the different group of insects such as terrestrial insects, aerial insects include Odonates and Butterflies, and aquatic insects.

a) **Terrestrial insects** around the water bodies are observed during the field visits and identified up to generic level by referring the manual for insect identification by Meenakshi Venkataraman (2010).

b) ***Aerial Insects*** in and near the water bodies are recorded in the field data sheet and also with the help of photographs. The photographs have been used for identification of genera by referring to the manuals for insect identification by Donald and Richard (1970) and Meenakshi Venkataraman (2010).

c) ***Odonates*** such as adult dragonfly and damselfly are recorded in and around the 30m vicinity of water bodies from the time of 10.00 to 14.00 (mid-day), when most odonates are active flying along offshore. Dragonflies and damselflies are observed for 30 minutes by eyesight as per the identification manual by Subramanian (2005 & 2009).

d) ***Butterflies*** in and around the 30m vicinity of water bodies are observed by following the methodology of '*Searching and Direct Observation*'. The method was adopted especially for open habitats with sparse vegetation; when direct observation is clear, on basis of recording day flying butterflies. Butterflies were identified by referring field manual by Krushnamegh Kunte (2008).

e) ***Aquatic insects*** in the water bodies are observed on the hydrophytes or bottom of the water bodies in shallow water, where most aquatic species spend a majority of their life-cycle. The aquatic insects are identified by following the field manual by Subramanian and Sivaramakrishnan (2007) and Edelstein (1999).

iii. ***Benthic fauna*** are found under the water bodies or in the sediments of water bodies called 'Benthic Zone'. Macro-benthic fauna has been identified based on the photographs and with the help of subject experts.

iv. ***Fish*** found in the water bodies are recorded based on the local name of the fish collected from the local fisherman. Further, the fish are photographed for confirmation of genus with the subject experts. The fish are also identified based on the external morphological characteristics and by using identification keys (Jayaram, 1999; Rema Devi and Indra, 2009; Hutchins *et al*., 2003; Nelson, 2006; Quentin Bone and Richard, 2008).

v. ***Herpetofauna*** include the Amphibians and Reptiles, which are observed in and around the water bodies by '*Scan Searching Method*' (Visual-Encounter method). Amphibians are searched systematically (Randomized walk) and identified by following the descriptions of Daniel (2002); Ranjit Deniels (2005). Reptiles are identified by following the method of Daniel (2002).

vi. ***Birds*** in and around the water bodies are observed by following the '*Random Stratified*' method (Mark *et al.,* 2000). Birds in the water bodies are observed in 360° arcs around the bund. Birds that are seen flying over the water bodies area (aerial) are also recorded and identified using the field guide (Grimmett and Rand, 2007).

vii. ***Mammals*** found in the water bodies and its vicinity as migration form, other than humans are recorded in the field with the help of photographs.

6.3. Biota of Water bodies:

Biota of the water bodies ranges from small plankton to big reptiles and they play an important role in the food chain. Biotic factors would cover all the living including single cell organisms, plants and animals. This would include the food chain/web of the aquatic biome under prey-predator relationship. Further, the aquatic food chain is controlled by the abiotic nutrients (Bottom-top control) and predators (Top-down control). The biota of the BMA water bodies are follows;

6.3.1. Trees in Water bodies:

About 36 types of trees coming under the 17 plant families are recorded (**Annexure-11**) in and around the vicinity of the water bodies. The list of the trees recorded in and around the vicinity of the water bodies are tabulated in Table-6.1. The maximum (10 types) trees are coming under the Fabaceae family and most of the trees in the peripheral area of water bodies are tamarind, neem, Indian banyan, jack fruit and Java plum trees. Trees such as coconut, arecanut (Figure-6.1), acacia, Rosewood, eucalyptus (Figure-6.2) and silver oak are nurtured as plantation near the water bodies vicinity and fruit bearing trees such as guava, sapota and mango are also cultivated in the water bodies vicinity as the commercial crops. Most of the trees in the peripheral area of the water bodies are grown naturally like neem, banyan, tamarind, asoka, etc. and only plantation in the water bodies vicinity have been nurtured by the farmers as commercial crop.

Figure-6.1. Arecanut plantation near the Lingadeeranahalli lake by farmers

Figure-6.2. Eucalyptus plantation near the Halanayakanahalli lake-1 by farmers

Trees in and around the vicinity of water bodies play an important role of shelter and provide food (fruit bearing trees) for the migratory birds as well as the nesting area. Trees in the vicinity of water bodies also act as the soil erosion barrier during the rainy seasons and strengthen the bunds. Trees around the urban water bodies act as the small barrier for the noise and air pollution, and increase the aesthetic value of urban lakes. Even trees in and near the water bodies have play an important role in cultural and traditional values of people. Due to the importance of trees around the water bodies, the Karnataka Forest Department with the BBMP, BDA and NGO have planted many tree saplings in the vicinity of water bodies.

6.3.2. Herbs & Shrubs in the water bodies:

Herbs are plants with little or delicate to no wood tissue, which can be easily uprooted from soil. About 26 types of herbs (**Annexure-12**) belonging to 17 families are recorded in and around the vicinity of BMA water bodies are tabulated in the Table-6.2. Species of *Ipomoea* (Figure-6.3), *Mimosa*, *Cortaderia*, *Cynodon* and *Parthenium* are the commonly distributed herbs in and around the water bodies.

Shrubs have multiple wood stems (branches) growing from a common center, which are bushy and taller than herbs. Their stems are hard, flexible but not fragile. About 22 types of shrubs (**Annexure-13**) belonging to 16 families are recorded in and around the vicinity of BMA water bodies (Table-6.2). Species of *Calotropis*, *Xanthium*, *Prosopis* (Figure-6.4), *Vitex* and *Lantana* are mostly observed in and around the water bodies. Just like trees, the herbs and shrubs are a sheltering place for the insects and act as the filter by trapping the silt in the water bodies.

Figure-6.3. Herb *Ipomoea* sp. in the Choodasandra Government *Kere*-3

Figure-6.4. Shrub *Prosopis Juliflora* plantation in Kodathi Gramadakere

6.3.3. Macrophytes:

Large plants that grow in and near the aquatic ecosystem and dominate the wetlands, littoral zones are called as macrophytes or hydrophytes. Hydrophytes play an important role in energy dynamics and structuring communities in the aquatic environment by providing the physical structure, increase habitat complexity and heterogeneity for invertebrates, fishes and aquatic-birds.

Hydrophytes provide food source, habitat, removal of CO_2, and production of oxygen through photosynthesis. Hydrophytes are also used as watershed health indicator viz… decline in community will indicate the water quality problem and changes in the aquatic ecology status. Hydrophytes are broadly classified into four categories based on its habitat are follows:

A. Emergent:

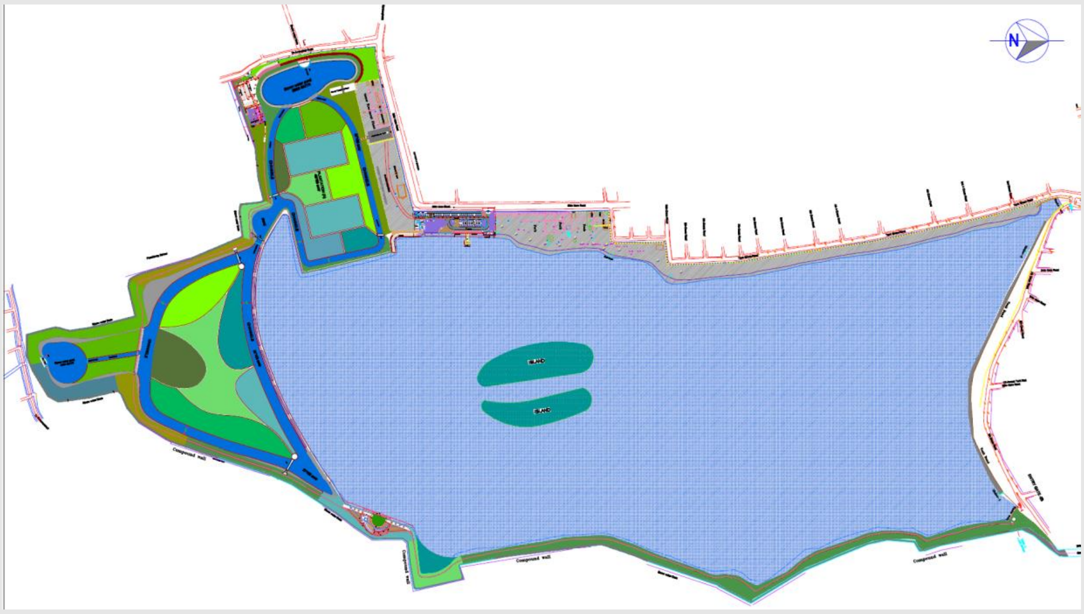
Emergent hydrophytes are defined as plants that are rooted in shallow water with vegetative parts emerging above the water surface (FAO, 2009), which are also called as shoreline or marginal plants due to their location. Emergent macrophytes are most productive than other hydrophytes, which includes grass-like and broad leaved plants. About eight plants (**Annexure-14**) coming under the seven families are recorded as the emergent hydrophytes in

Figure-6.5. Emergent *Typa* sp. in the Veerasandra lake-2 the BMA water bodies and are listed in Table-6.3. Alligator weed, Pink morning glory, Cyperus grass and cattail (Figure-6.5) are the common emergent hydrophytes that are recorded in the BMA water bodies.

Biodiversity Park

Karnataka Jnana Aayoga (Karnataka Knowledge Commission) has submitted the report on "Establishment of Biodiversity Park in Madivala lake system" on 25th February 2015 to the Government of Karnataka. Accordingly, Madivala Lake spread across 275.13 a-g is under the custodian of Karnataka Forest Department is selected by KLCDA to restore the part of water bodies as the biodiversity park with cost of 24.72 crore. The development of model biodiversity park in Madiwala lake is guided by Prof. C.R. Babu, Ecologist, University of Delhi, who worked on reviving the Yamuna banks. The state-of-art technology from Maharashtra will be used to desilt without water drain. Later, the herbal garden with native tree species, walkways and interpretation centre will be created as per approved plan. The biodiversity park will be established in the South-Eastern side of the lake included the herbal garden, butterfly park and Orchidarium.

Biodiversity Park will recreate self-sustaining ecosystems with native flora and fauna characteristic of the area for enhancing the quality of environment. The park will have mosaic of wetlands interspersed with grasslands and scattered trees, greenways with walkways, shelter belt of bamboo thicket, shrub-land of native fruit bearing shrubs, a shoreline community of marsh plant species, aquatic community, game fishing zone, herbal and scented garden and nature interpretation centre among others. The Biodiversity Park will buffer the local weather and serve as sink for CO_2, urban pollutants and also serve as an adaptation to climate change.



B. Submerged:

Submerged plants are defined as plants that are usually rooted in the bottom soil and grow up through the water with the vegetative parts predominately submerged. Flowers or flowering spikes often emerge above the water surface. About 13 plants (**Annexure-15**) belonging to the eight families are recorded as the emergent hydrophytes in the BMA water bodies and are listed in the Table-6.3. *Aponogeton*, *Hydrilla*, *Elodea* and *Potamogeton* are the common genus of submerged hydrophytes recorded in the BMA water bodies and most of the submerged hydrophytes are from the Hydrocharitaceae family. *Elodea* and *Hydrilla* are extremely invasive, and efforts are being made to eradicate them in many countries.

Submerged hydrophytes of the littoral zone provide a habitat for epiphytic algae, invertebrates, and fish by store substantial amounts of nutrients, a source of dissolved organic compounds and food source for herbivorous fish (grass carp). Diversity of freshwater macro-invertebrate community has been associated with the submerged hydrophytes (Khan, 2002).

C. Rooted Floating:

Rooted-floating plants have underground stems (rhizomes) from which new plants can sprout. Rooted floating hydrophytes are generally found in shallow water that has a depth of less than 4-5 ft., and their leaves and flowers float on the water's surface. About five species of plants (**Annexure-16**) belonging to different families are recorded as the rooted floating hydrophytes in the BMA water bodies and are listed in Table-6.3. Lotus and water lilly are the only two rooted floating hydrophytes, which are commonly observed in the BMA water bodies.

D. Free Floating:

Free floating aquatic hydrophytes are defined as plants that float on the water surface, usually with submerged roots (FAO, 2009) or plants that are generally not dependent on soil or water depth. About 10 species of plants (**Annexure-17**) belonging to five families are recorded as the emergent hydrophytes in the BMA water bodies and are listed in Table-6.3. *Lemna*, *Wolffia* and *Eichhornia* are the common genera of free floating hydrophytes, which are commonly observed in the BMA water bodies.

Most of the submerged hydrophytes are from Araceae family. Free-floating hydrophytes such as duckweed and water-meal can completely cover the surface of a pond, shading out submerged plants and depletes oxygen concentration in the water. Duckweed is extremely small and has a small root that hangs in the water; a water-meal plant has no roots and looks like a tiny green seed or green cornmeal. These plants are found in nutrient-rich waters, so restricting nutrient inputs is helpful in management. Oxygen production by hydrophytes and attached algae can decrease the rate of phosphorus release from sediments, and high denitrification rates in littoral vegetation can decrease nitrogen availability (Takashi Asaeda *et al.*, 2009).

Filamentous algae are usually considered as 'free floating hydrophytes' since they often form floating masses. Filamentous algae are commonly referred as 'pond scum' or 'pond moss' and form greenish mats upon the water surface. These stringy, fast-growing algae can cover a water body with slimy, lime-green clumps or mats in a short period of time, usually beginning their growth along the edges or bottom of the pond and 'mushrooming' to the surface.

Algal bloom or water bloom is a rapid growth of microscopic algae and accumulation in water resulting in coloured scum on the water surface**.** If these algal blooms have been impact on the aquatic fauna or ecology then it is called as the harmful algal bloom. Bright green algal bloom is frequently observed in few of the BMA water bodies, which is caused by blue-green algae *Microcystis* sp. (Figure-6.6).

Figure-6.6. Microcystis bloom in Kattiganahalli lake1

The major reason for the algal blooms in the water bodies are due to the presence of excess nutrients, particularly phosphate and nitrate. These excess nutrients inflow into the BMA water bodies through the domestic sewage. Residual sodium carbonate acts as a catalyst for algal bloom by providing dissolved carbon dioxide for enhanced photosynthesis in the presence of nutrients. Algae will grow quickly in the presence of high nutrients and due to its short life-period, the dead and decayed algae have resulted in the high concentration of the organic matter. This decay process consumes dissolved oxygen in the water and results in the 'hypoxic' condition, which leads to the 'fish kills'.

6.3.3.1. Weeds in the Water bodies:

A grown plant, which is considered as undesirable in a particular place is called as weed. Mostly invasive plants (non-native) are considered as the weeds. In the BMA water bodies, there are four herbs such as Amaranth (*Amaranthus* sp. & *Gomphrena* sp.), prickly chaff-flower (*Achyranthes* sp.), congress grass (*Parthenium* sp.) and railway creeper (*Ipomoea* sp.) of herbs and four shrubs such as milk weed (*Calotropis* sp.), cocklebur (*Xanthium* sp.), South West thorn (*Prosopis juliflora*) and lantana weed are recorded as the weeds around the water bodies.

Unabated hydrophytes grow rapidly and complete their life cycle in the water is called are 'Aquatic Weeds', which will impact the aquatic environment directly. These aquatic weeds are usually a problem during the summer season due to the optimum temperature for the weed's growth. Algae, duckweed (*Lemna* sp.), water-meal (*Wolffia* sp.), water hyacinth (*Eichhornia* sp. [Figure-6.7]), horse weed (*Colocasia* sp.) and water lilly (*Nymphaea* sp.) of floating hydrophytes; floating lace plant (*Aponogeton* sp.), musk grass (*Chara* sp.), water thyme (*Hydrilla* sp.) and pondweed (*Elodea* sp.) of submerged hydrophytes; and Cattail (*Typha* sp.), *Cyperus* sp., morning glory (*Ipomea* sp.) and Alligator weed (*Alternanthera* sp.) of emergent hydrophytes are recorded as the aquatic weeds of the BMA water bodies.

About 22 plant types are recorded as the weeds in and around the BMA water bodies. *Parthenium* sp. (Figure-6.8) weed is herb, which causes allergy to people in an urban environment. Aquatic weeds often reduce the effectiveness of water bodies for fish production by reduction of light transparency and cause depletion of DO concentration. Dense growth of aquatic weeds may provide the ideal habitat for the development of mosquito to cause vector borne diseases and increase water evaporation through evapo-transpiration. Aquatic weeds also reduce water storage capacity and impede flow of water in channels.

Figure-6.7. Free floating water hyacinth as weed in Gangashetty *Kere*, KR Puram

Figure-6.8. Shrub *Parthenium* sp. as weed in Tupinkere, Yelahanka hobli

6.3.4. Insects:

Insects are hexapod invertebrates with chitinous exoskeleton, which represent over 90% of animal life forms on Earth. Insects play a major role in the food web i.e. sole food source for many herpetofauna, birds and mammals. In relation to the water bodies, the insects are classified into three types based on its habitat such as terrestrial insects, aerial insects and aquatic insects. Insects are also classified as 'pests' when it is a nuisance to human beings and 'economically important insects' when its product is useful to mankind.

6.3.4.1. Terrestrial Insects:

Insects that live predominately or entirely on land are called as terrestrial insects, which are mostly invertebrates. About 31 terrestrial insects (**Annexure-18**) belonging to 23 families are recorded in the vicinity of the BMA water bodies are tabulated in Table-6.4. Ants, bees, beetles, flies, wasps and bugs are the common terrestrial insects found in the vicinity of water bodies. Apart from these, the observation of domino cockroach represents the dumping of domestic garbage in the water bodies vicinity.

6.3.4.2. Arial Insects:

Insects, which are flying in the air for the collection of food are called as aerial insects. Aerial insects play an important role in pollination. They are also the food source for the avifauna. Two types of the aerial insects are found in the vicinity of the water bodies - odonates and butterflies.

A. **Odonates**: Odanates are the order of carnivorous insects encompassing the dragonfly and damselfly. Dragonflies are generally larger, perch with its wings held out of the sides at rest and damselflies have slender bodies with wings hold over the body at rest. There are 12 types of dragonflies and seven types of damselflies (**Annexure-19**) belonging to two families recorded in the BMA water bodies and are tabulated in the Table-6.5. Most of the recorded dragonflies are crimson marsh glider, ditch jewel and long legged marsh glider belonging to Libellulidae family. Most of the recorded damselflies are coromandel marsh dart (Figure-6.9), pygmy and golden dartlet belonging to Coenagrionidae family.

Figure-6.9. Coromandel marsh dart

B. **Butterflies** belong to the Order Lepidoptera, which includes moths. Butterflies are also indicator insects for the climate change in the local area. There are 27 types (**Annexure-20**) of butterflies belonging to four families that have been recorded in the vicinity of the BMA water bodies and are tabulated in Table-6.6. Most of the recorded butterflies are plain Tiger and common Indian Crow belonging to family Nymphalidae.

6.3.4.3. Aquatic Insects:

Insect that live predominately on land or live some portion of their life cycle (i.e. mosquito) in water are called as aquatic insects or water insects. Aquatic insects are a food source for the fishes (Ana and Edmir, 2009) and amphibians. They are also good indicators for the pollution of the water bodies (Bijita Barman and Susmita Gupta, 2015). Five types of insect falls under the five different families that are recorded in the BMA water bodies are tabulated in the Table-6.7. The notable aquatic insects are water strider (Figure-6.10), hydrometra, water bugs (Figure-6.11) and meal worm larvae are one of the stages in the life cycles of the beetle.

Figure-6.10. Water strider in Ullal *Kere,* Yeshwanthpura hobli, Bengaluru North

Figure-6.11. Water bugs in Kanminiki mogikere, Kengeri hobli, Bengaluru South

6.3.5. Benthic Fauna:

Benthos is the community of organisms that live on or in the sediments of the water bodies. In the present study, the fauna which are larger, more visible to the naked eye that are greater than the 1mm size called as macro benthos, which are recorded from the BMA water bodies. Benthos are playing an important role in the organic substance decomposition,

Figure-6.12. Benthic snail in Kannaminiki *Kere*-2 nutrition cycling, major food web source for the carnivorous benthic fish (Alan *et al.*, 1999) and pollution indicators (Pawel Koperski, 2011). There are 11 macro-benthic fauna belonging to 10 families are recorded in the BMA water bodies and are tabulated in the Table-6.8. Benthos is also bio-indicators of the water quality. The presence of the snail (Figure-6.12) and bivalves in the water bodies are indicators of the good water quality and the presence of sewage worm is the indicator of the inflow of sewage into water bodies. In most of the BMA water bodies, the tubifex worm is observed due to the inflow of sewage.

6.3.6. Fishes:

Fish are the most important predators in the lake ecosystem because each fish is planktivorous at least in the juvenile stages. They have a large feeding capacity and their broad spectra of food size selectivity endanger almost all zooplankton because fish can easily switch from one prey type to another. There are 20 types of fishes (**Annexure-21**) belonging to eight families, which are recorded in the BMA water bodies and are tabulated in Table-6.9. Mostly the Cyprinidae family is too dominant within the distribution of fishes in the water bodies. Korava, tilapia (Figure-6.13) and carp are the commonly distributed fishes in the water bodies and invasive African catfish is also observed in the sewage influx water bodies. Interestingly, the ornamental fish (Koi) is maintained by the Residential welfare association (RWA) named SNN Raj Serenity in the Yelanahalli lake (Figure-6.14).

Figure-6.13. Tilapia fish caught from Hulimavu *Kere*

Figure-6.14. Ornamental fishes reared in Yelanahalli lake by RWA

Many native species cannot adopt to sewage inflow water bodies except the African catfish (Ramachandra *et al.*, 2011) and introduction of fast growing fish for profit has replaced the natural setup resulting in the thriving of invasive species. In the BMA water bodies, both the pelagic (korava) as well as benthic (carp) fishes are observed. In some cases, selective fish genera were dominated in the water bodies, which lead to the algal bloom was evident through the study conducted by Takashi Asaeda *et al*. (2009). They also found that the intense selective predation on zooplankton can eliminate large forms of zooplankton and thus increasing the algal biomass of the lake.

Fish Death:

Large scale mortality of the freshwater fishes is called as fish death or fish mortality, and if the mortality happens due to anthropogenic effect, then it is called as 'Fish Kill' (Figure-6.15). The major reason for the fish death is due to the depletion of dissolved oxygen concentration in water bodies called as 'hypoxic' condition. Fish mortality was first reported in the year 1995 from the Sankey and Lalbagh tanks of Bengaluru North taluk and until now there were 23 episodes (Ramachandra *et al*., 2016) reported from the 16 lakes and are tabulated in Table-6.10. Fish mortality on Sankey and Lalbagh tanks were reported by Benjamin *et al*. (1996), Ulsoor lake by Maheshwari (2005), Mallathalli lake by Nandini *et al*. (2011), and Jakkur lake (2015a) and Sankey tank (2015b) by Ramachandra *et al*. (2015). Five fish genera such as catla, rohu, tilapia, mosquito fish and ticto-barb are mostly dead during fish kill due to the possible reasons such as inflow of sewage, algal bloom, increase in temperature, turbidity, nitrates, phosphates, carbon-dioxide and BOD concentration.

Figure-6.15. Fish death documented in Sankey tank on August 2016

6.3.7. Herpetofauna:

Herp is the vernacular term for reptiles and amphibians that inhabit the water bodies. The compositions of herpetofaunal communities are primarily controlled by water regimes and structure of the vegetative community (Sandifer *et al*., 1980). Herpetofauna are dependent on permanent water sources or relatively independent on standing water (Gibbons and Coker, 1978). Reptiles and amphibians play an important role as predators to control the populations of various prey species (Burton and Likens, 1975). Changes in the herpetofauna diversity are indicating that there is change in the dependent habitats (water bodies) and therefore it serves as indicators of environmental changes or degradation. Few photographs of the herpetofauna recorded in the BMA water bodies are shown in (**Annexure-22**).

A. Amphibians:

Amphibians are ectothermic, tetrapod vertebrates that inhabit a wide variety of habitats and have been used as indicators of habitat changes (Fontenot *et al.*, 1996). Amphibian populations are often dependent on ephemeral water sources (Blaustein *et al.*, 1994). Their reliance on moist areas and the long life spans make them sensitive to changes in the hydroperiod of their habitats. The decline in amphibian populations is potentially a result of anthropogenic impacts at local and global levels. Changes such as wetland filling and urbanization can significantly change the moisture regime, resulting in changes to the herpetofaunal community (Phelps and Lancia, 1995). Habitat fragmentation, combined with the limited dispersal ability of many amphibians, may slow or eliminate this migration to the point where the habitat may not be re-colonized. There are four types of frogs belonging to Ranidae family and one type of toad belongs to Bufonidae family of Anura order are recorded in the BMA water bodies, which are tabulated in Table-6.11. Indian bull frog, Indian cricket frog, skittering frog and common Indian toad are commonly observed in the BMA water bodies and their vicinity.

B. Reptiles:

Reptiles are tetrapod vertebrates (The word ‘Tetrapoda’ means ‘four limbs’ in Greek) and don’t have an aquatic larval stage unlike amphibians. There are seven types of reptiles belonging to five families are recorded in the BMA water bodies, which are tabulated in the Table-6.12. Snakes and garden lizards are commonly observed in the BMA water bodies vicinity, and the tortoise is very rarely found in the two water bodies such as Lalbagh tank of Bengaluru North taluk and Byrasandra lake of Bangalore East taluk.

6.3.8. Avifauna:

Avifauna is commonly referred to the birds (subgroup of reptiles) of the BMA water bodies and birds that are dependent on water sources for their food or shelter is called as aquatic birds. Few types of birds adapted to the urban environment for their food and shelter, which is called as Synurbanisation for example, common crow and sparrow. There are 54 types of birds (**Annexure-23**) belonging to 31 families, which are recorded in the BMA water bodies and are tabulated in Table-6.13. In the rejuvenated or rejuvenating lakes, the creation of island becomes important to provide the roosting place for birds, which also increase the aesthetic value of the urban water bodies.

Most of the birds recorded in the BMA water bodies are water birds such as swamp hen, pelican, egret, kingfisher, duck, stork and heron. Water birds are seen roosting in the shrubs or nearby trees of the BMA water bodies. The study conducted by Rajashekara and Venkatesha (2011) had recorded the 35 species of aquatic birds in 15 major lakes of

Bangalore. Migrative birds such as ibis, eagle, plain prinia, dove, koel are also observed in the vicinity of water bodies. Further, the synurbanisation birds such as crow and sparrow are observed due to the garbage dumping in the vicinity of water bodies. About 330 types or species of birds were recorded with high density in the Bangalore by Joseph George (1994) but in the present scenario, the density as well as the diversity of birds has been reduced due to the destruction of roosting places due to urbanization, deterioration of water quality due to influx of sewage, reduction in the fish, increase in temperature due to climate change, etc.

6.3.9. Mammals:

Apart from local people, few mammals also utilize the water bodies for shelter, food (garbage dump & grazing) and to quench its thirst. There are 12 types of visiting mammals (**Annexure-24**) belonging to seven families, which are recorded in the BMA water bodies and are tabulated in Table-6.14. Within that, 6 types are domestic animals such as cattle and dog, cow, buffalo, sheep and goat are frequent visiting mammals of the water bodies for grazing, drinking water and bathing. But dogs and rats in the vicinity of water bodies are recorded, when they take food from the waste dumps in the water bodies. Mongoose is also observed in the big lakes, which are surrounded by agricultural land and bats are recorded in the parks located near the water bodies i.e. Lalbagh tank.

6.4. Conclusion:

Existence of water bodies are not only based on the presence of the water, which also depend on the presence of biota. Pollution, encroachment and urbanization of water body vicinity have adversely impacted the biota of the water bodies in terms of density as well as diversity. Each and every biota in the water bodies has been playing a critical role in the aquatic ecosystem. When there is no control on the biota of water bodies then it will cause nuisance such as growth of vegetation (weeds), breeding place for mosquito (vector borne disease), bad odour (decomposition of rapid grown biota), etc. Few biota also act as bio-indicator to show the status of water quality and some of the biota help in the cleaning process of the water bodies.

Hyper-urbanisation and toxic chemicals used by people would join lakes either due to solid waste dumping or urban runoff or entry of wastewater. The same has been consumed by the biota of the water bodies, which entered into food chain of humans as bio-magnification cannot be ruled out. Further the invasive species has erased the natural setup established over the years and thereby bringing in new health related challenges.

Administrative and planning Authorities have taken steps to conserve the aquatic biota such as construction of islands to conserve avifauna, introduce fingerlings in the rejuvenated water bodies and construct wetland as the breeding place for fishes and roosting area for aquatic birds. But it needs a lot of improvement in the conservation of water bodies using native biota. Further, regular management of the water bodies is the only solution for the conservation of water bodies consistently in the BMA.

Table.6.1. List of Trees recorded in and around the vicinity of BMR water bodies

SI. No.	Taxonomy Name	Kannada Name	Common Name	Family
1.	*Mangifera indica* L.	Ballimavu/ Mavina Mara/ Simavu	Mango tree	Anacardiaceae
2.	*Polyalthia longifolia* (Sonn.) Thwaites.	Putranjiva/ Ashoka Mara	False Ashoka	Annonaceae
3.	*Phoenix sylvestris* (L.) Roxb.	Eechalu/ Kharjura	Silver date palm	Arecaceae
4.	*Cocos nucifera* L.	Tengu	Coconut	
5.	*Elaeis guineensis* Jacq.	-	Oil palm	
6.	*Caryota urens* L.	Bayne/ Kondapana	Toddy palm	
7.	*Areca catechu* L.	Adike Mara	Areca Palm	
8.	*Tabebuia argentea* (Bureau & K. Schum.) Brit.	-	Yellow trumpet tree	Bignoniaceae
9.	*Spathodea campanulata* P. Beauv.	Lujjekaye/ Neerukayi Mara	Fountain tree	
10.	*Tabebuia rosea* (Bertol.) Bertero ex A. DC.	-	Pink Trumpet tree	
11.	*Casuarina equisetifolia* L.	Kyasurina/ Sarve Mara	Casuarina/ She oak	Casuarinaceae
12.	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Aatumaruthu/ Neer Maruthu/ Nirmatti	Arjun	Combretaceae
13.	*Terminalia catappa* L.	Taree	Indian almond	
14.	*Ricinus communis* L.	-	Castor oil plant	Euphorbiaceae
15.	*Pongamia pinnata* (L.) Pierre.	Honge	Indian Beech	Fabaceae
16.	*Bauhinia purpurea* L.	Basavanpada/ Devakanchan	Purple orchid tree	
17.	*Tamarindus indica* L.	Hunse Mara	Tamarind Tree	
18.	*Samanea saman* (Jacq.) Merr.	-	Rain Tree	
19.	*Acacia auriculiformis* Benth.	Aurculis	Acacia	
20.	*Dalbergia sissoo* Sensu Miq.	Beete/ Sissoo	Indian rosewood	
21.	*Peltophorum pterocarpum* Auct. non K.Heyne	-	Copper Pod	
22.	*Acacia nilotica* (L.) Delile	-	Babul/ Gum tree	
23.	*Delonix regia* (Hook.) Raf.	Kempu Torai	Gulmohar tree	
24.	*Tectona grandis* L.f.	Thega/ Saguvani	Teak/ Indian Oak	Lamiaceae

25.	*Thespesia populnea* (L.) Soland. ex Correa	Bangali/ Arasi/ Huvarasi/ Hulchi	Portia tree	Malvaceae
26.	*Azadirachta indica* A. Juss.	Bevu/ Kirubevu/ Turakabevu	Neem Tree	Meliaceae
27.	*Calliandra tweedii* Benth.	-	Powderpuff Tree	Mimosaceae
28.	*Ficus religiosa* L.	Ashvattha/ Arali	Peepal tree	Moraceae
29.	*Artocarpus heterophyllus* Lam.	Halasina Hannu	Jack fruit tree	
30.	*Ficus benghalensis* L.	Aalada Mara	Indian Banyan Tree	
31.	*Muntingia calabura* L.	Gasagase Hannina Mara	Bird's Cherry	Muntingiaceae
32.	*Syzygium cumini* (L.) Skeels.	Nerula/ Jum Nerale/ Neerama/ Narala	Jaman/ Java plum	Myrtaceae
33.	*Eucalyptus* sp.	Niligiri	Eucalyptus tree	
34.	*Psidium* Sp.	Sebaekayu Mara	Guava Tree	
35.	*Grevillea robusta* A. Cunn. ex R. Br.	Silver oak	Silver oak	Proteaceae
36.	*Manilkara zapota* (L.) P.Royen	Chikoo	Chiku Tree	Sapotaceae

Table.6.2. List of Herbs and shrubs recorded in and around the vicinity of BMR water bodies

SI. No.	Taxonomy Name	Kannada Name	Common Name	Family
Herbs				
1.	*Amaranthus spinosus* L.	Mulluharive Soppu	Spiny Amaranth	Amaranthaceae
2.	*Achyranthes aspera* L.	Uttaraani	Prickly Chaff-flower	
3.	*Gomphrena sp.*	-	Globe Amaranth	
4.	*Asclepias curassavica* L. (Herbs)	Raktapushpa	Blood Flower	Apocynaceae
5.	*Colocasia esculenta* (L.) Schott	Keshavana gadde	Wild Taro	Araceae
6.	*Parthenium hysterophorus* L.	Congress Geda	Congress Grass	Asteraceae
7.	*Tridax procumbens* L.	Gabbusanner savanthi	Coat Buttons	
8.	*Ipomoea cairica* (L.) Sweet.	Bekkina Hejje Balli	Railway creeper	Convolvulaceae
9.	*Evolvulus* sp.	-	Blue Daze	
10.	*Eriocaulon odoratum* Dalzell	-	Devil weed	Eriocaulaceae
11.	*Croton bonplandianum*	-	Ban Tulsi	Euphorbiaceae
12.	*Euphorbia hirta* L.	Kempuneneyakk/ Akkigida	Snake weed, Asthma herb	
13.	*Mimosa pudica* L.	Lajja	Touch Me not	Fabaceae
14.	*Crotalaria* sp.	-	Rattle pod	
15.	*Leucas aspera* (Willd.) Link	Thumbe gida	Common Leucas	Lamiaceae
16.	*Striga* sp.	-	Asiatic Witchweed	Orobanchaceae
17.	*Oxalis tetraphylla*	-	Iron Cross	Oxalidaceae
18.	*Bacopa monnieri* (L.) Pennell	Brahmi	Thyme Leaved Gratiola	Plantaginaceae
19.	*Cortaderia* sp.	-	Feathery Grass	Poaceae
20.	*Cynodon dactylon* (L.) Pers.	Hullu	Common/ Bahama Grass	
21.	-	Biduru	Bamboo	
22.	*Polygonum glabrum* Willd.	-	Common Marsh Buckwheet	Polygonaceae
23.	*Borreria stricta* (L.f.) K. Schum.	-	Tharthavel	Rubiaceae
24.	*Borreria hispida* L.	-		

25.	*Stachytarpheta indica* (L.) Vahl	Kariyutta Rani	Indian Snakeweed	Verbenaceae
26.	*Hybanthus enneaspermus*	Purusharathna	Spade Flower	Violaceae
Shrubs				
27.	*Barleria* sp.	-	Lavender Lace	Acanthaceae
28.	*Calotropis gigantea* (L.) W.T.Aiton	-	Giant Milk Weed	Apocynaceae
29.	*Dracaena* sp.	-	Dracaena	Asparagaceae
30.	*Xanthium strumarium* L.	Maruluummatti	Common Cocklebur	Asteraceae
31.	*Cassia auriculata* L.	-	Tanner's Cassia	Caesalpiniaceae
32.	*Cassia tora* L.	-	Pot Cassia	
33.	*Ricinus communis*	Oudla	Castor Oil Plant	Euphorbiaceae
34.	*Tephrosia tinctoria*	-	Orange Tephrosia	Fabaceae
35.	*Prosopis juliflora*	Jaali Mara	South West Thorn	
36.	*Indigofera* sp.	-	Creepy Indigo	
37.	*Vitex negundo* L.	Nochi/ Lakkigida/ Karilakki	Common Chaste Tree	Lamiaceae
38.	*Pavonia zeylanica* (L.) Cav.	Balarakshasi/ Antutogari/ Topala	Lead Wort-White Flowered	Malvaceae
39.	*Abutilon indicum*	Tutti	Khangi/ Country Mallow	
40.	*Bougainvillea spectabilis* Willd.	-	Bougainvillea	Nyctaginaceae
41.	*Passiflora foetida* L.	Kukkiballi	Common Passion Flower	Passifloraceae
42.	*Ziziphus zizyphus* (L.) Karst.	-	Jujube	Rhamnaceae
43.	*Canthium coromandelicum* (Burm.f.) Alston	Kaare-gida/ Karemullu	Wild jessamine	Rubiaceae
44.	*Hamelia patens* Jacq.	-	Scarlet Bush	
45.	*Dodonaea viscosa* (L.) Jacq.	Bhandaru	Hopseed Bush	Sapindaceae
46.	*Datura* sp.	-	Angel's Trumpet/ Thorn Apple	Solanaceae
47.	*Solanum torvum* Sw.	Sundekkayi	Turkey Berry/ Devils Fig	
48.	*Lantana camara* L.	Rozagida/ Aripu	Lantana weed	Verbenaceae

Table.6.3. List of macrophytes recorded in and around the vicinity of BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
Emergent			
1.	*Hygrophila schulli* M.R.Alm.& S.M.Alm.	Marsh Barbel/ Kolavalike	Acanthaceae
2.	*Alternanthera philoxeroides* (Mart.) Griseb.	Alligator weed	Amaranthaceae
3.	*Alocasia* sp. (Schott) G. Don.	Alocasia	Araceae
4.	*Ipomoea fistulosa* Mart. ex Choisy.	Pink morning glory	Convolvulaceae
5.	*Cyperus* sp. L.	Cyperus grass	Cyperaceae
6.	*Cyperus alternifolius* L.	Umbrella sedge	
7.	*Sacciolepis myosuroides* (R.Br.) A.Camus.	Cupscale grass	Poaceae
8.	*Polygonum glabrum* Willd.	Common marsh buckwheat	Polygonaceae
9.	*Typha angustifolia* L.	Narrow leaf-cattail	Typhaceae
Submerged			
10.	*Sagittaria* sp.	Arrow head	Alismataceae
11.	*Aponogeton natans* (L.) Engl. & K.Krause.	Floating lace plant	Aponogetonaceae
12.	*Chara* sp.	Musk grass	Characeae
13.	*Ottelia* sp.	Duck Lettuce/ Kottigensu Balli	Hydrocharitaceae
14.	*Najas* sp.	Water Nymphs	
15.	*Vallisneria* sp.	Eel grass/ Tape grass	
16.	*Hydrilla verticillata* (L.f.) Royle	Water thyme	
17.	*Elodea* sp.	Pondweed	
18.	*Utricularia* sp.	Bladderwort	Lentibulariaceae
19.	*Marsilea* sp.	Water Clover	Marsileaceae
20.	*Nymphoides indica* (L.) Kuntze.	Water snow flake	Menyanthaceae
21.	*Nymphoides aquatica*	Banana lilly	
22.	*Potamogeton illinoensis* Morong	Illinois Pondweed	Potamogetonaceae
Rooted Floating			
23.	*Barleria* sp.	Lamb Koranti	Acanthaceae
24.	*Colocasia* sp.	Horse Weed	Araceae
25.	*Convolvulus* sp.	Bindweed	Convolvulaceae
26.	*Nelumbo* sp.	Lotus	Nelumbonaceae
27.	*Nymphaea* sp.	Water lilies	Nymphaeaceae
Free Floating			
28.	*Pistia stratiotes* L.	Water cabbage	Araceae
29.	*Lemna* sp.	Duck weed	
30.	*Spirodela polyrhiza* (L.) Schleid.	Common duck meat	
31.	*Wolffia* sp.	Water-meal	
32.	*Ceratophyllum* sp.	Horn worts	Ceratophyllaceae
33.	*Eichhornia crassipes* (Mart.) Solens.	Water hyacinth	Pontederiaceae
34.	*Salvinia molesta* Mitch.	Kariba Weed	Salviniaceae
35.	*Azolla* sp.	Water Fern	
36.	*Microcystis* sp.	Alage	Microcystaceae

Table.6.4. List of recorded terrestrial insects around vicinity of BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Crytacanthacris tatarica*	Spur Throted grasshopper	Acrididae
2.	*Schistocerca* sp.	Short Horned grasshopper	
3.	*Acrida exaltata*	Indian grasshopper	
4.	*Acrida cinerea*	Oriental longheaded locust	
5.	*Apis cerana*	Oriental Honey Bee	Apidae
6.	*Apis dorsata*	Indian Rock Bee	
7.	*Xylocopa sp.*	Carpentar Bee	
8.	*Periplaneta Indiana*	Domino cockroach	Blattidae
9.	*Argyromoeba aperta*	Bee Fly	Bombyliidae
10.	*Sternocera* sp.	Jewel beetle	Buprestidae
11.	*Cicindela aurofasciata*	Gold cross Tiger beetle	Carabidae
12.	*Trigonophorus delessert*	Shining leaf Chafers	Cetoniidae
13.	*Platypleura* sp.	Cicada	Cicadidae
14.	*Neochetina eichhorniae*	water hyacinth weevil	Curculionidae
15.	*Carausius* sp.	Stick Insect	Diapheromeridae
16.	*Eurybrachys tomentosa*	Laef Hopper	Eurybrachyidae
17.	*Paratrechina longicornis*	Black Crazy Ant	Formicidae
18.	*Oecophylla smaragdina*	Weaver Ant	
19.	*Phaneroptera* sp.	Tree Cricket	Gryllidae
20.	*Spilostethus pandurus*	Seed bug	Lygaeidae
21.	*Mantis religiosa*	Praying mantis	Mantidae
22.	*Mylabris pustulata*	Blister beetle	Meloidae
23.	*Mesovelia mulsanti*	Water Treader	Mesoveliidae
24.	-	Bess beetle	Passalidae
25.	*Erthesina acuminata*	Stink bug	Pentatomimidae
26.	-	Elephant Dung beetle	Scarabaeidae
27.	*Sisyphus* sp.	Dung beetle	
28.	*Chrysocoris stolli*	Jewel bug	Scutelleridae
29.	*Odontotermes* sp.	Termite	Termitidae
30.	*Lobesia* sp.	Grapevine moth	Tortricidae
31.	*Polistes hebraeus*	Vespid Wasp	Vespidae
32.	*Ropalidia* sp.	Vespid Wasp	

Table.6.5. List of recorded Odonates around the vicinity of BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
Dragonfly			
1.	*Ictinogomphus rapax*	Common Clubtail	Gomphidae
2.	*Trithemis aurora*	Crimson Marsh Glider	Libellulidae
3.	*Brachythemis contaminata*	Ditch Jewel	
4.	*Brachydiplax sobrina*	Little Blue Marsh Hawk	
5.	*Rhyothemis variegata*	Common Picture Wing	
6.	*Orthetrum sabina*	Green Marsh Hawk	
7.	*Diplacodes trivialis*	Ground Skimmer	
8.	*Crocothemis servilia*	Ruddy Marsh Skimmer	
9.	*Rhodothemis rufa*	Rufous Marsh Glider	
10.	*Orthetrum luzonicum*	Tricoloured Marsh Hawk	
11.	*Tramea limbata*	Black Marsh Trotter	
12.	*Trithemis pallidinervis*	Long Legged Marsh Glider	
Damselfly			
13.	*Pseudagrion microcephalum*	Blue Grass Dartlet	Coenagrionidae
14.	*Ceriagrion coromandelianum*	Coromandel Marsh Dart	
15.	*Ischnura aurora*	Golden Dartlet	
16.	*Agriocnemis pygmaea*	Pygmy Dartlet	
17.	*Ischnura senegalensis*	Senegal Golden Dartlet	
18.	*Lestes praemorsus*	Sapphire-Eyed Spreadwing	Lestidae
19.	*Lestes elatus*	Emerald Spread Wing	

Table.6.6. List of recorded Butterflies around the vicinity of BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Jamides celeno*	Common Cerulean	Lycaenidae
2.	*Freyeria trochylus*	Grass Jewel	
3.	*Pseudozizeeria maha*	Pale Grass Blue	
4.	*Leptotes plinius*	Zebra Blue	
5.	*Castalius rosimon*	Common Pierrot	
6.	*Lampides boeticus*	Pea Blue	
7.	*Junonia iphita*	Chocolate Pansy	Nymphalidae
8.	*Danaus chrysippus*	Plain Tiger	
9.	*Junonia almana*	Peacock pansy	
10.	*Tirumala limniace*	Blue tiger	
11.	*Euploea core*	Common Indian Crow	
12.	*Hypolimnas bolina*	Great Eggfly	
13.	*Mycalesis perseus*	Common Bushbrown	
14.	*Ariadne merione*	Common castor	
15.	*Junonia hierta*	Yellow Pansy	
16.	*Elymnias hypermnestra*	Common Palmfly	
17.	*Pachliopta aristolochiae*	Common Rose	Papilionidae
18.	*Papilio polytes*	Common Mormon	
19.	*Pachliopta hector*	Crimson Rose	
20.	*Graphium doson*	Common Jay	
21.	*Graphium agamemnon*	Tailed Jay	
22.	*Catopsilia pomona*	Common Emigrant	Pieridae
23.	*Catopsilia pyranthe*	Mottled Emigrant	
24.	*Eurema hecabe*	Common Grass Yellow	
25.	*Belenois aurota*	Pioneer White	
26.	*Colotis etrida*	Small Orange Tip	
27.	*Leptosia nina*	Psyche	

Table.6.7. List of recorded aquatic insects in the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Gerris* sp.	Water Strider	Gerridae
2.	*Tenebrio* sp.	Meal Worm larvae	Glossosomatidae
3.	*Hydrometra stagnorum*	Hydrometra	Hydrometridae
4.	*Nepa cinerea*	Water Scorpion	Nepidae
5.	*Microvelia*	Water bug	Veliidae

Table.6.8. List of recorded macro benthic fauna in the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Bithynia tentaculata*	Mud Bithynia/ Faucet snail	Ammicolidae
2.	*Lymnaea stagnalis*	Great Pond Snail/ Pond Snail	Lymnaeidae
3.	*Pomacea canaliculata*	Columbia Apple snail/ Apple snail	Pilidae
4.	*Marisa cornuarietis*	Giant Ramshorn snail/ Marisa snail	
5.	*Coretus corneus*	Orb snail	Planorbidae
6.	*Notopala sublineata*	River snail	Pleuroceridae
7.	*Pisidium casertanum*	Bivalves	Sphaeridae
8.	*Tarebia granifera*	Thiarid snail/ Tarebia	Thiaeidae
9.	*Tubifex tubifex*	Tubifex / Sludge Worm or Sewage Worm	Tubificidae
10.	*Valvata sincera*	Valvata/ Mossy Valvata or Boreal Turret Snail	Valvatidae
11.	*Campeloma decisum*	Campeloma	Viviparidae

Table.6.9. List of observed fishes in the BMR water bodies

SI. No.	Taxonomy Name	Kannada Name	Common Name	Family
1.	*Parambassis ranga* (Hamilton)	Bachanike meenu	Indian glassy fish	Ambassidae
2.	*Mystus cavasius* (Hamilton)	Girlu/ Nai-kirle	Gangetic Mystus	Bagridae
3.	*Channa* Sp.	Kuchhu	Korava	Channidae
4.	*Cirrhinus* Sp.	Mrigal, Bangari	Mrigal	Cichlidae
5.	*Oreochromis mossambicus* (Linnaeus)	Jilebi/ Baduvara meenu	Tilapia	
6.	*Oreochromis niloticus* (Linnaeus)	Jilebi	Tilapia	
7.	*Clarias batrachus* (Linnaeus)	Anemeenu/Murgodu	Walking Catfish	Clariidae
8.	*Clarias gariepinus* (Burchell)	Ane-meenu	African catfish	
9.	*Cyprinus carpio* (Linnaeus)	Pare/Samanya Gende	Common Carp	Cyprinidae
10.	*Ctenopharyngodon idella* (Valenciennes)	Hullu Gende	Grass Carp	
11.	*Hypophthalmichthys molitrix* (Valenciennes)	Belli-gende	Silver Carp	
12.	*Catla catla* (Hamilton)	Catla/ Dodda Gende	Indian Carp	
13.	*Aristichthys nobilis* (Richardson)	Belli-gende	Bighead carp, Belli-gende	
14.	*Labeo calbasu* (Hamilton)	Kurrimeenu	Orangefin Labeo	
15.	*Labeo rohita* (Hamilton)	Rohu	Rohi or Rohu	
16.	*Puntius ticto* (Hamilton)	Naya-paisa	Ticto barb	
17.	*Labeo fimbriata* (Bloch)	Kem-meenu, Wengarlu, Kijan	Fimbriatus	
18.	*Carassius gibelio*	Koi	Prussian carp	
19.	*Gambusia affinis* (Baird & Girard)	Gambusia, Hechige pakke, Solle meenu	Mosquito fish	Poeciliidae
20.	*Ompok bimaculatus* (Bloch)	Godalae/ Kembari	Catfish	Siluridae

Table.6.10. Documented fish death in the Bengaluru lakes

SI. No.	Name of Lake	Documented Month and Year	Reasons
1.	Sankey lake and	June 1995	Depletion of DO levels caused by sewage let into the lake resulting in asphyxiation
2.	Lalbagh lake	July 1995	
3.	Ulsoor Lake	January 2005	Increased oxygen demand and chemicals flushed into lake
4.	Vengaiana lake	May 2005	Drastic drop in oxygen level in the water caused by untreated sewage water
5.	Puttenahalli lake	June 2005	Depletion of dissolved oxygen level
6.	Siddapura lake	October 2008	Depletion of dissolved oxygen level caused by untreated sewage water
7.	Marathalli lake		
8.	Jakkur lake	January 2009	Sewage entered the lake from a damaged storm water drain
9.	Cubbon Park pond	April 2010	Sewage water cause a severe depletion of oxygen level
10.	Deverabisanahalli Lake	November 2010	Organic pollutants discharged into the aquatic ecosystem
11.	Iblur lake	January 2011	Depletion of dissolved oxygen level
12.	Dubasipalya lake	February 2011	
13.	Kommaghatta lake		
14.	Giddana lake	April 2011	
15.	Mallathalli lake	2011	
16.	Sankey lake	August 2013	Oxygen depletion, toxic algal blooms and sudden changes in temperature and increased ammonia levels
17.	Dorekere	May 2014	Sewage flooded into lake after heavy rain
18.	Jakkur lake	January 2015	Underground drain from Yelahanka and Allasandra is blocked because of sewage water is overflowing into the lake
19.	Dorekere	April 2015	Sewage flooded into the lake after heavy rain
20.	Devarabeesanahalli lake	June 2015	Inflow of sewage and industrial pollutants into the lake
21.		March 2016	
22.	Ulsoor lake		Chemicals flushed from Ulsoor swimming pool and untreated sewage water into the lake cause a drastic drop in oxygen level
23.	Hebbal Lake	May 2016	Inflow of sewage
24.	Sankey Tank	August 2016	
25.	Nagawara lake		

Table.6.11. List of recorded Amphibian (Order: Anura) in the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Bufo melanostictus* (Schneider)	Common Indian Toad	Bufonidae
2.	*Hoplobatrachus tigerinus* (Daudin)	Indian Bull Frog	Ranidae
3.	*Euphlyctis cyanophlyctis* (Schneider)	Skittering Frog	
4.	*Hoplobatrachus crassus* (Jerdon)	Jerdon's Bull frog	
5.	*Limnonectes limnocharis*	Indian Cricket frog	

Table.6.12. List of recorded Reptiles around the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Psammophilus* sp.	South Indian Rock Agama	Agamidae
2.	*Agama* sp.	Southern Rock Agama	
3.	*Calotes* sp.	Common Garden Lizard	
4.	*Xenochrophis piscator* (Schneider)	Checkered Keel back	Colubridae
5.	*Naja naja* (Linnaeus)	Indian Cobra	Elapidae
6.	*Melanochelys* sp.	Black tortoise	Geoemydidae
7.	*Mabuya carinata* (Smith)	Common Skink	Scincidae

Table.6.13. List of recorded avifauna in and around the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Haliastur indus* (Boddaert)	Brahminy Kite	Accipitridae
2.	*Circaetus gallicus* (J.F.Gmelin)	Short Toed Snake Eagle	
3.	*Haliastur indus* (Boddaert)	Brahminy Kite	
4.	*Milvus migrans* (Boddaert)	Black Kite/ Garuda	
5.	*Mirafra assamica* (Horsfield)	Rufous Winged Bushlark	Alaudidae
6.	*Alcedo atthis* (Linnaeus)	Common Kingfisher	Alcedinidae
7.	*Ceryle rudis* (Linnaeus)	Lesser Pied Kingfisher	
8.	*Halcyon smyrnensis* (Linnaeus)	White Throated Kingfisher	
9.	*Anas crecca* (Linnaeus)	Common Teal	Anatidae
10.	*Anas* Sp.	Indian Runner Duck	
11.	*Anas poecilorhyncha* J.R.Forster	Indian Spot Billed Duck	
12.	*Anhinga* sp.	Darter	Anhingidae
13.	*Anhinga melanogaster* Pennant		
14.	*Ardea purpurea* (Linnaeus)	Purple Heron	Ardeidae
15.	*Ardea cinerea* (Linnaeus)	Grey Heron	
16.	*Ardeola grayii* (Sykes)	Indian Pond Heron	
17.	*Bubulcus ibis* (Linnaeus)	Cattle Egret	
18.	*Egretta garzetta* (Linnaeus)	Little Egret	
19.	*Mesophoyx intermedia* (Wagler)	Intermediate Egret	
20.	*Vanellus indicus* (Boddaert)	Red Wattled Lapwing	Charadriidae
21.	*Vanellus malabaricus* (Boddaert)	Yellow Wattle Lapwing	
22.	*Mycteria leucocephala* (Pennant)	Painted Stork	Ciconiidae
23.	*Anastomus oscitans* (Boddaert)	Asian Openbill	
24.	*Prinia inornata* Sykes	Plain Prinia	Cisticolidae
25.	*Streptopelia senegalensis* (Linnaeus)	Laughing Dove	Columbidae
26.	*Corvus splendens* Vieillot	Common House Crow	Corvidae
27.	*Eudynamys scolopacea* (Linnaeus)	Asian Koel	Cuculidae
28.	*Dicrurus macrocercus* Vieillot	Black Drongo	Dicruridae
29.	*Amandava amandava* (Linnaeus)	Red Avadavat	Estrildidae
30.	*Lonchura punctulata* (Linnaeus)	Scaly Breasted Munia	
31.	*Motacilla* sp.	Lesser Pied Wagtail	Motacillidae
32.	*Motacilla maderaspatensis* J.F.Gmelin	White browed Wagtail	
33.	*Copsychus saularis* (Linnaeus)	Oriential Magpie Robin	Muscicapidae
34.	*Nectarinia zeylonica* (Linnaeus)	Purple Rumped Sunbird	Nectariniidae
35.	*Passer domesticus* (Linnaeus)	House Sparrow	Passeridae

36.	*Pelecanus philippensis* J.F.Gmelin	Spot billed Pelican	Pelecanidae
37.	*Phalacrocorax* sp.	Cormorants	Phalacrocoracidae
38.	*Phalacrocorax niger* (Vieillot)	Little Cormorant	
39.	*Phalacrocorax carbo* (Linnaeus)	Great Cormorant	
40.	*Ploceus philippinus* (Linnaeus)	Baya Weaver	Ploceidae
41.	*Tachybaptus ruficollis* (Pallas)	Little Grebe	Podicipedidae
42.	*Pycnonotus jocosus* (Linnaeus)	Red whiskered Bulbul	Pycnonotidae
43.	*Pycnonotus luteolus* (Lesson)	White Browed Bulbul	
44.	*Pycnonotus cafer* (Linnaeus)	Red vented Bulbul	
45.	*Fulica atra* (Linnaeus)	Common Coot	Rallidae
46.	*Porphyrio porphyrio* (Linnaeus)	Grey headed Swamphen	
47.	*Porphyrio indicus* (Horsfield)	Black-Backed Swamphen	
48.	*Megalaima zeylanica* (Gmelin)	Brown Headed Barbet	Ramphastidae
49.	*Megalaima haemacephala* (Statius Muller)	Coppersmith Barbet	
50.	*Himantopus himantopus* (Linnaeus)	Black Winged Stilt	Recurvirostridae
51.	*Tringa ochropus* (Linnaeus)	Green Sandpiper	Scolopacidae
52.	*Acridotheres tristis* (Linnaeus)	Common Myna	Sturnidae
53.	*Plegadis falcinellus* (Linnaeus)	Glossy Ibis	Threskiornithidae
54.	*Pseudibis papillosa* (Temminck)	Indian Black Ibis	

Table.6.14. List of observed Mammals in and around the BMR water bodies

SI. No.	Taxonomy Name	Common Name	Family
1.	*Bos taurus indicus* (Linnaeus)	Cow	Bovidae
2.	*Bubalus bubalis* (Linnaeus)	Buffalo	
3.	*Ovis aries* (Linnaeus)	Sheep	
4.	*Capra hircus* (Linnaeus)	Goat	
5.	*Canis familiaris* (Linnaeus)	Dog	Canidae
6.	*Equus* Sp.	Horse	Equidae
7.	*Equus africanus asinus*	Donkey	
8.	*Herpestes javanicus* (E.Geoffroy Saint-Hilaire)	Mongoose	Herpestidae
9.	*Bandicota bengalensis* (Gray & Hardwicke)	Lesser Bandicoot rat	Muridae
10.	*Pteropus giganteus*	Bat/ Indian Flying Fox/ Baavuli	Pteropodidae
11.	*Funambulus palmarum* (Linnaeus)	Indian Palm Squirrel	Sciuridae
12.	*Sus* Sp.	Pig	Suidae

Gantiganahalli *Kere*

CHAPTER

7

POLLUTION & ISSUES

Chapter-7: Pollution and Issues

7.1. Introduction:

The word pollution is derived from Late Latin pollutio (“defilement”), from Latin polluere (“to soil, defile, contaminate”) related to lutum (“mud”) and to lues (“filth”); Old Irish *loth* "mud, dirt", Lithuanian lutynas (“pool, puddle”). The meaning "that which makes physically foul" is from 1540’s. The sense of "contamination of the environment" was first recorded around 1860, but not common until about 1955. Later parallel word derived in many languages. It is known as *‘Malinya’* in Kannada, *‘Pradooshan’* in Hindi, *‘Saastuminen’* in Finnish, *‘skażenie’* in polish, *‘förorening’* in Swedish, *‘forurensing’* in Norwegian. "Water Pollution" means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms [Water (Prevention and Control of Pollution) Act, 1974, Act No. 6 of Year 1974].

The importance of *clean* water was not appreciated until the second half of the nineteenth century, which is relatively recent development. In ancient Rome, sewers carried human filth into the Tiber River. By 312 B.C., the river was so polluted the Romans constructed aqueducts to obtain clean drinking water. The pollution of water with raw sewage was the catalyst for many typhoid and cholera outbreaks throughout the centuries, in numerous parts of the world. Even today, water-borne diseases kill tens of thousands each year because clean drinking water is not available, or accessible, to everyone which is the scenario in India as well. Bengaluru (previously Bendakaluru) was founded by Kempe Gowda I, who built a mud fort at the site in 1537, a period around the same time when the word pollution was being recorded and felt in Europe. As the years passed Europeans and developed countries were able to manage pollution while it is yet to be managed in Bangalore.

In 1957, the Natural History Museum declared the Thames biologically dead and late 1960s onwards, London's sewage system gradually improved along with the country's wider post-war recovery. Late 1960s onwards, London's sewage system gradually improved along with the country's wider post-war recovery, when the river began to breathe again. But parallelly just the opposite happened in Bangalore, which started growing because of rapid migration without readiness to accept the population and manage pollution. People who migrated for jobs and business continued to pollute water bodies both on surface water and groundwater.

7.2. Methodology:

In order to study the impact of pollution on water bodies (*Kere*, *Katte* & *Kunte*) in the study area comprising BBMP and BDA region of Bangalore was visited to know their current status. The supporting documents such as village maps, google maps and records of rights, tenancy and crops (RTC) were referred for identification of the water bodies during the field visit. The existing and disused water bodies were identified along with their geo-tagged reference and the same transferred on GIS maps. The current status of water bodies such as morphometric, biodiversity, surrounding land use, any encroachments, purpose of usage of water, pollution status of water, and any other sort of existing issues leading to pollution of the water bodies were documented in the field data sheets. Photographs were taken. During the field visits the interactions with the local communities were made and information regarding the water bodies was collected by the EMPRI project team visiting the water bodies. The extent of development in the lakes, i.e. whether, the lakes are rejuvenated or whether the lakes are under rejuvenation or lakes without any rejuvenation were documented.

The pollution issues documented were Inflow of sewage and effluents, dumping of various types of solid wastes, encroachments, land use changes and usage of foreshore area for other activities, etc. along with the surroundings (current land use) with reference to the feeder canal, and existing catchment conditions.

7.2.1. Prioritizing the Lakes for Conservation:

Practically, it's not possible to implement the action plan for conservation of all the lakes in same time due to the huge cost and the lack of adequate staffs. Therefore, in order to implement the action plan for conservation, the prioritizations of lakes have been done by following methodology;

Existing lakes in the study area were segregated on the basis of its beneficiary and pollutant impact using Environmental Impact Assessment (EIA) matrix by "*Modified Battelle Method*". Here, EIA is a tool, which identifies, predicts, interprets and communicates information, and proposes ameliorative measures about impacts of the ecosystem (lakes) upon which human survival depends. Even though this tool has different methods, the Battelle method is approximately suitable to find the status of lakes in study area.

Battelle Method: The Battelle Environmental Evaluation System (EES) is a methodology for conducting environmental impact analysis developed at Battelle Columbus Laboratories by an interdisciplinary research team under the contract with the U.S. Bureau of Reclamation (Dee *et al*., 1972 and 1973) based on a hierarchical assessment of environmental quality indicators. The system is based on a classification consisting of four levels;

- <u>Level-I</u>: Categories,
- <u>Level-II</u>: Components,
- <u>Level-III</u>: Parameters, and
- <u>Level-IV</u>: Measurements

Each category (Level-I) is divided into several components, each component (Level-II) into several parameters, and each parameter (Level-III) into one or more measurements (Level-IV). The EES identifies a total of four categories, 18 components and 78 parameters. The EES methodology is based on the assignment of an importance unit to each parameter. Collectively, these "importance units" are referred to as "*Parameter Importance Units*" or PIU. Effectively, for each parameter, it's PIU represents a weight. EES assessment of the environmental impacts of water resources is based on commensurate "*Environmental Impact Units*" (EIU). The scores are based on the magnitude and importance of specific impacts. Two EIU scores are produced, one "with project/ beneficial (+)" and another "without project/ with adverse (-)". The difference between the two scores is a measure of the environmental impact.

$$EIU = \sum_{i=1}^{m} (Vi)_1 w_i - (Vi)_2 wi$$

Where:

$(Vi)_1$ is environmental quality for indicator "i" in the project conditions (Present),
$(Vi)_2$ is environmental quality for indicator "i" without the project (Past),
wi is relative weight of the indicator "i" (PIU),
m is total number of indicators.

<u>*CLC Modified Battelle Method*</u>*:* The methodology developed by US or European countries are not suitable to our country due to the geographical and climatic conditions. Moreover, our country has problem of population density and the waste generated by them. In Bangalore, unplanned urbanization forms additional problem to foil the application of same methodology to find out the status of waterbodies. So the Centre for Lake Conservation (CLC) team of EMPRI has modified the Battelle method to implement on study area to find out the status of waterbodies and the PIU value of each parameters are elaborated in Table-7.1. Same EIU formula is applicable, but only thing is that the 'with' and 'without' project has modified as beneficiary and adversary conditions respectively.

$$EIU = \sum_{i=1}^{m} (Vi)_1 w_i - (Vi)_2 wi$$

Where:

$(Vi)_1$ is environmental quality for indicator "i" in the beneficiary impacts,
$(Vi)_2$ is environmental quality for indicator "i" in the adversary impacts,
wi is relative weight of the indicator "i" (PIU),
m is total number of indicators

In modified Battelle method, the PIU value is standard on the basis of its occurrence in the lake. Modifications done in CLC modified Battelle method is discussed in Table-7.2. The PIU value, standardized by following the Impact significance method of Thompson (1990) are;

a) *Scaling* is the standardisation of empirical data onto a common scale to allow comparisons between different types of impacts. The scale of importance ranges from one to ten. If the value is high, then its importance is also high; if the value is low then its importance is also low.

b) *Weighting* is the imposition of values (by professionals) onto a range of impacts. Assignment of a numerical value for importance is based on the subjective judgment.

c) *Aggregation* is the combination of different types of impact values to produce composite scores.

Assessments of pollutant in the Bengaluru Metropolitan Area lakes give the clear picture about the range of polluted lakes. After the assessment of polluted lakes in the BMA area, all the existing lakes are subjected to colour code on the basis of its EIU to predict the preference list for preservation. Five different colour codes like black; red; yellow; green and blue are made to predict the lakes, whether the revival needed; immediate action needed; conservation needed; action should be taken and in future action should be taken to avoid pollutant and for preservation due to developments in the urbanization respectively.

7.3. Assessment of Pollution level in Water bodies:

A total of 1521 water bodies (*Kere, Katte* and *Kuntes*) were inventoried in the study area. Out of which 683 water bodies (45%) were found to be existing while 838 water bodies (55%) were disused (as shown in Figure-7.1). The study of current status of both existing and disused water bodies was carried out. The study revealed that 683 water bodies are facing problems concerning pollution due to inflow of sewage and effluents, dumping of solid waste, runoff, encroachments of the lake area, growth of weeds, soil excavation, etc. Some of the lakes were found to be dry as the natural drains were destroyed or there was obstruction of the inflow of water,

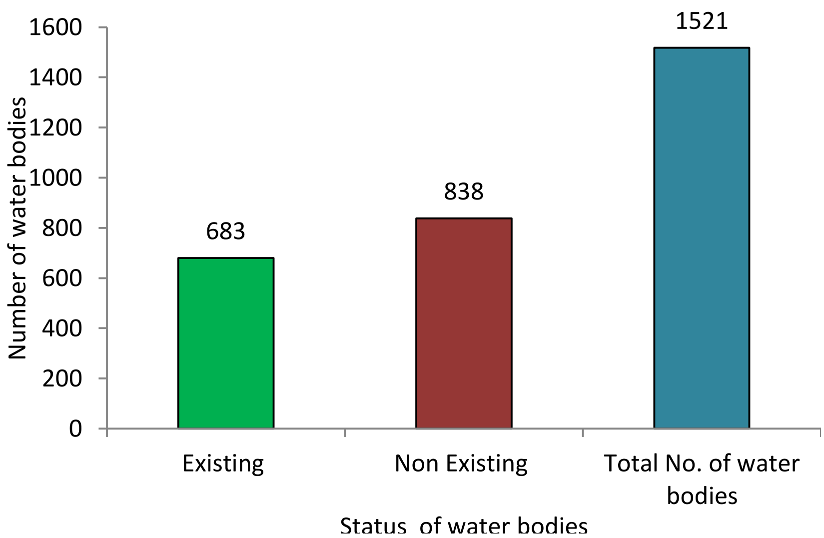


Figure-7.1. Status of Water bodies in the study area increase in siltation resulting in reduction of water holding capacity, and diversion of storm water drains (as they were carrying sewage). 838 water bodies have lost their characteristics and the land use pattern has undergone changes. The lakes have been converted into play grounds, layouts, parks, schools & colleges, bus depot, building, roads & railway tracks, agricultural land, as dumping sites, etc. and few were vacant. The lake land was found to be converted into other land uses by both Government and the private sectors.

7.4. Pollution Status of Existing Water bodies:

The pollution in lakes of Bangalore from various pollutants documented are categorised into point source (PS) pollution and non-point source pollution.

7.4.1. Point Source Pollution:

The known source of pollutants and their entry into water bodies is called as Point Source (PS) pollution. The main sources of water body pollution originate mainly from point sources. This point source pollution is broadly classified into direct point source pollution and indirect point source pollution based upon the U.S. EPA Clean Water Act (Section 301), 1972. Point sources are relatively easy to identify, quantify and control.

7.4.1.1. Direct Point Source pollution:

Pollutants that are directly discharged into the water bodies from discrete and identifiable sources are called as 'Direct Point Source Pollution'. In the study area out of 683 water bodies; 375 water bodies are being subjected to seven types of direct point source pollutants as follows, as per Figure-7.2 and Table-7.3.

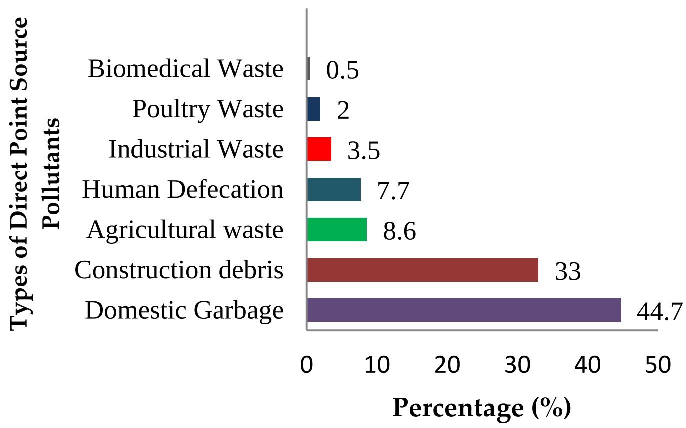


Figure-7.2. Direct Point Source Pollution in water bodies

7.4.1.1a. Domestic Garbage:

Bangalore generates around 4000 Tonnes of Municipal Solid Waste daily. The sprawling urbanisation and the changing life style have led to the increase of generation of waste from 0.16 (1988) to 0.58 kg/capita/day (2009) (Chanakya *et al*, 2009). The existing solid waste treatment system in the city was not able to clear this amount of waste and only about 60% of the waste was being cleared by the BBMP and the BDA. Presently, to encourage segregation at source, BBMP has established 170 Dry Waste Collection Centres, which collect only dry waste from Wards. Bulk Generators of waste like Hotels, Restaurants, Kalyana Mantaps, Apartments etc., have been notified to establish a system to handle Municipal Solid Waste generated in their premises or through empanelled service providers. Seven sites have been identified for disposal of construction and demolition waste in the city. BBMP is also setting 13 decentralized Bio-methenation Plants, out of which 4 have been made functional. After taking all these measures, the quantum of waste which is being received at the BBMP processing centres is around 3000 TPD. The same is being managed through the Private Processors. Out of the above facilities, land fill without processing is being done only at Bingipura and Laxmipura facilities. To achieve 100% processing of waste, Government has sanctioned setting up of six new facilities.

Residences, markets, hotels and restaurants, commercial premises, slums, street sweepings and parks are the different sources generating waste. Residences owing to 55% of total wastes are highest among all other sources. Bangalore waste comprises of fermentable (vegetable & fruit peel, left over food, etc.), paper and cardboard, cloth, rubber, PVC and leather, glass, polythene/plastics, metals dust and waste gathered by sweeping. Of these, waste generated- fermentable components is high about 72% (TIDE, 2000). 350 to 400 MT of plastic is estimated to be generated per day in Bangalore city. The insufficient handling and management of waste accompanied with lack of people's participation at various stages of disposal is clearly evident from the waste dumping on the road sides, vacant places, in and around the water bodies in the city.

In about 44.7% water bodies solid waste dumping (Figure-7.3 and 7.4) was found, out of which in 33 water bodies burning of solid waste was observed. The solid waste also contained batteries, CLF bulbs etc. which are hazardous wastes.

Figure-7.3. Solid wastes dumped at the Rayasandra *Kunte*-2

Figure-7.4. Solid wastes dumped in Sarakki *Kere*

Figure-7.5. Plastic wastes dumped in Doddanagamangala *Kunte*-3

Unscientific disposal of solid waste or dumping of solid waste in and around the water bodies has many ill effects on both water bodies and on human health. Solid wastes clogs the drains, during rainy season causes flooding, creates stagnant water making it an ideal place for the breeding of disease vectors like mosquitos, while the leachates pollutes the water and the soil, burning of the waste leads to air pollution, soil pollution and ultimately water pollution. Further, the plastic in the solid waste find their way in the gut of cattle and asphyxiating animals (Figure-7.5).

The leachate from the dumping yard near Bingipura lake, Lakshmipura lake, Thippasandra *Kere* and Rayasandra *Kunte*-2 holds the potential for polluting the soil and lake water. The leachate is the liquid that seeps through solid waste and has extracts of dissolved or suspended material from it. In the uncapped landfills and in solid waste dumping during precipitation the water percolates through the waste and gets contaminated. This leachate poses health hazards as it pollutes the ground water and surface water. The leachate composition and quantity is subject to seasonal and daily fluctuations.

Plastic Ban

Karnataka state government has banned plastic carry bags, plastic banners, plastic buntings, flex, plastic flags, plastic plates, plastic cups, plastic spoons, cling films and plastic sheets used for spreading on dining table irrespective of thickness, including the above items made of thermocol and plastic which use plastic micro beads by no person including the shopkeeper, vendor, wholesaler, retailer, trader, hawker or sales man with effect from 11.03.2016.

However, exemption has been given to plastic carry bags manufactured exclusively for export purpose against any export orders located in a special economic zone (SEZ) and export oriented units (EOU). The State has also exempted plastic used for milk and milk products, and those which constitute an integral part of packaging in which goods are sealed prior to use. Also, the plastic bags and sheets used in Forestry and horticulture nurseries against the orders from the Govt. Departments or from the firms concerned.

7.4.1.1b. Construction and Demolition Wastes:

Construction and Demolition (C & D) debris consists of building material wastes generated during construction, re-modelling, repair and demolition of any civil structure (Figure-7.6). The waste material includes mainly bricks, ceramics, wood, asphalt, concrete, soil waste, dry wall with painting, asbestos sheet and other masonry waste (Figure-7.7). Dumping of construction wastes leads to clogging of drains, increases silt in water bodies which eventually decrease the depth of the water body. The composition of trace amount of hazardous materials (of non-toxic chemicals) of the construction waste not only contaminates the water but also has adverse impact on human health such as lead in paints in some of the old building rubbles, asbestos sheet (causes air pollution), etc. About 33% water bodies were found to be subjected to dumping of construction debris. During the field visit a tractor was dumping huge amount of construction debris on the sides of the lake bund (Manganahalli lake-2).

Figure-7.6. C&D waste in Srigandhakavalu *Kere*

Figure-7.7. C&D wastes dumped in Kanalli *Kere*

7.4.1.1c. Agricultural Waste:

In the midst of the urban sprawl agricultural activities such as cultivation of crops (paddy, jowar, etc) and plantations (mango, eucalyptus etc.) were observed around some of the lakes in the study area. Wastes are generated from the agricultural activities as the by-product of crop harvesting, saw mills, agro-industrial processing and others (Figure-7.8).

Piling and storing of cow dung along with other crop waste to produce organic compost to apply to the fields (Figure-7.9), paddy straw and husk, wastes of vegetables, tree logs, and tender coconut waste were found dumped in the water bodies. About, 8.6% water bodies were found to contain the agricultural waste.

Figure-7.8. Dumping of agricultural waste in Bhujangadasana Amani *Kere*

Figure-7.9. Agricultural waste stored in Byalakere *Kere* (Uramundina *Kere*)

7.4.1.1d. Biomedical Waste:

Biomedical waste is any waste which includes waste generated during the diagnosis, treatment or immunisation of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps, including expired or discarded medicines, etc. In Kasagattapura *Kere*-3 injection vials, injection needles, syrup bottles and expired pills were dumped by the local clinic (Figure-7.10), and in Kuppareddy *Kere* and Ganigarahalli *Kere* expired pills, syrup bottles were documented.

7.4.1.1e. Poultry Waste:

Poultry waste is generated from the poultry slaughter houses especially of the meat chicken commonly called Broilers. The poultry industry in India represents a major success story. Today, India is the third largest egg producer in the world (after China and the United States of America), and the nineteenth largest broiler producer. The processing of poultry results in waste materials including offal (feathers, entrails and organs of slaughtered birds), processing wastewater and bio solids (Figure-7.11).

Figure-7.10. Bio-medical waste in Kasagattapura *Kere*-3

Figure-7.11. Poultry waste dumped in Kochohalli *Kere* -1

This waste poses potential environmental and human health concerns as the sources of elements, compounds (including veterinary pharmaceuticals), vectors for insects and vermin, and pathogenic microorganisms (William, 2013). The discharge of biodegradable organic compounds and macronutrients (nitrogen, phosphorus) causes a strong reduction of dissolved oxygen in the water bodies, which in turn may lead to reduced levels of activity or even death of aquatic life (Verheijen, *et al.*, 1996). In 2% of the lakes, poultry wastes were documented.

7.4.1.1f. Industrial waste

The growing population needs and demands are being met through setting up different industries for different products. In the course of production from the beginning to the finishing point i.e. from obtaining of raw materials, processing them and production of finished products a number of wastes are generated which are polluting the environment. Industry contributes various kinds of pollutants to the environment as shown in Figure-7.12. In 3.5% of water bodies the industrial waste dumps were found as follows:

***i. Fibre (Synthetic) Waste*:**

Man-made fibre wastes with the chemical composition of several synthetic components (polyamide, acrylic and polyester polypropylene) are dumped in the lakes from the fibre industries. Fibreglass made by glass reinforced polymers (FRP), from industry was found in the Kuppareddy *Kere* & Kanaminiki Sarkari *Kere*. Other fibre wastes like fibre board slate and carbon fibre with asbestos cement were also documented in the lakes Kannalli *Kere* (Figure-7.13) & Abbigere *Kere*.

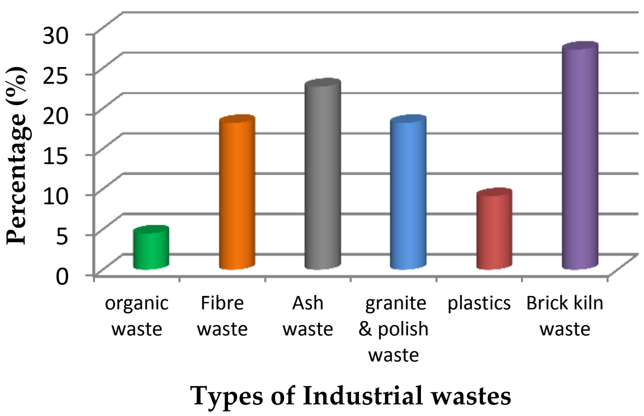


Figure-7.12. Types of industrial wastes in water

Figure-7.13. Fibre slate waste in Kannalli *Kere*

***ii. Plastic*:**

Plastic means any of the items made out of poly propylene (PP), non-woven poly propylene, multi layered co extruder poly propylene, poly ethylene (PE), poly vinyl chloride (PVC), high & low density poly ethylene (HDPE & LDPE), poly styrene (PS) which is also called thermocol, poly amides (Nylon), poly terephthalate (PT), poly methyl methacrylate (PMM) and plastic micro beads as per Karnataka Govt. Notification No.FEE 17 EPC 201, Bangalore 11.03.2016.

Irrespective of purpose of use of plastics as in packaging industry, construction industry, disposable cutlery, storage, as carry bags in households etc, poses several environmental and health issues. Plastics dumped in and around the water bodies not only choke the drains but are also harmful to health as they contain toxins. Plastic releases some toxic chemicals such as Styrene Trimer, Bisphenol A, and a by-product of Polystyrene which deteriorates the quality of drinking water. Bisphenol A is a harmful chemical that damages the reproductive system of animals. Ethylene oxide, xylene, and benzene are some of the chemical toxins present in plastic, which can have hazardous effects on the environment and it can cause permanent harm to living beings. Several additives found in plastic such as phthalates, adipates, and even alkyl phenols have been recognized as toxic materials. Vinyl chloride, used in the manufacturing of PVC pipes, is classified as a carcinogen (Dana Gopal *et al*., 2014).

Plastic waste from the industrial sheds was found dumped on the lake shore of Sheegehalli *Kere* and also burning of plastic wastes was observed. The burning of plastic waste generates highly toxic and carcinogenic fumes resulting in air and soil pollution. Also, the plastic was dumped in the Thotadaguddadahalli *Kunte*-2 by packaging industry (Figure-7.14).

***iii. Ash Waste*:**

Ash is the solid waste generated due to incineration or combustion process. Ash was dumped in the Ganigarahalli lake (Figure-7.15), Mavalipura *Kere*-3, Adikamaranahalli *Kunte*, Kuduregere *Kere* and Tippasandra *Kere*. If heavy metals and dioxin concentrations are high enough ash can affect the public and ecological health.

***iv. Granite and Polish Waste*:**

Granite cutting and polishing factories generates two types of wastes namely rock fragments and slurry. The slurry results during the sawing and polishing processes of the marble and granite. Some factories use additives like slaked lime and iron powder to act as abrasive and lubricants to facilitate the sawing process and to extend the life of the saw blade.

Figure-7.14. Plastic wastes dumped inside the Thotadaguddadahalli *Kunte*-2 by packaging industry

Fig: 3.15. Ash waste in Ganigarahalli Lake

The mixture of water and fine powder produced is a semi-liquid substance known as slurry or sludge. The settled slurry (with 50% water) is collected and thrown outside the factory on the land or into the water bodies (Allam *et al*., 2014). Slurry when completely dried, its particles become airborne. The weathering of the worn steel grit and blades used in processing granite transfer some quantities of toxic metals like chromium which is dangerous to both surface and ground water (Rania Hamza *et al*., 2011). Dumping of granite cuttings and the sludge in the lake affects the quality of water, reduces storage capacity and damages the aquatic life. The granite and polish waste was found in Chikkabanavarakere, Anagalapura *Kunte*-2, Kommasandra *Kunte*-5 and Bidarekere lake (Figure-7.16).

***v. Brick Kiln Waste*:**

The brick making industries apart from causing land degradation, air pollution also causes degradation of water quality. The lakes are contaminated by harmful compounds and by continuous silt and ash deposition from the brick kilns. Coal ash is the main solid waste generated in brick kilns. In addition to the silt and ash over burnt and broken bricks are the waste generated which are dumped in the lakes. The brick bats and the silt were found in the Honnenahalli Sarkari *Kere*, Mavalipura *Kere*-3 (Figure-7.17), Mylappana *Kere*-1, Mylappana *Kere*-2, Tigalara Choudenahalli *Kere* and Ganigarahalli *Kere*.

***vi. Organic Waste*:**

Organic waste is biodegradable waste consisting of materials from plants and animals. Food processing industry especially the fruit juice processing industry is an important industry contributing significantly to the organic solid waste. Processing of fruits includes canning, drying, freezing, and preparation of juices, jams, and jellies. The organic waste generated if unscientifically disposed leads to problem of bad odour and forms a heaven for breeding of flies. In Khajisonnenahalli *Kunte*-10 from food processing industry the mango waste including seeds, skin, and fruit pulp was dumped (Figure-7.18).

Figure-7.16. Granite polish dump in Bidarekere Lake

Figure-7.17 Brick kiln waste in Mavalipura *Kere*-3

7.4.1.1g. Human Defecation:

Open defecation on land and defecation in trains falling on tracks eventually will enter water bodies resulting in water pollution which leads to health hazards. Open defecation on lake shore, on lake bed by surrounding villagers and trespassers was observed in about 7.7% water bodies.

Figure-7.18. Dumping of mango wastes in Khajisonnenahalli *Kunte*-10

The direct point source pollution in the water bodies (Figure-7.2) is largely contributed by Domestic garbage (44.7%) followed by construction debris (33%), agricultural waste (8.6%), defecation (7.7%), Industrial waste (3.5%), poultry waste (2%) and biomedical waste (0.5%).

7.4.1.2. Indirect Point Source Pollution:

7.4.1.2a. Domestic Sewage:

City sewage that is indirectly discharged into the water bodies through the public sewer from identifiable sources is called as 'Indirect Point Source Pollution'. In India discharge of untreated sewage is found to be the single most important cause for pollution of surface and ground water. In India about 78% of the urban population has access to safe drinking water and about 38% of the urban population has access to sanitation services.

So is the case in Bangalore having a population of more than eight million generates nearly 1000 million litres per day of sewage even with conservative estimate assuming 120 litres per person per day and around 80% of water consumed becomes sewage. In Bangalore, BWSSB is mandate to provide drinking water and to treat the sewage generated in the city. The existing STPs (18 nos, with an installed capacity of 846 MLD as per data collected from BWSSB) with in the city are not able to completely treat sewage generated, ultimately resulting in large gap between generation and treatment of domestic wastewater. The huge discharge of untreated or partially treated sewage into the water bodies is also due to the unplanned development escorted with mushrooming layouts and apartments. Further, the direct discharges from the houses without sewerage connections and houses built on the side of Storm Water Drain, damages in the sewerage system, ageing of sewers, etc., are also contributing to the flow of wastewater through Storm Water Drains into the lakes (https://bwssb.gov.in/content/about-bwssb-2).

Bangalore Water Supply and Sewerage Board (BWSSB) is an autonomous body formed by the State legislature under Bangalore Water supply and Sewerage Board Act on 10-09-1964 for Water Supply & Sewage disposal. It is one of the first Water supply & Sanitation Utilities in India with jurisdiction of entire Bruhat Bengaluru Mahanagara Palike Area. Water supply system as displayed in BWSSB website is presented in Table-7.4.

Apart from the water supply from BWSSB people pump out ground water and buy water which vary from 100 ml bottle to water tankers making it most challenging problem for controlling pollution as there is huge supply and demand gap (Table-7.5). The projected water supply requirements for the city of Bangalore and population projections are shown in the Table-7.5:

In spite of several criminal cases lodged on BWSSB, and other establishments pollution still persists demanding huge public funds to maintain sewerage summarised below (https://bwssb.gov.in/content/about-bwssb-2)

- Total length of sewer system - 6,800 Kms
- Number of manholes - 2.25 lakhs
- Sanitary house service connections - 9 lakhs
- Number of sewer cleaning combination (Jetting & Sucking machines) for cleaning & maintaining of sewer system - 125 nos
- Total no. of desilting machines - 6 nos.
- Sewerage network Laterals (< 300 mm dia) – 3367 Kms
- Trunk Sewers (>300 mm dia) – 302 Kms Number of plants – 14

- Sewage generation – 1400 MLD
- Sewage treatment capacity – 721 MLD (STPs number updated to 18 with total installed capacity of 846 MLD as per the data collected from BWSSB)
- Average treatment – 520 MLD

Cause for foam and fire in lakes –Varthur and Bellandur

As per Ramachandra et al, 2015, Bellandur and Varthur lake have been receiving a mix of untreated and partially treated wastewaters (~500 million litres per day, MLD), from major residential areas and some industries, both synthetic and natural compounds that are present have contributed to the formation of foam.

This sustained inflow of sewage into the Varthur and Bellandur contains natural and synthetic dissolved organic compounds – soaps and detergent, fats, oils, greases and biosurfactants. These are surface –active agents or surfactants that are causing the foam. The natural surfactants include carboxylic fatty acids derived from lipids from macrophytes/weeds, etc. While, the synthetic surfactants are widely used in household cleaning products (detergents/soaps), cosmetics and personal care products (shampoo, toothpaste, etc.). These surfactants are released into water and contribute to a large variety of soluble organic material known as dissolved organic carbon (DOC). Major contribution of DOC is from synthetic surfactants in the sewage. Also, detergents contains branch-chained alkyl benzene sulfonate surfactants, which are non-biodegradable resulting in extremely persistent foam accumulating below the fall levels in the lake and other wastewater outfall. There are set of advanced detergents that exclude phosphates but contain biodegradable linear alkyl benzene sulfonate surfactants, such as sodium or ammonium lauret or lauryl sulphate.

Also, surfactants are used by many industries as melting agents, dispersants, defoamers, de-inkers, antistatic agents, and in paint and protective coatings, pesticides, leather processing, plastics and elastomer manufacturing, and oil extraction and production. Many industries present in upstream of Bellandur and Varthur lakes have also contributed to high levels of surfactants in the waters in addition to the domestic sewage (Ramachandra and Solanki, 2007). These surfactants are persistent in environment, bioaccumulatic in organisms and humans with various biological consequences.

In contrast to natural foam, fresh detergent based foam is of white colour with noticeable odour. Discharge of untreated effluents (rich in hydro carbon) with accidental fire (like throwing cigarettes, beedi) has led to the fire in the lake.

Foam in Varthur Lake

The existing infrastructure can just cater to part of total pollution. Hence, BWSSB in order to increase treatment capacity has further proposed new treatment plants which are under construction (Table-7.6). Recently, construction work of 4 STPs of total capacity - 136 MLD has been completed (Bellandur Amani kere (90MLD), Doddabele (20MLD), Horamavu Agara (20MLD) and Kadugodi (6MLD) and included with the existing infrastructure. The water flow chart for Bengaluru is shown in Figure-7.19.

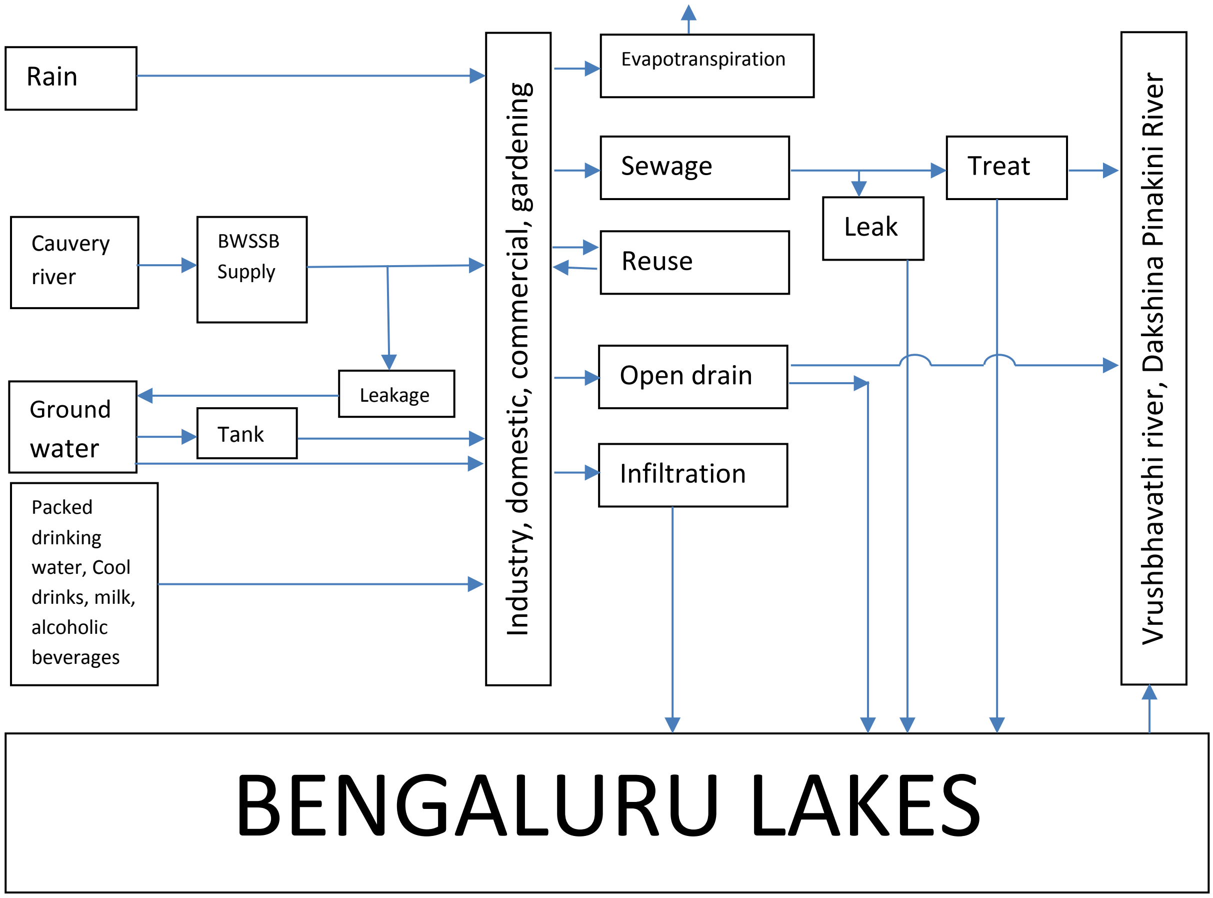


Figure-7.19. Water flow chart for Bengaluru

Presently, in the study area the sewage inflow in about 30% of existing water bodies was documented (Figure-7.20). Also, good practice of treating the wastewater and then letting into the lakes was documented in lakes such as Doraikere lake.

Figure-7.20. Sewage inflow in Doddakanneli *Kere*

Inflow of sewage not only causes enrichment of nutrients (Phosphates) leading to eutrophication of water bodies, but also continuous inflow of sewage is causing severe problem of foam and fire. The foam and fire are frequently been reported in the Varthur and Bellandur lakes causing nuisances and chaos among the surrounding dwellers and public. To avoid pollution of Bellandur and Varthur lakes BWSSB has proposed to construct waste water treatment plants in the upstream areas of Hulimavu, Begur, Sarakki and Agarm.

7.4.2. Nonpoint Source Pollution (NPS):

The Nonpoint source pollution is caused by multiple discharge point i.e diffuse sources where pollution cannot be traced to a single point of discharge. Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification in the catchment area. It is difficult to monitor and control this type of pollution. The pollutants may come from agricultural land and other open spaces, urban area or settlement, construction sites, roads and parking lots. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into water bodies and also polluting ground waters. The natural buffers- the wetlands between uplands and the adjacent water bodies act as natural filters for NPS, filtering sediment, nutrients, pathogens and metals. Therefore preserving these wetlands are very crucial for retaining the quality of the water. Various NPS are given in the Table-7.7 and is discussed below:

7.4.2.1. Agricultural Runoff:

The runoff from agricultural fields due to rain, irrigation is called agricultural runoff. The abundant use of fertilizers and pesticides in agricultural activities in order to obtain good yield is posing severe threat to the groundwater and surface water on a large scale. Organic materials, such as farm manures, composts contain higher concentration of trace elements than most of agricultural soils reaches natural water bodies through agricultural runoff and affects the aquatic species and in turn ecosystem (Hariprasad and Dayananda, 2013). Agricultural runoff also carries nitrates, pesticides, phosphates, total salts and sodium. Impacts can be generated from activities such as poorly located or managed animal feeding operations and manure, overgrazing, ploughing too often or at the wrong time. The nutrients such as nitrates and phosphates leads to eutrophication of lakes, while the pesticide contamination poses significant risks to the non-target organisms ranging from beneficial soil microorganisms to insects, plants, fish and birds.

7.4.2.2. Urban runoff:

During rains in the urban and suburban area large volume of runoff is generated. This is because the land surface is covered by buildings, and impervious surfaces like roads, parking lots and rooftops which do not allow the rain to soak into the ground causing flooding in the area. The runoff is conveyed to the water bodies via the storm water drains. Apart from entry of large volume of runoff, pollutants such as sediments from muddy construction sites, denuded surfaces; oil & grease, toxic chemicals such as Polycyclic aromatic hydrocarbons (PAH) from motor vehicles and from innumerable number of unauthorized vehicle washing units; Pesticides and nutrients from lawns and gardens; Viruses, bacteria and nutrients from pet waste and sewer overflows; heavy metals from motor vehicles and other sources; organic pollutant such as pet waste, leaves, grass clippings & litter; outdoor storage of scrap metal, coal and salt, etc., are conveyed to the water bodies. The pollutant apart from increasing the silt deteriorates the quality of the water and is detrimental to the plant and animal life.

7.4.2.3. Road Runoff:

In Bangalore the roads have been classified as arterial, sub-arterial, inter-ward roads and roads within a ward. The roads surfaces are either asphalted or concrete. The roads are sloped towards the sides and rainwater falling on the roads is guided to the side drains. Road pollution is a source of diffuse pollution that affects the soil and the water bodies in the vicinity. The level and types of emission given out are based on the road design, vehicle size (cars, lorries, motorcycles, and others), type of fuel used and the way the vehicles are used. The pollutants are given out from fuel combustion, road accessories (like lateral crash barriers) degradation, road degradation, tire wear, leakage, trash, accidents from the roadways, maintenance procedures (application of chemicals), and from the parking lots. The pollutants are being put down on the road surface, which is then washed off during the first flush period of a rainfall and reaches the water bodies along with the runoff. Furthermore, the type of storm water collection systems associated with the road (i.e., drains, grassy swale, etc.) plays a significant role in storm water runoff quality and its impact on receiving water bodies.

To mitigate the road runoff flow into the water bodies, infiltration trench rainwater harvesting from road and constructed wetland in water bodies should be initiated. The major compositions of all the runoff from Bangalore are as follows:

a. **Toxic contaminants** like heavy metals (Pb, Zn, & Cu, etc.), Poly-Chlorinated Biphenyls (PCB), Polycyclic aromatic hydrocarbons , fire retardants, oil, grease, and other chemicals from the source, include combustion of fossil fuel, pesticides, industrial wastes, petroleum spills, auto emissions, nurseries, etc.
b. **Sedimen**t is eroded soil or sand, including the silt and suspended solids, and other organic matter (dust, dirt, humus) which smothers aquatic habitat, carries pollutants, and reduces water clarity through turbidity. Sources of sediment include construction sites, agricultural fields and disturbed areas.

c. **Nutrients** such as phosphorous and nitrogen though is required for the plant growth, when the same nutrients are present in excess leads to eutrophication of water bodies.
d. **Pathogens** include disease causing bacteria, virus, protozoa, and helminths associated with the presence of fecal matters and animal droppings on road side can cause health hazard in drinking water and bathing water.
e. **Debris** includes plastic and other trash, which threaten aquatic life and detract from recreational and aesthetic values. Sources may include illegal dumping, street litter, and boating waste.

7.4.3. Other Issues:

Water bodies are degrading and the water quality is deteriorating not only due to pollution but also due to issues such as encroachment, soil excavation, stone quarry around the water bodies and due to activities such as religious, washing, as follows:

7.4.3.1. Encroachment:

To enter by gradual steps or by stealth into the possessions of other properties is called as encroachment. If more than one person encroaches a single water body land is called Multiple Encroachers. During field visit, the encroachments in 345 (50.5%) water bodies were observed and documented (Table-7.8). The encroachments were categorized as follows and as shown in Figure-7.21.

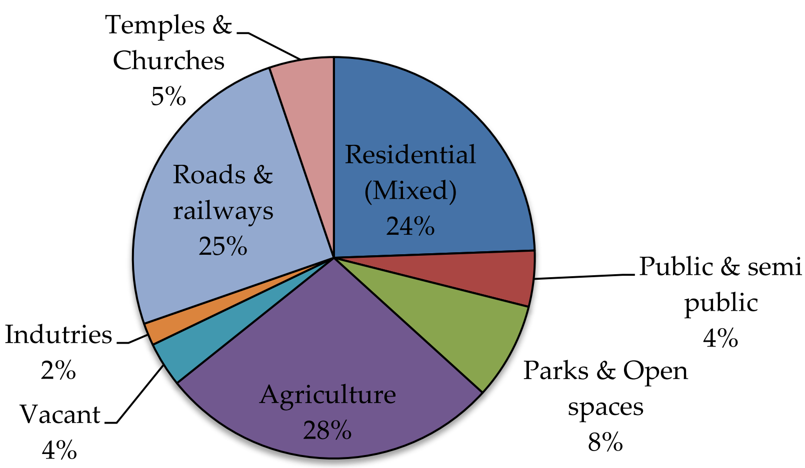


Figure-7.21. Different percentage of encroachment of water bodies

7.4.3.1a. Agricultural Encroachment:

The agricultural encroachment is the encroachment of lake land by farmers for agricultural activities such as growing of crops or plants, storing manure or their by-products, and livestock feeding. 28% (Figure-7.21) of water bodies were encroached by the farmers for agricultural purposes. On the basis of possession two types of agricultural encroachment are discussed as follows:

i. **Temporary:** Temporary agricultural encroachment involves cultivation of seasonal crops in the lake land when there is recession in water level. The marginal area of the lake is occupied by the farmers practicing agriculture adjacent to the lake. Apart from cultivation of crops the lake land is used for other agricultural activities such as harvesting crops like drying of paddy in the bare land called kana land, storing crop wastes and cattle wastes, etc. Due to lack of proper management, accompanied with frequent temporary encroachment leads to permanent encroachment of the lake land. Hay stack inside the Dasanayakanahalli *Kere* for feeding cattle (Figure-7.22).

ii. **Permanent**: When, the lake land is not only encroached for the cultivation of cash crops and/or plantation by the farmers but also the land is tried to be owned by litigation and political powers is called permanent agricultural encroachment. Arecanut and coconut plantations are common plantation documented in the lake land (Figure-7.23). Also conversion/ construction of park in part of the lake land and planting of saplings in the entire lake land is also considered as permanent encroachment.

Figure-7.22. Hay stack in Dasanayakanahalli *Kere*

Figure-7.23. Arecanut plantation in Kommaghatta *Gokatte*

7.4.3.1b. Residential (Mixed) Encroachment:

Encroachment of lake land for housing purpose is called as Residential encroachment. In the current study 'mixed land use' area involving employment, shopping and residential buildings are considered which are integrated in a compact urban form, highly accessible by public transit. Also, commercial buildings such as kalyana mantapas, conventional halls etc., are included for convenience of study. Also, sheds and overcrowded poor inhabitants (slums) around the margins of the lakes were also documented. 24% (Figure-7.21) of water bodies were found to be encroached for residential (mixed) purposes (Figure-7.24). Such type of encroachment not only leads to the shrinkage of water bodies but also leads to the indirect contamination of lake land. Unplanned urban sprawl/leapfrog development, absence of fence and buffer zone and negligence of water bodies is leading to such encroachment.

7.4.3.1c. Encroachment by Roads and Railways:

The urban sprawl, changing life style and economic growth of the city has led to the infrastructure development such as construction of roads to meet the needs of the rapidly increasing motor vehicles. But this development has led to the encroachment of certain water bodies in the city especially by the NICE road. Also, the rail way track was documented encroaching some of the lakes such as Shivanahalli lake, Panattur Govt. *Kere*, Avalahalli *Kere*, and Huskur Govt. Both road and railway together are accounting for 25% (Figure-7.21) encroachment of the lake land (Figure-7.25).

Figure-7.24. Residential encroachment of Madiwala lake

Figure-7.25. Encroachment of Avalahalli *Kere* by railway track

7.4.3.1d. Encroachment by Temples and Churches:

There is no restriction for religious activities hence there has been no restriction for the construction of temples on the government land. In many places the temples are near the water bodies (Figure-7.26). During festival season, the shore land is encroached and after few years, devotees of that temple construct a wall on the encroached land of the water body. 5% of water bodies (Figure-7.21) were found to be encroached by the temples and churches. Due to the construction of temples and churches on the shore land the wetlands are lost, leads to shrinkage of water body, inlet may be blocked and the solid waste generated especially during the festival times is dumped on the shore land of the water bodies which ultimately pollutes the lake.

7.4.3.1e. Industries:

About 2% water bodies (Figure-7.21) were found to be encroached by the industries such as brick industries, IT and BT sectors and poultry farm. A poultry farm- an agro business industry was found in the Ittagalapura lake -2 (Figure-7.27).

Figure-7.26.Temple encroaching Kaggadasanapura *Kere*

Figure-7.27. Poultry farm in Ittagalapura lake-2

7.4.3.1f. Park and Open Space:

Park and open space includes parks, playgrounds, burial grounds/grave yard in the study area. Ignorance among the public and the lack of dedicated land for the graveyard has resulted in the utilization of marginal areas of water bodies for graveyard (Figure-7.28). Villagers bury or burn the dead bodies in lake land. Park, grave yard and playground accounts for 8% (Figure-7.21) encroachment of lake land.

7.4.3.1g. Public and Semi-Public Encroachment:

Includes Government owned complexes and civic amenities and large infrastructure facilities of health, education, sports, cultural and social institutions (Figure-7.29). Public toilets inside the lakes were also documented 4% (Figure-7.21) of water bodies were encroached.

Figure-7.28. J.P. Park in Mattikere

Figure-7.29. Jindal Hospital in Madavara *Kere*

7.4.3.1h. Vacant land:

In some of the water bodies the encroached lake land was left vacant the during field visit. In 4% (Figure-7.21) of water bodies such encroachment was documented. Apart from the above mentioned different types of encroachments, Over Head Tanks (OHT) was found in the lakes Huskuru *Kere* and Narasipura *Kunte*-1. Also, drinking water plant unit was built at the edge of the lake in Narasipura *Kunte*-1. Further, different encroachers who have encroached the water bodies are mainly categorized (Figure-7.30) as follows:

i. **Private**: The local villagers, private apartments/layouts, owners of commercial buildings have encroached the water body land for construction of buildings or for further extension. After few years of encroachment, they have also applied for the 'Akrama Sakrama' to retain the encroached water body land. This process is frequently happening during the extension of old settlement area by local villagers; the newly created residential area by private layout developers approved by BDA/BMRDA. About 39% (Figure-7.21) of water bodies are encroached by private developers for residential buildings and commercial buildings.

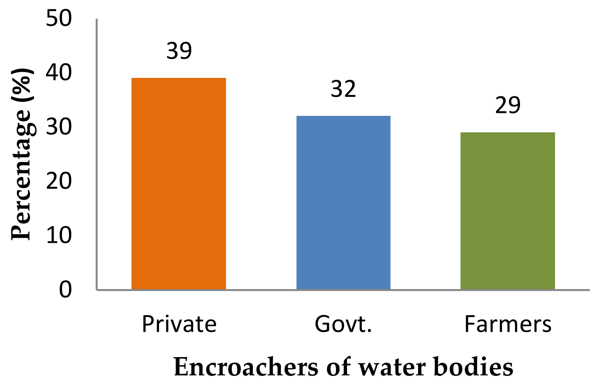


Fig: 3.31. Percentage of different encroachers on water bodies

ii. **Farmers**: The local villagers-the farmers are encroaching the lake land for cultivation or other agricultural activities. About 29% (Figure-7.21) of lake land was encroached by farmers.

iii. **Government**: About 32% (Figure-7.21) of the lake land is encroached by the buildings and have regularized their illegal constructions. A residential layout such as SMVL developed by BDA has encroached the lake land (Manganahalli Lake-1) and no buffer zone has been maintained.

7.4.3.2. Soil Excavation:

Soil excavation is another activity which is leading to the desecration of water bodies. Soil excavation involves removal of soil from one place and disposing them or use in other places (Figure-7.31 and Table-7.7). Soil excavation is done mainly to remove the siltation hoarded in the water bodies to increase the storage capacity of water bodies and ground water recharge. But due to the increase in usage of soil for the construction and agricultural purposes, mass soil excavation carried out in the water bodies has become common issue in developing area.

Soil excavation was observed in 131 (19%) water bodies. The impact of mass and/or heavy soil excavation will decrease the storage capability of surface water bodies, decrease the fertility of lake land thereby decrease the aquatic biodiversity, and increase the contamination of groundwater through the pollutants present in the surface water bodies. During summer season, dried water bodies are prone for the mass soil excavation and the soil is used for brick making, road construction and to improve fertility of the agricultural lands.

Figure-7.31. Soil excavation in Huralichikkanahalli *Kere*

7.4.3.3. Sand Mining:

In sand mining the soil is extracted from the water body land and is washed to obtain sand. During the process a large amount of silt –clay is produced. This clay gets accumulated and blocks the pores, which results in the reduction of ground water recharge. Thus, sand mining not only reduces water quality by increasing the turbidity but also destroys aquatic life, as sand is a habitat for crustacean species. Sand mining was observed in Veerasagara *Kere* and K. Gollahalli *Kere* (Figure-7.32 and Table-7.7). Due to increased constructional and industrial activities, demand for sand is growing.

Figure-7.32. Sand mining in Kumbalagodu Gollahalli *Kere*

7.4.3.4. Sand Washing:

Sand washing is a mechanical process to remove silt and clay from sand using water. For this purpose a traditional soil washing pit is constructed in the lake land with sand entrap as part of the sand mining/harvesting technique and washed with water using mechanical pump. This practice results in the increase of turbidity and siltation in the lake to alarming levels and becomes a threat to aquatic organisms, even leading to killing of fish. Sand washing in Vaderahalli Govt lake and Kumbalagodu Gollahalli kere was documented (Table-7.7).

7.4.3.5. Stone Quarry:

The activity involves excavation of siliceous dimensional stone (granite) through drilling, blasting and also to supply the raw materials to the stone crushers. Due to quarrying, heavy silt accumulates in the lake causing high turbidity of water through the settlement of fine sediment, which is a by-product. When an undisturbed hill is present adjacent to the water bodies the hill adds to the surface area of the catchment. The rain falling on the hill conveyed to the water bodies present in the lower land through runoff. But when the same hill is destroyed by the quarry activity, the rain fall is collected in the deep quarry pits itself depriving the low lying water bodies of any water. Quarry in Yarappanahalli *Kere*-2 (Figure-7.33) is documented. In Marenahalli *Kere*, the rain water collected in the quarry was pumped back into lake.

Figure-7.33. Quarry inside the Yarappanahalli *Kere*- 2

7.4.3.6. Religious Activity:

7.4.3.6a. Idol Immersion:

It is one of the religious activities where the idols of Ganesha and Gowri are immersed in the lakes during the festivals of 'Vinayaka chathurthi' and 'Durga puja'. For these activities, most of the lakes have the constructed 'Idol Immersion Tank' or 'Kalyani', to stop the impact of idol immersion all over the water bodies. The Idol immersion in the Sadaramangala lake, Vijinapura *Kere*-2, Basavanapura *Kere*, Bhimmanakuppe Govt. lake, Ramagondanahalli *Kere*, Byrasandra Melina *Kere* and Beguru lake-1 (Figure-7.34 and Table-7.7) was documented. The idols have toxic metals like lead and chromium, harm the aquatic life by increasing the acid content and TDS of water.

7.4.3.6b. Organic Waste:

Water has an important place in the practices and beliefs of many religions. Not only during idol immersion but during many occasions, puja is performed near the water bodies. During performing puja offerings are made such as flowers, fruits, coconuts, cloth, incense, camphor, etc. to the water bodies. These offerings being organic in nature degrade and results in nutrient enrichment ultimately leading to eutrophication of water bodies. In about 19 water bodies such religious activity was observed (Figure-7.35 and Table-7.7).

Figure-7.34. Idol immersion waste piled up in Begur lake-1

Figure-7.35. Organic waste in Bingipura *Kunte*-1

7.4.3.7. Washing Activities:

Washing activities involving washing of vehicle, clothes, vegetables, animal bathing and bathing/swimming was documented in 56 water bodies in the study area. Sources of water also get polluted when they are used for bathing animals, washing clothes and washing self after defecation. Pollution in water bodies caused by various washing activities are as follows:

7.4.3.7a. Vehicle Washing:

Washing of vehicles in the water bodies contributes to a number of organic pollutants into the water bodies like Polycyclic Aromatic Hydrocarbon (PAH), dirt, grime, grease, oily dirt (asphalt and vehicle exhaust particles), hydraulic oils, surfactants, and corrosion. Vehicle washing is in 16% of water bodies and poses threat to the fishes and degrade the water quality (Figure-7.36).

7.4.3.7b. Washing Cloths:

Washing of house hold cloths is not of big concern but the lakes are already in the state of deterioration. Washing of huge amount of clothes by the dhobis has detrimental effect on the water bodies. In 30% of water bodies, washing of cloths was documented (Figure-7.37). The phosphates in detergents leads to enrichment of water bodies while the detergents itself have detrimental effect on fishes.

Figure-7.36. Washing auto in Bilwaradahalli *kere*

Figure-7.37. Washing clothes in Madiwala *Kere*

7.4.3.7c. Animal Bathing:

Bathing of domestic animals in water bodies leads to microbial pollution, the outbreak of water borne zoonosis. Bacteria like *Campylobacter jejuni*, *E. coli*, *Salmonella* sp. and *Yersinia* sp. often shed by apparently healthy animals that are capable of causing severe disease in humans. Zoonotic protozoa like microsporidia, the amoeba *Entamoeba histolytica*, *Giardia duodenalis*, *G. lamblia*, *Toxoplasma gondii*, and *Cryptosporodium* sp. also responsible for causing disease in humans. In 39% of water bodies the buffalo, ox, cow (Figure-7.38) were given bath.

7.4.3.7d. Bathing:

The soaps and shampoos used during bathing has adversely influence the water quality of lentic water bodies for limited time. But the mass bathing, during religious rituals or as recreational activity may lead to faster eutrophication of water bodies and also outbreak of pathogenic diseases. In 13% of water bodies bathing activity was documented (Figure-7.39).

Figure-7.38. Bathing cow in Chikkanekkundi *Kere*

Figure-7.39. Bathing in Rayasandra *Kere*

7.4.3.7e. Vegetable washing:

It is been a common practice of washing the vegetables in the water bodies especially the root vegetables such as carrots, radish, beet root and the roots of leafy vegetables to remove the soil. Washing of vegetable in unhealthy water bodies or deteriorating water bodies leads to contamination of vegetables with harmful bacteria. Washing of radish in Huskur Govt. Lake was documented (Figure-7.40).

Figure-7.40. Vegetable washing in Huskur *Kere*

7.4.3.8. Weeds:

Aquatic weeds are unwanted plants, growing in water. About 140 weeds are recorded in India. They are nuisance in lakes as they provide breeding sites for the mosquitoes, hold debris and hastens sedimentation, they are also invasive, grow robustly on availability of high nutrition hindering the aerobic functioning of the lake. Weeds cover the surface of water bodies, there by restricting sunlight penetration shading out any submerged plant life and also affecting algal photosynthesis. This results in anoxic environment due to blockage of air-water interface, influencing oxygen diffusivity. The reduction in Dissolved oxygen (0 mg/l) impacts the viability of aquatic biota and result in the disappearance of biodiversity. Also, the lake manifested with the weeds has lower aesthetic appeal. In 683 existing water bodies, 79% had partially growing weeds, 10% water bodies were almost completely covered in weeds, while 11% had negligible weeds (Figure-7.41). The aquatic weeds documented are as follows:

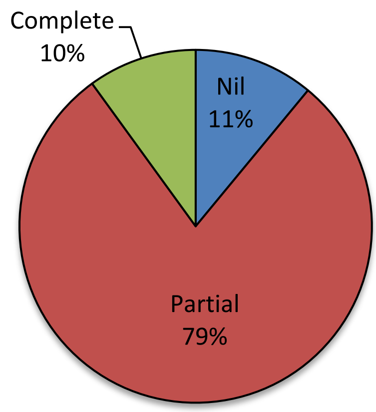


Figure-7.41. Percentage of weeds in water bodies

i. ***Eichhornia crassipes***: It is popularly known as 'water hyacinth' and is free floating. It is one of the most serious weed found in India. It is also an indicator of sewage infestation of water bodies (Figure-7.42).

ii. ***Ipomea carnea***: Also called 'Besharam' or 'Morning glory' or in *Kannada* language as 'Ganeshna kadi'. It is an emergent invasive weed introduced in India as green manure crop only a few decades ago. It is left almost untouched by the cattle due to its toxic effects, turns into a typical pasture weed (Figure-7.43).

Figure-7.42. Water hyacinth in Rayasandra *Kere*

Figure-7.43. *Ipomea carnea* in Bannerughatta Kempanayana *Kere*

iii. ***Salvinia sp.***: Salvinia is a free-floating fern that forms dense mats on water (Figure-7.44). Salvinia is an aquatic weed that can choke waterways. It floats on still or slow-moving water and can grow rapidly to cover the entire water surface with a thick mat of vegetation, making the water unsuitable for fish and other animals. Salvinia infestations reduce the natural beauty and biodiversity of wetlands.

iv. ***Pistia stratiotes*** **(**Water lettuce**)**: It is a free-floating aquatic with feathery roots. *Pistia stratiotes* has the ability to crowd out native aquatic plants, as well as to make infested water bodies inhospitable to different animals. It also impedes recreational activities such as boating and swimming (Figure-7.45).

Figure-7.44. Salvinia in Puttenahalli *Kere* (Uttarahalli)

Figure-7.45. *Pistia stratiotes* in Ullalu *Kere*

Other weeds documented in the water bodies are *Cyperus rotundus, Lemna minor, Typha latifolia* and *Alternanthera* spp. (Alligator weed). Also, terrestrial weeds such as

Parthenium sp., *Lantana camara*, *Eupatorium odoratum* were documented in the fringes, in the dry and silted regions of the water bodies.

7.4.3.9. Chemical fishing:

Usage of chemicals to catch the fish was documented in the Krishnasagara *Kere* (Figure-7.46).

Figure-7.46. Usage of chemical for fishing in Krishnasagara *Kere*

7.5. Grading and Prioritization of Lakes:

BMA lakes are rated by positive weightage and negative impacts based on the presence of pollutants in the lakes (Table-7.9). Subsequently, the lakes are assigned grades based on the estimation of Environmental Impact Unit (EIU) on basis of 22 parameters and are categorised by five colours such as black, red, yellow, green and blue. The black alert lakes have EIU value of below 0, red alert lakes have EIU value 1 to 8, yellow alert lakes have EIU value 9 to 17, green alert lakes have EIU value 18 to 26, and blue alert lakes have EIU value above 27, respectively.

In the BMA, about 8% of lakes need revival (black alert lakes), 46% of lakes need immediate action (red alert lakes), 39% of lakes need conservation (yellow alert lakes), 6% of lakes need action to mitigate pollution (green alert lakes) and 1% of lakes needs preservation in future from pollution and other issues (blue alert lakes). The prioritisation pie chart for the lakes in BMA is plotted in the Figure-7.47.

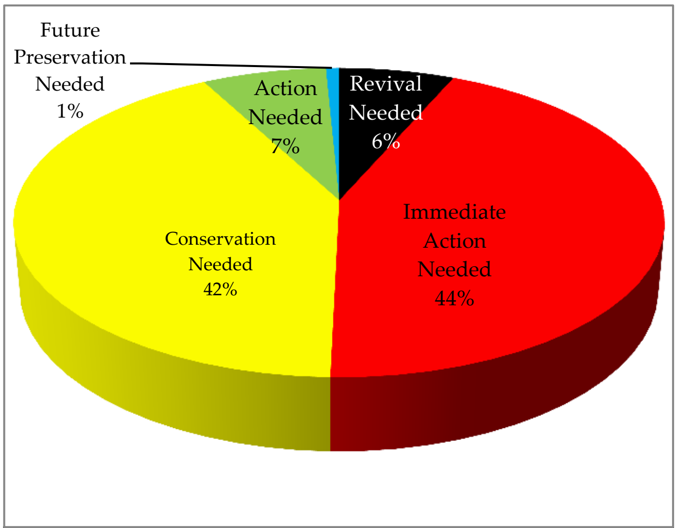


Figure-7.47. Prioritization of BMA lakes for conservation

7.5.1. Black alert lakes (Immediate Revival needed):

These 26 lakes (Table-7.10) are under deteriorated conditions due to pollution caused by dumping of solid waste including bio-medical waste, sewage discharge and encroachment. These lakes require effective revival action and protection.

7.5.2. Red alert lakes (Immediate action needed):

Majority of the lakes, 173 (46%) in the BMA (Table-7.11) are falling in the red alert that requires immediate action. lakes under this category are under deterioration due to pollution issues and encroachment. About 12 lakes among the red alert have EIU value of 1 and are under severe deterioration condition and require immediate action. While, lakes such as Thirumenahalli lake, Veerasagara *Kere* and Venkateshapura lake are even though rejuvenated and seasonal, yet face the problem of sewage entry or dumping of solid waste. Hence, mitigation of pollution due to the dumping of liquid waste and solid waste into these lakes has to be stopped immediately to enhance the water quality and augment the existing biodiversity.

7.5.3. Yellow alert lakes (Conservation needed):

About 165 (39%) of lakes are moderately polluted and require restoration followed by conservation (Table-7.12). Pollutions in these lakes are due to waste dumping and discharge of sewage. Abatement of these pollution entering the lake and regular maintenance is need of the hour.

7.5.4. Green alert lakes (Action needed):

Jakkur lake has the highest EIU value in the green category with 25 EIU followed by Ulsoor lake and Lalbhagh lake with 23 EIU (Table-7.13). Jakkur lake has STP at the inlet where the water gets treated and before entering the lakes is again passed through the wetland. These lakes are moderate with rich biodiversity. Out of 28 lakes, 9 lakes under these categories such as Jakkur lake, Hebbal lake, Yelahanka lake, etc. have an area more than 100 acres while 43% of the lakes are rejuvenated. The action is required to mitigate and abate pollution and encroachment present and conserve the lakes for future.

7.5.5. Blue alert lakes (Future preservation needed):

Only three lakes namely Nagawara lake and Gattihalli Govt. lake (Table-7.14) are coming under this category. Nagawara lake is rejuvenated and leased to M/s Lumbini gardens and the water front is converted to an amusement park. The sewage drain is diverted in this lake and at the inlet, the wetland is maintained. Similarly, pollution level and encroachment is very less in the Gattihalli Govt. lake. But, these lakes need to be preserved along with long-term conservational strategies in order to safeguard them from any sort of pollution or encroachment presently and in the coming years.

Conclusion:

Water bodies irrespective of their size - *Kere*, *Kunte* or *Katte* are very crucial for sustainability of life on earth. From the analysis of the crucial issues documented from the field, it is found that various pollution levels are existing in 45% of water bodies. Dumping of garbage waste and construction and demolition debris were the major direct source pollutants in the water bodies. Similarly, the inflow of sewage into the water bodies was the major non-direct source pollutant. Irrespective of pollution rate, the lakes are under continuous threat of being encroached for various purposes. Major encroachments were done by the public Departments to provide the infrastructure to the public. Astonishingly, about 55% of water bodies are disused. The main reason is the persistent changing land use pattern in the catchment area. The destruction of catchment area has led to decrease in the water retention capacity and increased silting. Ultimately, the silted water bodies due to lack of maintenance attracts the dumping of construction debris, garbage waste and encroachment leading to losing its identity and function. The grading and prioritisation of BMA lakes have reaveled that 26 lakes were hugely polluted and needed immediate revival, whereas 173 lakes are higly polluted and should be considered for the conservation on priority basis.

Hence, in order to address the problems the urban water bodies are facing, a holistic approach involving strict prohibition on the polluters and encroachers are needed. Continuous monitoring and maintenance of the water bodies irrespective of the size by involving the stakeholders and the public is required. Rejuvenation and maintenance of water bodies based on the services delivered or depending on various uses of water bodies is required i.e. If a water body is rich in bird diversity then the lake should be rejuvenated and maintained such that there is minimal public interference so that the birds can breed.

Table-7.1. Details of Parameter Importance Unit (PIU) in modified Battelle method (Dee *et al.*, 1973)

Categories	Components	Parameters	Sub classification	Description	Parameter Importance Unit (PIU)	Remarks
Aesthetics *(Max. PIU= +20/ -10)*	Extent *(Max. PIU= +10)*	1. Size *(Max. PIU= +10)*	Small	3 Acres	3	*Modified EMPRI classification* (Used for SoER) is used for sub classification of parameter and it's PIU is given on basis of lake size
			Medium	3.01 – 4 Acres	4	
				4.01 – 5 Acres	5	
			Large	5.01 – 10 Acres	6	
				10.01 – 20 Acres	7	
			Biggest	20.01 – 50 Acres	8	
				50.01 – 75 Acres	9	
			Very large	Above 75 Acres	10	
	Water Holding Period *(Max. PIU= +10)*	2. Water Retention *(Max. PIU= +10)*	Intermittent	1 Month	1	*CLC classification:* Water retaining parameter is sub-classified on the basis of ground truth/ public query and its PIU is given on basis of water holding period (month)
				2 Months	2	
			Ephemeral	3 Months	3	
				4 Months	4	
			Seasonal	5 Months	5	
				6 Months	6	
			Perennial	7 Months	7	
				8 Months	8	
				9 Months	9	
				Above 9 Months	10	
	Land *(Max. PIU= -10)*	3. Encroachment *(Max. PIU= -10)*	Very Small Area	Up to 9.9%	-2	*CLC classification:* Land encroachment parameter is sub-classified on basis of ground truth/ public query and its PIU is given on basis of its adverse impact on lakes
			Small Area	10 to 19.9%	-4	
			Large Area	20-39.9%	-6	
			Largest Area	40-59.9%	-8	
			Huge Area	Above 60%	-10	
Economy	Socio-Economic	4. Lake Usage *(Max.*	-	Bathing	1	*CLC classification:* PIU is

Categories	Components	Parameters	Sub classification	Description	Parameter Importance Unit (PIU)	Remarks
(Max. PIU= +13)	*(Max. PIU=+13)*	*PIU= +13)*	-	Washing	1	given on the basis of lake usage
			-	Cattle Feeding	1	
			-	Fishing	2	
			-	Irrigation	1	
			-	Recreational activity	1	
			-	Religious activity	1	
			-	Groundwater recharge	1	
			-	Drinking	4	
Ecology *(Max. PIU= +17/ -7)*	Habitats and Communities *(Max. PIU= +10)*	5. Biodiversity *(Max. PIU= +10)*	Fishes	Pelagic & Benthic	2	*CLC classification:* Biodiversity parameter is sub-classified on the basis of ground truth and PIU is given on basis of their hierarchy
			Amphibians	-	1	
			Reptiles	-	0.5	
			Benthos	Molluscan, Shells	1	
			Butterflies	-	1	
			Dragonflies	-	1	
			Aquatic birds	-	1	
			Aquatic insects	-	0.5	
			Aquatic plants	-	1	
			Littoral plants	-	1	
	Quality *(Max. PIU= +7/ -7)*	6. Water Quality	Class-A		4	Based on the result of water quality analysis and classification done as per the CPCB guidelines
			Class-B		2	
			Class-C		1	
			Dry		0	
			Class-D		-1	
			Class-E		-2	
			Below Class-E		-4	

Categories	Components	Parameters	Sub classification	Description	Parameter Importance Unit (PIU)	Remarks
Pollution *(-1.0)*	Point-Source (Direct/ Dumping) *(Max. PIU=-22.0)*	7. Agriculture wastes	-	-	-2	*CLC classification:* Parameters are selected on the basis of ground truth and it's PIU is given on the basis of adverse impacts
		8. Construction & demolition debris	-	-	-2	
		9. Domestic garbage	-	-	-4	
		10. Bio-medical wastes	-	-	-6	
		11. Industrial wastes	-	-	-6	
		12. Organic waste	-	-	-1	
		13. Defecation in lake land	-	-	-1	
	Point-Source (Indirect) *(Max. PIU=-10.0)*	14. Domestic sewage	-	-	-4	
		15. Industrial Effluent	-	-	-6	
	Non-Point Source (Runoff) *(Max. PIU=-3.0)*	16. Agriculture Runoff	-	-	-1	
		17. Road & Urban Runoff	-	-	-2	
Others	Issues *(Max. PIU=-10.0)*	18. Soil excavation	-	-	-2	*CLC classification*: Parameters are selected on basis of ground truth and its PIU is given on basis of adverse impacts
		19. Sand washing	-	-	-2	
		20. Washing	-	Vehicles, cloth	-3	
		21. Religious practice	-	Idol immersion	-2	
		22. Weed infestation	-	Aquatic weeds	-1	

Negative Impact

Table-7.2. Modified details of CLC modified Battelle method

SI. No.	Modification of	Battelle Method	CLC Modified Battelle Method
1.	Categories	Ecology, Pollution, Aesthetics & Human interest	Aesthetics, Economy, Ecology, Pollution & Others
2.	Components	18	Only 10
3.		Consider surrounding area	Focus on lakes only
4.	Parameters	78	Only 22
5.		Specific	Broad
6.		1000	Unit value is not fixed
7.	PIU value	Unit is fixed on basis of parameter	Unit value is given on basis of expertise discussion as Thompson Significance Scaling technique
8.		Only beneficiary points	Contain both beneficiary and also the adverse impact points
9.	EIU value	With project – Without project	Beneficiary – Adversary parameters
10.	Measurement	Project impact on Environment	Status of lakes
11.		Project impact is coded by colour on basis of % of EIU value	Conservation preferences of lake is coded by colour on basis of segregated EIU value

Table-7.3. Documented point source pollutant in and around the water bodies

Water body Name	Garbage	Agri. waste	C&D waste	BM waste	Poultry waste	Industrial waste						Defecation in lake land
						organic	Fibre	Ash	Granite & polish	Plastics	Brick	
Kajarakanahalli Lake	✓	✓	✓	-	-	-	-	-	-	-	-	-
Kempambudhi lake	✓	-	-	-	-	-	-	-	-	-	-	-
Abbigere Kere	✓	-	✓	-	✓	-	✓	-	-	-	-	✓
Bagalagunte Govt.Lake	✓	-	✓	-	✓	-	-	-	-	-	-	-
Chikkabanavara kere	✓	-	-	-	✓	-	-	-	✓	-	-	-
Chikkabanavara kunte-1	-	-	✓	-	-	-	-	-	-	-	-	-
Chokkasandra Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Doddabidarakallu lake	✓	-	-	-	-	-	-	-	-	-	-	-
Doddabidarakallu Kunte-4	✓	-	-	-	-	-	-	-	-	-	-	-
Doddabidarakallu Kunte-9	✓	-	✓	-	-	-	-	-	-	-	-	-
Ganigarahalli kere	✓	✓	-	✓	-	-	-	✓	-	-	✓	✓
Andhrahalli Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Herohalli Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Herohalli kunte 4	✓	-	✓	-	-	-	-	-	-	-	-	-
Herohalli Kunte- 6	✓	-	-	-	-	-	-	-	-	-	-	-
Kammagondanahalli lake	-	-	✓	-	-	-	-	-	-	-	-	-
Kannalli kere	✓	✓	✓	-	-	-	✓	-	-	-	-	-
Kannalli Katte-1	✓	-	✓	-	-	-	-	-	-	-	-	-
Parvatana katte	-	-	✓	-	-	-	-	-	-	-	-	-
Kannalli Katte-2	-	-	✓	-	-	-	-	-	-	-	-	-
Ajjegowdana katte	✓	-	✓	-	-	-	-	-	-	-	-	-
Laggeri Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Lakshmipura kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Mallasandra Lake-1	✓	-	-	-	-	-	-	-	-	-	-	✓
Mallasandra Lake-2	✓	-	✓	-	✓	-	-	-	-	-	-	-
Mallathahalli Lake	✓	-	✓	-	✓	-	-	-	-	-	-	-
Badakukere	-	-	✓	-	-	-	-	-	-	-	-	-
Nelagadiranahalli Lake	✓	-	-	-	-	-	-	-	-	-	-	-

Seegehalli kere	-	-	-	-	-	-	-	-	-	✓	-	✓
Srigandhakavalu Karabu Katte	✓	-	✓	-	-	-	-	-	-	-	-	-
Ullalu lake-2	✓	-	✓	-	-	-	-	-	-	-	-	-
Amruthahalli Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Atturu kere	✓	-	-	-	-	-	-	-	-	-	-	-
Chikkabettahalli katte- 1	✓	-	-	-	-	-	-	-	-	-	-	-
Chokkanahalli Katte	✓	-	-	-	-	-	-	-	-	-	-	-
Gantiganahalli Kunte-2	-	-	✓	-	-	-	-	-	-	-	-	-
Gantiganahalli Kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Honnenahalli Govt Kere	✓	✓	✓	-	-	-	-	-	-	-	✓	-
Kasaba Amanikere	-	-	✓	-	-	-	-	-	-	-	-	-
Kodigehalli Kunte-3	✓	-	✓	-	-	-	-	-	-	-	-	-
Kogilu kere	✓	-	-	-	-	-	-	-	-	-	-	-
Krishnasagara Kere	-	✓	✓	-	-	-	-	-	-	-	-	-
Lakshmisagara Kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Medi Agrahara Kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Thupinkere	✓	-	✓	-	-	-	-	-	-	-	-	-
Nagadasanahalli Kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Puttenahalli Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Ramagondanahalli kere	-	-	✓	-	-	-	-	-	-	-	-	-
Singanayakanahalli katte- 2	✓	-	✓	-	-	-	-	-	-	-	-	-
Singanayakayahalli Govt Gokatte	✓	-	✓	-	-	-	-	-	-	-	-	-
Shivanahalli lake	-	-	✓	-	-	-	-	-	-	-	-	-
Srinivasapura lake	-	-	✓	-	-	-	-	-	-	-	-	-
Thirumenahalli lake	✓	-	-	-	-	-	-	-	-	-	-	-
Vaderahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Veerasagara kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Venkateshapura lake	✓	-	-	-	-	-	-	-	-	-	-	-
Bettahalsur kere	✓	-	-	-	-	-	-	-	-	-	-	-
Jomala kunte	-	-	✓	-	-	-	-	-	-	-	-	-
Chagalatti kunte 2	-	-	✓	-	-	-	-	-	-	-	-	-

Chagalatti kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Dasanayakana halli kunte	✓	-	-	-	-	-	-	-	-	-	-	✓
Dasanayakanahalli Doddukunte	-	-	✓	-	-	-	-	-	-	-	-	-
Kodatti Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Hunasemaranahalli kere	-	-	✓	-	-	-	-	-	-	-	-	-
Kattigenahalli lake	-	-	✓	-	-	-	-	-	-	-	-	-
Kattigenahalli karabu lake	✓	-	-	-	-	-	-	-	-	-	-	-
Marenahalli Chokkanahalli kunte	✓	-	-	-	-	-	-	-	-	-	-	-
Marenahalli kunte 3	✓	-	-	-	-	-	-	-	-	-	-	-
Marenahalli kere	-	-	✓	-	-	-	-	-	-	-	-	-
Sathanur karabu 4	✓	✓	✓	-	-	-	-	-	-	-	-	✓
Sathanoor kunte 6	✓	-	-	-	-	-	-	-	-	-	-	-
Suggata kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Thimmasandra kunte	-	-	-	-	✓	-	-	-	-	-	-	-
Anurah katte	-	-	✓	-	-	-	-	-	-	-	-	-
Bilijaji kere	✓	-	-	-	-	-	-	-	-	-	-	-
Byalakere Kere	✓	✓	-	-	-	-	-	-	-	-	-	-
Byalakere Govt Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Guniagrahara Kere 1	✓	-	✓	-	-	-	-	-	-	-	-	-
Ivarakandapura Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Ittagalapura lake 2	✓	-	-	-	-	-	-	-	-	-	-	-
Ittagalapura lake 3	-	-	✓	-	-	-	-	-	-	-	-	-
Kalenahalli Kere	-	✓	✓	-	-	-	-	-	-	-	-	-
Kasagattapura Kere 2	✓	-	-	-	-	-	-	-	-	-	-	-
Kasagattapura Kere 3	✓	-	-	✓	-	-	-	-	-	-	-	-
Kondashettihalli Kunte	✓	✓	-	-	-	-	-	-	-	-	-	-
Kumbarahalli Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Lingarajapura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Lingarajasagara Kunte 1	✓	-	-	-	-	-	-	-	-	-	-	-
Lingarajasagara Kunte 2	✓	✓	-	-	-	-	-	-	-	-	-	-
Mavallipura Karabu Lake	✓	✓	-	-	-	-	-	-	-	-	-	-

Mavallipura Kere 3	-	-	-	-	-	-	-	✓	-	-	✓	-
Mylappanahalli kere 1	-	-	-	-	-	-	-	-	-	-	✓	-
Mylappanahalli Kere 2	✓	-	-	-	✓	-	-	-	-	-	✓	-
Kallakatte	✓	-	-	-	-	-	-	-	-	-	-	-
Rajanakunte-9	✓	-	-	-	-	-	-	-	-	-	-	-
Earannana Kunte	✓	-	-	-	-	-	-	-	-	-	-	-
Adikamaranahalli Kunte	-	-	-	-	-	-	-	✓	-	-	-	-
Alur katte	✓	-	✓	-	-	-	-	-	-	-	-	-
Byandahalli Kunte1	✓	-	-	-	-	-	-	-	-	-	-	-
Dasanapura kunte-2	✓	-	-	-	-	-	-	-	-	-	-	-
Shanthi Nagar kunte	✓	-	-	-	-	-	-	-	-	-	-	-
Hanumanthasagara Kunte	-	✓	-	-	-	-	-	-	-	-	-	-
Hanumanthasagara Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Harokyathanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Heggadaevanapura kere-1	✓	-	✓	-	-	-	-	-	-	-	-	-
Kachohalli Kere-1	✓	-	-	-	✓	-	-	-	-	-	-	-
Kachohalli Kere-2	-	-	✓	-	-	-	-	-	-	-	-	-
Kuduregere kere	✓	✓	-	-	-	-	-	✓	-	-	-	-
Lakshmipura Kere	✓	✓	✓	-	✓	-	-	-	-	-	-	-
Torenagasandra urkunte	-	✓	-	-	-	-	-	-	-	-	-	-
Thotadaguddadahalli kunte1	-	✓	-	-	-	-	-	-	-	-	-	-
Thotadaguddadahalli kunte2	-	-	-	-	-	-	-	-	-	✓	-	-
Ambalipura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Balagere kunte2	✓	-	✓	-	-	-	-	-	-	-	-	✓
Bellandur Amanikere	✓	✓	✓	-	-	-	-	-	-	-	-	✓
Varthur Amanikere	✓	-	✓	-	-	-	-	-	-	-	-	-
Bhoganahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Chikkabellanduru kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Chikkanayakanahalli kunte2	-	-	✓	-	-	-	-	-	-	-	-	-

Chikkanayakanahalli kunte4	✓	-	-	-	-	-	-	-	-	-	-	-
Devarabisanahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Bellandure Gramadakere	✓	-	-	-	-	-	-	-	-	-	-	-
Gunjuru kunte2	-	-	✓	-	-	-	-	-	-	-	-	-
Gunjur Kere-1	✓	-	✓	-	-	-	-	-	-	-	-	-
Gunjuruplaya kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Gunjur Kelaginakere	✓	-	✓	-	-	-	-	-	-	-	-	-
Halanayakanahalli kere1	✓	-	✓	-	-	-	-	-	-	-	-	-
Haraluru kere	✓	-	-	-	-	-	-	-	-	-	-	-
Junnasandra Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kachamaranahalli Govt. Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Kachamaranahalli kunte 6	-	-	-	-	-	-	-	-	-	-	-	✓
Kaikondanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kasavanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kodathi kunte 1	-	-	-	-	-	-	-	-	-	-	-	✓
Kodathi Kunte 11	-	-	✓	-	-	-	-	-	-	-	-	-
Kodathi Kunte 12	✓	-	-	-	-	-	-	-	-	-	-	✓
Mulluru kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Munekolalu kere	-	-	-	-	-	-	-	-	-	-	-	-
Panthuru kunte 2	✓	-	-	-	-	-	-	-	-	-	-	-
Panatthur kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Panthuru kunte 4	✓	-	✓	-	-	-	-	-	-	-	-	✓
Panattur Govt. Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Hadosiddapura kunte	-	-	-	-	-	-	-	-	-	-	-	✓
Siddapura Kunte 6	✓	-	✓	-	-	-	-	-	-	-	-	✓
Siddapura kere	-	-	✓	-	-	-	-	-	-	-	-	-
Sorahunase kunte 1	-	-	✓	-	-	-	-	-	-	-	-	✓
Otikere	-	-	✓	-	-	-	-	-	-	-	-	-
Varthuru kunte 1	✓	-	-	-	-	-	-	-	-	-	-	-
Varthuru kunte 7	-	-	-	-	-	-	-	-	-	-	-	✓
Basavanapura kere	✓	✓	✓	-	-	-	-	-	-	-	-	-

Benniganahalli Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Byappanahalli kunte1	✓	-	✓	-	-	-	-	-	-	-	-	-
B.Narayanapura kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Byrasandra kere1	✓	-	✓	-	-	-	-	-	-	-	-	-
Byrasandra kunte	✓	-	✓	-	-	-	-	-	-	-	-	-
Byrasandra Melinakere	✓	-	-	-	-	-	-	-	-	-	-	-
Chellakere kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Dyavasandra kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Doddanekundi kere 2	✓	-	✓	-	-	-	-	-	-	-	-	-
Hoodi kere	✓	-	-	-	-	-	-	-	-	-	-	-
Giddanakere	✓	-	-	-	-	-	-	-	-	-	-	-
Horamavu kere	✓	-	-	-	-	-	-	-	-	-	-	-
Gramadakere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Kaggadasapura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kowdenahalli Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Vijinapura kere2	✓	-	-	-	-	-	-	-	-	-	-	-
Vengaiahanakere	✓	-	✓	-	-	-	-	-	-	-	-	-
Krishnaraja puram kere-1	✓	-	-	-	-	-	-	-	-	-	-	-
Kundalahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Garudacharplayakere	✓	-	-	-	-	-	-	-	-	-	-	-
Garudacharya palya lake (Goshala)	✓	-	✓	-	-	-	-	-	-	-	-	-
Mahadevapura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Bande Mahadevapura kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Nagareshvara Nagenahalli Kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Nallurahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Nallurahallin kunte1	✓	-	✓	-	-	-	-	-	-	-	-	✓
Pattaduru Agrahara kere-1	✓	-	✓	-	-	-	-	-	-	-	-	-
Pattandur Agrahara kunte 11	✓	✓	✓	-	-	-	-	-	-	-	-	-
Rachenahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Shegehalli kere	✓	-	-	-	-	-	-	-	-	-	-	-

Sonnathimmanahalli kunte	✓	-	✓	-	-	-	-	-	-	-	-	-
Sonnenahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Vibhutipura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Whitefield kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Anagalapura kunte 2	-	-	✓	-	-	-	-	-	✓	-	-	-
Bhattarahalli kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Bidarahalli kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Bidarena agrahara kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Byappanahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Bhairathi Kunte 3	✓	✓	✓	-	-	-	-	-	-	-	-	-
Chimasandra Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Chikkabanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Chikkagubbi kere	✓	-	-	-	-	-	-	-	-	-	-	-
Doddagubbi kere	-	✓	-	-	-	-	-	-	-	-	-	-
Goravigere kunte2	✓	✓	✓	-	-	-	-	-	-	-	-	-
Goravigere kunte3	✓	-	-	-	-	-	-	-	-	-	-	-
Kada Agrahara kunte	✓	-	-	-	-	-	-	-	-	-	-	-
Khajisonnenahalli Kunte 4	✓	-	-	-	-	-	-	-	-	-	-	-
Khajisonnenahalli Kunte 1	✓	-	-	-	-	-	-	-	-	-	-	-
Khajisonnenahalli Kunte 10	-	-	-	-	-	✓	-	-	-	-	-	-
Kannamangala kere	✓	✓	-	-	-	-	-	-	-	-	-	-
Katamnalluru Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kithaganuru Kere	✓	✓	✓	-	-	-	-	-	-	-	-	-
Konadasapura kere	-	-	✓	-	-	-	-	-	-	-	-	-
Kumbena agrahara Kunte	✓	-	✓	-	-	-	-	-	-	-	-	-
Medihalli Kunte 4	✓	✓	✓	-	-	-	-	-	-	-	-	-
Seegihalli kunte 1	✓	-	✓	-	-	-	-	-	-	-	-	-
Seegihalli katte 1	✓	-	-	-	-	-	-	-	-	-	-	-
JinkeTimmasandra Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Yellamallappashetti Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Yarappanahalli Kere 1	-	✓	✓	-	-	-	-	-	-	-	-	-
Avalahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Govt. Gulimangalada lake	-	-	✓	-	-	-	-	-	-	-	-	-

Chikkanagamangala Govt. Kere	-	-	✓	-	-	-	-	-	-	-	-	-
Chikkanekundi Lake land	✓	✓	-	-	-	-	-	-	-	-	-	-
Chikkavaderapura Govt. Kunte-2	-	-	✓	-	-	-	-	-	-	-	-	-
Chokkasandra lake-1	✓	-	-	-	-	-	-	-	-	-	-	-
Govt. Vaddakere-2	✓	-	✓	-	-	-	-	-	-	-	-	-
Choodasandra Govt Lake-3	✓	-	✓	-	-	-	-	-	-	-	-	-
Dommasandra Govt Lake-1	✓	-	-	-	-	-	-	-	-	-	-	-
Dommasandra Kunte-7	✓	-	-	-	-	-	-	-	-	-	-	-
Dommasandra Govt. Lake 2	✓	-	✓	-	-	-	-	-	-	-	-	-
Gattihalli Govt. lake	-	-	✓	-	-	-	-	-	-	-	-	-
Halasahalli Thippasandra Kunte-2	-	-	✓	-	-	-	-	-	-	-	-	-
Halasahalli Thippasandra Kunte-3	-	-	✓	-	-	-	-	-	-	-	-	-
Tippasandra lake	✓	✓	✓	-	-	-	-	✓	-	-	-	-
Harohalli Govt lake	✓	✓	✓	-	-	-	-	-	-	-	-	-
Heggondahalli Kunte-1	-	✓	-	-	-	-	-	-	-	-	-	-
Heggondahalli Govt. lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Hosahalli Govt. lake	✓	-	-	-	-	-	-	-	-	-	-	-
Hosahalli Kunte-6	-	-	✓	-	-	-	-	-	-	-	-	-
Madhagar Kunte	-	✓	-	-	-	-	-	-	-	-	-	-
Huskuru Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kada Agrahara Kere	-	-	✓	-	-	-	-	-	-	-	-	-
Kagalipura Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Kommasandra Kunte-1	✓	✓	-	-	-	-	-	-	-	-	-	-
Rocherenvu	-	-	✓	-	-	-	-	-	-	-	-	-
Kommasandra Kunte-4	-	-	✓	-	-	-	-	-	-	-	-	-
Kommasandra Kunte-5	-	-	✓	-	-	-	-	-	✓	-	-	-
Kathriguppe Kunte-1	-	-	✓	-	-	-	-	-	-	-	-	-
Kodlu lake-1	-	-	✓	-	-	-	-	-	-	-	-	-
Kodlu Kere-2	✓	-	-	-	-	-	-	-	-	-	-	-

Ramanayakanahalli Govt. Kere-2	✓	✓	-	-	-	-	-	-	-	-	-	-
Rayasandra Kunte-2	✓	-	✓	-	-	-	-	-	-	-	-	-
Rayasandra Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Tigalara Chowddenahalli Govt. Karabukere	✓	-	✓	-	-	-	-	-	-	-	✓	-
Gollahalli Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Uramundinakere	✓	-	✓	-	✓	-	-	-	-	-	-	-
Hebbagodi Govt. Attikere	✓	-	✓	-	-	-	-	-	-	-	-	-
Veerasandra Govt. Kere-1	✓	-	✓	-	-	-	-	-	-	-	-	-
Veerasandra Govt. Kere-2	✓	-	✓	-	-	-	-	-	-	-	-	-
Bhujangadasana Amanikere Govt lake	-	✓	✓	-	-	-	-	-	-	-	-	-
Bannerughatta kunte1	-	✓	-	-	-	-	-	-	-	-	-	-
Kumbarakere	-	-	✓	-	-	-	-	-	-	-	-	-
Bannerughatta Kunte 2	-	-	✓	-	-	-	-	-	-	-	-	-
Bhutanahlli lake	-	-	-	-	-	-	-	-	-	-	-	✓
Byatarayanadoddi kere	✓	✓	✓	-	-	-	-	-	-	-	-	✓
Bilwaradahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Bingipura lake	-	✓	-	-	-	-	-	-	-	-	-	-
Honnashetti kere	-	-	✓	-	-	-	-	-	-	-	-	-
Gollahalli lake	✓	-	-	-	-	-	-	-	-	-	-	-
Hulimangala Govt. kere	-	✓	✓	-	-	-	-	-	-	-	-	-
Hullahalli Kharab Kere	✓	✓	-	-	-	-	-	-	-	-	-	-
Matadakere	-	✓	-	-	-	-	-	-	-	-	-	-
Hullahalli Kunte2	-	-	✓	-	-	-	-	-	-	-	-	-
Govt. Kharabu Kattehonge kere	-	-	✓	-	-	-	-	-	-	-	-	-
Hullahalli Kere	-	-	-	-	-	-	-	-	-	-	-	✓
Kallakere lake land	✓	-	-	-	-	-	-	-	-	-	-	-
Lakshmipura lake	✓	✓	-	-	-	-	-	-	-	-	-	-
Maragondanahalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Nanjapura lake	-	✓	-	-	-	-	-	-	-	-	-	-

Nanjapura kunte	✓	-	-	-	-	-	-	-	-	-	-	-
Bidarekere lake land	-	-	✓	-	-	-	-	-	✓	-	-	✓
Sakalavara kunte	✓	-	✓	-	-	-	-	-	-	-	-	-
Vaderahalli Govt. lake	✓	-	-	-	-	-	-	-	-	-	-	-
Chanenahalli kunte 5	✓	-	-	-	-	-	-	-	-	-	-	✓
Hosa Kere	-	-	✓	-	-	-	-	-	-	-	-	-
Koluru Gururayanapura Kunte1	-	-	-	-	-	-	-	-	-	-	-	✓
Yelachaguppe karabu Katte	✓	-	-	-	-	-	-	-	-	-	-	-
Chinnammanakere	✓	-	✓	-	-	-	-	-	-	-	-	-
Hosakere - 2	-	-	✓	-	-	-	-	-	-	-	-	-
Kuppareddy kere	✓	-	✓	✓	-	-	✓	-	-	-	-	-
Bheemanakuppe kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Deevatigeramanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Devagere kere	-	✓	-	-	-	-	-	-	-	-	-	-
Doddabele kunte 2	✓	-	✓	-	-	-	-	-	-	-	-	✓
Bheemana katte	-	-	-	-	-	-	-	-	-	-	-	✓
Halagevaderahalli kere-2	✓	-	-	-	-	-	-	-	-	-	-	-
Kambhipura Govt. Karabu kere-1	✓	-	-	-	-	-	-	-	-	-	-	-
Kambipura kunte1	-	-	✓	-	-	-	-	-	-	-	-	✓
Kambhipura Govt. Karabu kere-2	✓	-	✓	-	-	-	-	-	-	-	-	-
Kanaminiki Govt. Katte	✓	-	-	-	-	-	-	-	-	-	-	-
Kanaminiki Govt. kere	✓	-	✓	-	-	-	✓	-	-	-	-	-
Kaniminike Kunte 4	✓	-	✓	-	-	-	-	-	-	-	-	-
Kaniminike Kunte 6	✓	-	✓	-	-	-	-	-	-	-	-	-
Kenchinahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Kenchanapura Govt. Lake	-	✓	-	-	-	-	-	-	-	-	-	-
Kasaba Kengeri kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Hosa Bairohalli	✓	-	✓	-	-	-	-	-	-	-	-	-
Mallammana katte	✓	-	-	-	-	-	-	-	-	-	-	-
K. Gollahalli kere	-	-	✓	-	-	-	-	-	-	-	-	-

Maligondanahalli Lake 1	✓	✓	✓	-	-	-	-	-	-	-	-	-
Maligondanahalli Lake 2	-	✓	✓	-	-	-	-	-	-	-	-	-
Muppatu Kavalu Sakari	✓	-	-	-	-	-	-	-	-	-	-	-
Nayandanahalli kere	✓	-	-	-	-	-	-	-	-	-	-	-
Chikkakere	✓	-	✓	-	-	-	-	-	-	-	-	-
Ramasandra Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Kallapanakatte kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Thimappanakere	✓	-	-	-	-	-	-	-	-	-	-	-
Ramohalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Valagerehalli kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Bandimatta Hosa kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Alahalli Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Arehalli Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Devarakere	✓	-	-	-	-	-	-	-	-	-	-	-
Byrasandra Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Chunchanaghatta Kere	✓	-	-	-	-	-	-	-	-	-	-	-
Doddakallasandra kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Subbedarana kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Gottigere Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Subarayanakere	✓	-	-	-	-	-	-	-	-	-	-	-
Gubbalal kere	✓	-	-	-	-	-	-	-	-	-	-	-
Hosakerehalli Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Goudanakere	✓	-	-	-	✓	-	-	-	-	-	-	-
Kembathahali kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Konanakunte kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Krishna Nagar kere	✓	-	-	-	-	-	-	-	-	-	-	-
Puttenahalli Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Sarrakki kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Gowdarakere	✓	-	-	-	-	-	-	-	-	-	-	✓
Thippasandra kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Thurahalli kunte	✓	-	✓	-	-	-	-	-	-	-	-	-
Subramhanyapura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Uttarahalli	✓	-	-	-	-	-	-	-	-	-	-	-

Manavarthekaval kunte 4												
Vajarahalli kunte 2	-	-	✓	-	-	-	-	-	-	-	-	-
Muniyappana katte	✓	-	-	-	-	-	-	-	-	-	-	-
Vasanthapura katte	✓	-	-	-	-	-	-	-	-	-	-	-
Janaradhan kere	✓	-	-	-	-	-	-	-	-	-	-	-
Annamma kere	✓	-	✓	-	✓	-	-	-	-	-	-	-
Arekere Govt. lake	✓	-	-	-	-	-	-	-	-	-	-	✓
Basapura Govt.lake	-	-	✓	-	-	-	-	-	-	-	-	-
Basavanapura Kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Chikkabegur kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Begur Lake1	-	-	✓	-	-	-	-	-	-	-	-	-
Subbedarana kere	-	-	-	-	-	-	-	-	-	-	-	✓
Nyanappanahalli Kere	-	-	✓	-	-	-	-	-	-	-	-	-
Beratena Agrahara Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Govt. Kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Doddatogur lake	✓	-	✓	-	-	-	-	-	-	-	-	✓
Doddatogur kunte 2	✓	-	-	-	-	-	-	-	-	-	-	-
Chikkatogur kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Doddanagamangala Kunte3	✓	-	-	-	-	-	-	-	-	-	-	-
Kythasandra Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Hongasandra Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Hulimavu Kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Ibbalur Govt. Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Kalena Agrahara Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Kammanahalli Govt. Lake	✓	-	-	-	-	-	-	-	-	-	-	✓
Kammanahalli Lake	✓	-	-	-	-	-	-	-	-	-	-	✓
Konappana Agrahara lake	✓	-	-	-	✓	-	-	-	-	-	-	✓
Koramangala kere 2	✓	-	✓	-	-	-	-	-	-	-	-	✓
Madivala Kere	✓	-	-	-	-	-	-	-	-	-	-	✓
Mylasandra Buddagana katte	-	-	✓	-	-	-	-	-	-	-	-	-
Mylasandra	✓	-	✓	-	-	-	-	-	-	-	-	-

Urumundinakere												
Mylasandra Illuvarajana Katte	✓	-	-	-	-	-	-	-	-	-	-	✓
Mylasandra Hosakere	✓	-	-	-	-	-	-	-	-	-	-	✓
Mylasandra Govt. Lake	-	-	-	-	-	-	-	-	-	-	-	✓
Naganathapura kere	✓	-	-	-	-	-	-	-	-	-	-	-
Naganathapura kunte1	✓	-	-	-	-	-	-	-	-	-	-	✓
Parapana Agahara Lake	✓	-	-	-	-	-	-	-	-	-	-	-
Parappana Agrahara kunte 5	-	-	-	-	-	-	-	-	-	-	-	✓
Kodagi Singasandra kere	✓	-	✓	-	-	-	-	-	-	-	-	✓
Agara kere	✓	-	✓	-	-	-	-	-	-	-	-	-
Vitasandra Govt. Lake	-	-	✓	-	-	-	-	-	-	-	-	-
Yellakunte Govt. Lake	✓	-	✓	-	-	-	-	-	-	-	-	-
Yelenahalli Lake	✓	-	✓	-	-	-	-	-	-	-	-	-

Note: - denotes absence of pollutant and ✓ denotes presence of pollutant

Table-7.4. Water Supply System in BBMP area

Present Supply from Cauvery source	1350 MLD
Present population served	8.5 Millions
Area of water supply served	570 sq. kms
House service connections	8.65 lakhs
Total length of water supply pipelines	8,746 kms
Pipe diameters' range	100 to 1800 mm
Number of Ground Level Reservoirs	57 (885 ML)
Number of Over Head Tanks	36 (33 ML)
Booster pumping stations	62 nos
Public taps providing free water	7,477 nos
Water tanker lorries	62 nos
Quantity of water supplied/month	42,200 ML
Average per capita consumption	65 L/day

Source: BWSSB (2017)

Table-7.5: Population and water supply requirements

Year	Population (Million)	Water Demand (MLD)	Water Demand (TMC)	Present supply & projected water supply		Shortfall in Demand	
				MLD	TMC	MLD	TMC
2011	8.499	1400	18.05	950	12.25	450	5.80
2021	10.581	2100	27.1	1450	26.7	650	0.4
2031	14.296	2900	37.39	2070	26.7	1450	10.69
2041	17.085	3400	43.84	2070	26.7	1950	17.14
2051	20.561	4100	52.86	2070	26.7	2650	26.16

Table-7.6 Inventorization of BWSSB Sewage Treatment Plants (STPs) in Bengaluru

Sl No	STP Location	STP installed capacity in MLD	Technology (UASB/ASP/OP/SBR/MBR/FAB etc)	Disposal (land, River, sea or any other)
STPs under Operation				
1	K & C Valley	248	Secondary-Activated Sludge Process	Koramangala Valley
2	Kadabeesanahalli	50	Secondary-Extended Aeration	Koramangala Valley
3	Rajacanal	40	Secondary-Extended Aeration	Hebbal
4	Hebbal	60	Secondary-Activated Sludge Process	Hebbal
5	Jakkur	10	Secondary –UASB + Extended Aeration	Hebbal
6	Yelahanka	10	Tertiary-Activated Sludge Process + filtration +Chlorination	Hebbal
7	Nagasandra	20	Secondary-Extended Aeration	Vrishabhavathi valley
8	Mailasandra	75	-	Vrishabhavathi Valley
9	V.Valley	180	Secondary-Two stage high rate trickling process	Vrishabhavathi Valley
10	Madivala	4	UASB	Koramangala Valley
11	Lalbagh	1.5	Tertiary – Activated aeration + Plate settlers + UV disinfection	Koramangala Valley
12	Cubbon Park	1.5	Tertiary – Membrane Bio Reactor	Koramangala Valley
13	K.R.Puram	20	Secondary- UASB + Extended Aeration	Hebbal
14	Kempambudhi	1	Secondary – Extended Aeration	Vrishabhavathi Valley
15	K & C Valley	60	ASP with power generation	Koramangala Valley
16	Rajacanal	40	Extended Aeration	Hebbal
17	Nagasandra	20	SBR	Vrishabhavathi Valley
18	Chikkabanavara	5	SBR	-
19	Bellandur Amani	90	Secondary-Activated Sludge Process	Koramangala Valley

	Kere			
20	Doddabele	20	Secondary-Sequential Batch Reactor	Vrishabhavathi Valley
21	Kadugodi	6	Secondary-Sequential Batch Reactor	Koramangala Valley
22	Horamavu Agara	20	Secondary-Sequential Batch Reactor	Hebbal
STPs Under Construction				
23	Yelemallappa Chetti kere	15	Secondary-Sequential Batch Reactor	-
24	Kengeri	60	Secondary-Activated Sludge Process	Vrishabhavathi Valley
25	K & C Valley	150	Secondary-Activated Sludge Process	Koramangala Valley
26	Hebbal	100	Secondary-Sequential Batch Reactor	Hebbal
27	Doddabele	40	Secondary-Sequential Batch Reactor	Vrishabhavathi Valley
28	V.Valley	150	Secondary-Activated Sludge Process	Vrishabhavathi Valley
29	Hulimavu	10	Secondary-Sequential Batch Reactor	Koramangala Valley
30	Chikkabegur	5	Secondary-Sequential Batch Reactor	Koramangala Valley
31	Sarakki	5	Secondary-Sequential Batch Reactor	Koramangala Valley
32	Agaram	35	Secondary-Sequential Batch Reactor	Koramangala Valley
33	K.R.Puram	20	Secondary-Sequential Batch Reactor	Hebbal
34	Cubbon park TTP upgradation	2.5	Tertiary-Membrane Bio Reactor	Koramangala Valley
35	Halsoor	2	-	Koramangala Valley
36	Hennur	1	-	Hebbal

Table-7.7. Identification and documentation of nonpoint source pollutants and key issues in the water bodies

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
1.	Hebbal kere	-	-	✓	-	-	-	-	-	✓	-
2.	Kajarakanahalli Lake	-	-	-	-	-	-	-	-	✓	-
3.	Kempambudhi lake	✓	-	-	-	-	-	-	-	✓	-
4.	Mattikere Kere	✓	-	-	-	-	-	-	-	-	-
5.	Rajamahal Kere	-	-	✓	-	-	-	-	-	✓	-
6.	Sankey Tank	-	-	✓	-	-	-	✓	-	✓	-
7.	Sampinge Kere	-	-	✓	-	-	-	✓	-	✓	-
8.	Lalbhagh kere	-	-	-	-	-	-	-	-	✓	-
9.	Abbigere Kere	✓	-	-	-	-	-	-	-	✓	-
10.	Bagalagunte Govt.Lake	✓	-	-	-	-	-	-	-	✓	-
11.	Chikkabanavara kere	✓	-	-	-	-	-	-	-	✓	-
12.	Chikkabanavara kunte-1	-	-	-	-	-	-	-	-	✓	-
13.	Chokkasandra Lake	-	-	-	-	-	-	-	-	✓	-
14.	Doddabidarakallu lake	✓	-	-	-	-	-	-	-	✓	-
15.	Doddabidarakallu kunte4	-	-	-	-	-	-	-	-	✓	-
16.	Doddabidarakallu kunte9	-	-	-	-	-	-	-	-	✓	-
17.	Ganigarahalli kere	-	-	-	✓	-	-	-	-	✓	-
18.	Andhrahalli Lake	-	-	-	-	-	-	-	-	✓	-
19.	Herohalli Lake	✓	-	-	-	-	-	-	-	✓	-
20.	Herohalli kunte1	-	-	-	-	-	-	-	-	✓	-
21.	Herohalli Thotadakere	✓	-	-	-	-	-	-	-	✓	-
22.	Herohalli kunte4	✓	-	-	-	-	-	-	-	✓	-
23.	Herohalli kunte6 (Newly Created)	✓	-	-	-	-	-	-	-	✓	-
24.	Kammagondanahalli lake	✓	-	-	✓	-	-	-	-	✓	-
25.	Kannalli kere	✓	✓	-	✓	-	-	-	-	✓	-
26.	Channabasappana katte (Newly Created)	-	✓	-	✓	-	-	-	-	✓	-
27.	Kannalli Katte-1 (Newly Created)	-	✓	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
28.	Parvatana katte	-	✓	✓	-	-	-	-	-	✓	-
29.	Kannalli kunte-4	-	-	✓	-	-	-	-	-	✓	-
30.	Mande Katte (Newly Created)	-	✓	-	-	-	-	-	-	✓	-
31.	Kannalli Katte-2 (Newly Created)	-	✓	-	-	-	-	-	-	✓	-
32.	Karihobanahalli kere	-	-	-	✓	-	-	-	-	✓	-
33.	Ajjegowdana katte	-	✓	✓	✓	-	-	-	-	✓	-
34.	Kodigehalli kere	✓	-	-	-	-	-	-	-	✓	-
35.	Laggeri Lake	✓	-	-	-	-	-	-	-	✓	-
36.	Lakshmipura kere	✓	-	-	✓	-	-	-	-	✓	-
37.	Lingadheeranahalli Lake	-	-	-	-	-	-	-	-	✓	-
38.	Malgalu lake	-	-	✓	-	-	-	-	-	✓	-
39.	Mallasandra Lake-1	-	-	-	-	-	-	-	-	✓	-
40.	Mallasandra Lake-2	-	-	-	-	-	-	-	-	✓	-
41.	Mallathahalli Lake	✓	-	-	-	-	-	-	-	✓	-
42.	Haranakatte		-	-	-	-	-	-	-	✓	-
43.	Badakukere	✓	-	-	-	-	-	-	-	✓	-
44.	Nagarabhavi Kere	✓	-	-	-	-	-	-	-	✓	-
45.	Nelagadiranahalli Lake	✓	-	-	-	-	-	-	-	✓	-
46.	Nelagadiranahalli Hosakere	✓	-	-	-	-	-	-	-	✓	-
47.	Narasahalli Lake	✓	-	-	-	-	-	-	-	✓	-
48.	Seegehalli kere	-	✓	-	✓	-	-	-	-	✓	-
49.	Ullalu lake-2	✓	-	-	-	-	-	-	-	✓	-
50.	Allasandra Lake	✓	-	-	-	-	-	-	-	-	-
51.	Amruthahalli Lake	-	-	-	-	-	-	-	-	✓	-
52.	Atturu kere	✓	-	-	-	-	-	-	-	✓	-
53.	Avalahalli Kere	-	✓	-	-	-	-	-	-	✓	-
54.	Avalahalli Katte3	-	-	-	-	-	-	-	-	✓	-
55.	Bellihalli kere	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
56.	Chikkabettahalli katte 1	✓	-	-	-	-	-	-	-	✓	-
57.	Chokkanahalli Katte	-	-	-	-	-	-	-	-	✓	-
58.	Chokkanahalli lake	✓	-	-	-	-	-	-	-	-	-
59.	Doddabettahalli kunte 1	-	-	-	-	-	-	-	-	✓	-
60.	Dodda Bommasandra Lake	✓	-	-	-	-	-	-	-	✓	-
61.	Gantiganahalli Kunte-2	-	-	-	✓	-	-	-	-	-	-
62.	Gantiganahalli Kere	✓	✓	-	✓	-	-	-	-	✓	-
63.	Gantiganahalli kunte-3	-	-	-	-	-	-	-	-	✓	-
64.	Harohalli kere	✓	-	✓	-	-	-	-	-	✓	-
65.	Honnenahalli Govt Kere	-	✓	-	✓	-	-	-	-	✓	-
66.	Jarakabande kavalu kunte1	-	-	-	-	-	-	-	-	✓	-
67.	Jarakabande Kavalu Kunte 3	-	-	-	-	-	-	-	-	✓	-
68.	Jarakabande kavalu kunte4	-	-	-	-	-	-	-	-	✓	-
69.	Kasaba Amanikere	✓	-	-	-	-	-	-	-	✓	-
70.	Kodigehalli kunte1	-	-	-	-	-	-	-	-	✓	-
71.	Kodigehalli kunte3	✓	-	-	-	-	-	-	-	✓	-
72.	Kodigehalli plantation Kunte-2	-	-	-	-	-	-	-	-	✓	-
73.	Krishnasagara Kere	-	-	-	✓	-	-	-	-	✓	-
74.	Krishnasagara Kunte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
75.	Lakshmisagara Kere	-	-	-	✓	-	-	-	-	✓	-
76.	Medi Agrahara Kere	-	✓	-	✓	-	-	-	-	✓	-
77.	Thupinkere	-	✓	-	✓	-	-	-	-	✓	-
78.	Nagadasanahalli Kere	-	✓	-	✓	-	-	-	-	✓	-
79.	Narasipura Lake-1	✓	-	-	-	-	-	-	-	✓	-
80.	Narasipura Lake-2	✓	-	-	-	-	-	-	-	✓	-
81.	Puttenahalli Lake	✓	-	-	-	-	-	-	-	✓	-
82.	Ramagondanahalli kere	-	✓	-	-	-	-	-	✓	✓	-
83.	Singanayakanahalli kunte 1	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
84.	Singanayakayahalli Govt Gokatte	-	✓	-	✓	-	-	-	-	✓	-
85.	Singapura lake	-	-	-	-	-	-	-	-	✓	-
86.	Shivanahalli lake	-	-	-	-	-	-	-	-	✓	-
87.	Srinivasapura lake	-	-	-	-	-	-	-	-	✓	-
88.	Thirumenahalli lake	✓	-	-	-	-	-	-	-	-	-
89.	Vaderahalli kere	-	-	-	-	-	-	-	-	✓	-
90.	Veerasagara kere	✓	-	-	-	✓	✓	-	-	✓	-
91.	Venkateshapura lake	-	-	-	-	-	-	-	-	✓	-
92.	Bagaluru Majare kunte	-	-	-	-	-	-	-	-	✓	-
93.	Bettahalsur kunte 1	-	-	-	-	-	-	-	-	✓	-
94.	Bettahalsur kere	✓	-	-	✓	-	-	-	-	✓	-
95.	Bettahalsur kunte 2	-	-	-	-	-	-	-	-	✓	-
96.	Bettahalsur Narayanapura kunte (Newly Created)	-	-	-	✓	-	-	-	-	✓	-
97.	Chagalatti kunte 1	-	-	-	-	-	-	-	-	✓	-
98.	Chagalatti kunte 2	-	-	-	-	-	-	-	-	-	-
99.	Chagalatti kere	-	✓	-	✓	-	-	-	-	✓	-
100.	Dasanayakana halli kunte	-	✓	✓	✓	-	-	-	-	✓	-
101.	Dasanayakanahalli Doddukunte	-	✓	-	✓	-	-	-	-	-	-
102.	Kodatti Kere	✓	✓	-	✓	-	-	-	-	✓	-
103.	Hunasemaranahalli kere	-	✓	✓	✓	-	-	-	-	✓	-
104.	Kattigenahalli lake	✓	✓	-	-	-	-	-	-	-	-
105.	Kattigenahalli karabu lake	✓	-	-	-	-	-	-	-	-	-
106.	Marenahalli Chokkanahalli kunte	-	-	✓	-	-	-	-	-	✓	-
107.	Marenahalli kunte 3	-	-	-	-	-	-	-	-	✓	
108.	Marenahalli kere	-	-	✓	✓	-	-	-	-	✓	-
109.	Nellakunte kere	-	✓	-	✓	-	-	-	-	✓	-
110.	Sathanur karabu 4	-	✓	-	-	-	-	-	-	✓	-
111.	Sathanoor kunte 5	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
112.	Sathanoor kunte 6 (Newly Created)	-	-	-	-	-	-	-	-	✓	-
113.	Suggata kere	-	✓	✓	✓	-	-	-	-	✓	-
114.	Suggatta kunte	-	✓	-	-	-	-	-	-	✓	-
115.	Thimmasandra kere	-	✓	-	-	-	-	-	-	✓	-
116.	Thimmasandra kunte	-	-	✓	-	-	-	-	-	✓	-
117.	Pattalamman katte	-	-	-	✓	-	-	-	-	-	-
118.	Anurah katte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
119.	Bilijaji kere	-	✓	-	✓	-	-	-	-	✓	-
120.	Byalakere Kere	✓	✓	-	✓	-	-	-	-	✓	-
121.	Byalakere Govt Kere	-	✓	-	✓	-	-	-	-	✓	-
122.	Guniagrahara Kere 1	✓	✓	-	✓	-	-	-	-	✓	-
123.	Huralichikkanahalli Kere	-	✓	-	✓	-	-	-	-	✓	-
124.	Huralichikkanahalli Kunte	-	-	-	✓	-	-	-	-	✓	-
125.	Ivarakandapura Kere	-	✓	-	✓	-	-	-	-	✓	-
126.	Ittagalapura lake 1	-	-	-	-	-	-	-	-	✓	-
127.	Hanuman kunte (Newly created)	-	-	-	-	-	-	-	-	✓	-
128.	Ittagalapura lake 2	-	✓	-	✓	-	-	-	-	-	-
129.	Ittagalapura lake 3	-	✓	-	-	-	-	-	-	-	-
130.	Ura kunte	-	-	-	-	-	-	-	-	✓	-
131.	Kalatammanahalli Kere	-	✓	-	-	-	-	-	-	✓	-
132.	Kalenahalli Kere	-	-	-	✓	-	-	-	-	-	-
133.	Kasagattapura Kere 2	-	✓	-	✓	-	-	-	-	✓	-
134.	Kasagattapura Kere 3	✓	✓	-	✓	-	-	-	-	✓	-
135.	Kempapura Kunte 2	-	-	-	-	-	-	✓	-	✓	-
136.	Kondashettihalli Kunte	-	-	-	-	-	-	-	-	✓	-
137.	Krishnarajapura Kunte	-	-	-	-	-	-	-	-	✓	-
138.	Krishnarajapura Karabu katte	-	-	-	-	-	-	-	-	✓	-
139.	Kumbarahalli Kere	-	✓	-	✓	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
140.	Linganahalli Kere	-	✓	-	✓	-	-	-	-	✓	-
141.	Lingarajapura kere	-	✓	-	-	-	-	-	-	✓	-
142.	Lingarajasagara Kunte 1	-	-	-	✓	-	-	-	-	✓	-
143.	Lingarajasagara Kunte 2	✓	-	-	-	-	-	-	-	✓	-
144.	Madappanahalli Kere 1	-	✓	-	✓	-	-	-	-	✓	-
145.	Madappanahalli Kunte 1	-	-	-	-	-	-	-	-	✓	-
146.	Aralakunta	-	✓	-	-	-	-	-	-	✓	-
147.	Madappanahalli Kunte 3	-	-	-	-	-	-	-	-	✓	-
148.	Madappanahalli Kunte 4	-	-	-	-	-	-	-	-	✓	-
149.	Madappanahalli Kunte 5	-	-	-	-	-	-	-	-	✓	-
150.	Mavallipura Karabu Lake	✓	✓	-	-	-	-	-	-	-	-
151.	Mavallipura Kunte 1	-	-	-	-	-	-	-	-	✓	-
152.	Mavalipura Kere 2 (Newly Created)	-	-	-	-	-	-	-	-	✓	-
153.	Mavallipura Kere 3	-	-	-	✓	-	-	-	-	✓	-
154.	Mavallipura Kere 4	-	✓	-	✓	-	-	-	-	-	-
155.	Muthukadhahalli / Muthakarahalli Kunte 1	-	-	-	✓	-	-	-	-	✓	-
156.	Muthukadhahalli / Muthakarahalli Kunte 2	-	-	-	✓	-	-	-	-	✓	-
157.	Mylappanahalli kere 1	-	-	-	✓	-	-	-	-	✓	-
158.	Mylappanahalli Kere 2	-	✓	-	✓	-	-	-	-	✓	-
159.	Rajanakunte-7 (New)	-	-	-	-	-	-	-	-	✓	-
160.	Shivakote Katte	-	-	-	✓	-	-	-	-	-	-
161.	Shivakote Kunte 2	-	-	-	✓	-	-	-	-	-	-
162.	Earannana Kunte	-	-	-	-	-	-	-	-	✓	-
163.	Adikamaranahalli Kunte	✓	-	-	-	-	-	-	-	✓	-
164.	Alur kere	-	✓	-	-	-	-	-	-	✓	-
165.	Alur katte	-	✓	-	✓	-	-	-	-	✓	-
166.	Byandahalli Kunte1	-	-	-	-	-	-	-	-	✓	-
167.	Byandahalli kere	-	✓	✓	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
168.	Dasanapura kunte-2	-	-	-	✓	-	-	-	-	✓	-
169.	Dasanapura kere	✓	✓	-	-	-	-	✓	-	✓	-
170.	Gangondanahalli kere	-	-	-	-	-	-	✓	-	-	-
171.	Hanumanthasagara Kunte	-	-	✓	-	-	-	-	-	-	-
172.	Hanumanthasagara Kere	-	-	✓	✓	-	-	-	-	✓	-
173.	Harokyathanahalli kere	✓	✓	✓	✓	-	-	-	-	✓	-
174.	Harokyathanahalli kunte2	-	-	-	-	-	-	-	-	✓	-
175.	Heggadaevanapura kere-1	-	✓	-	-	-	-	-	-	✓	-
176.	Kachohalli Kere-1	✓	✓	-	✓	-	-	-	-	-	-
177.	Kachohalli Kere-2	-	✓	-	-	-	-	-	-	✓	-
178.	Kuduregere kere	-	-	-	✓	-	-	-	-	✓	-
179.	Lakkenahalli Kunte 1	✓	✓	✓	-	-	-	-	-	✓	-
180.	Lakkenahalli Kunte 2	-	✓	-	-	-	-	-	-	✓	-
181.	Lakshmipura Kere	✓	✓	-	✓	-	-	-	-	✓	-
182.	Narasipura Kunte-1	-	✓	-	-	-	-	-	-	✓	-
183.	Thammenahalli kunte-1	-	-	-	✓	-	-	-	-	✓	-
184.	Thammenahalli kunte-2	-	-	-	-	-	-	-	-	✓	-
185.	Torenagasandra urkunte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
186.	Torenagasandra kunte1	-	✓	-	✓	-	-	-	-	✓	-
187.	Thotadaguddadahalli kunte1	-	-	-	-	-	-	-	-	✓	-
188.	Thotadaguddadahalli kunte2	-	-	-	✓	-	-	-	-	✓	-
189.	Vadarahalli Kunte	-	-	-	-	-	-	-	-	-	-
190.	Ambalipura kere	✓	-	-	-	-	-	-	-	✓	-
191.	Balagere kunte2	-	-	-	-	-	-	-	-	✓	-
192.	Bellandur Amanikere	✓	-	-	-	-	-	-	-	✓	-
193.	Varthur Amanikere	✓	-	-	-	-	-	-	-	✓	-
194.	Bhoganahalli kere	✓	-	-	-	-	-	-	-	✓	-
195.	Chikkabellanduru kere	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
196.	Chikkanayakanahalli kunte2	-	-	-	-	-	-	-	-	✓	-
197.	Chikkanayakanahalli kunte4	-	-	-	-	-	-	-	-	✓	-
198.	Devarabisanahalli kere	✓	-	-	-	-	-	-	-	✓	-
199.	Doddakanneli kere	✓	-	-	-	-	-	-	-	✓	-
200.	Bellandure Gramadakere	✓	-	-	-	-	-	-	-	✓	-
201.	Gunjuru kunte2	-	-	-	-	-	-	-	-	✓	-
202.	Gunjuru kunte3	-	-	-	-	-	-	-	-	✓	-
203.	Gunjur Kere-1	-	✓	-	✓	-	-	-	-	✓	-
204.	Gunjuruplaya kere	✓	-	-	-	-	-	-	-	✓	-
205.	Gunjur Kelaginakere	-	-	-	-	-	-	-	-	✓	-
206.	Gunjuru kunte5	-	-	-	-	-	-	-	-	✓	-
207.	Gunjuru kunte6	-	-	-	-	-	-	-	-	✓	-
208.	Gunjuru kunte9	-	-	-	-	-	-	-	-	✓	-
209.	Halanayakanahalli kere1	-	-	-	✓	-	-	-	-	✓	-
210.	Haraluru kere	-	-	-	-	-	-	-	-	✓	-
211.	Junnasandra Kere	-	-	-	-	-	-	-	-	✓	-
212.	Kachamaranahalli kunte1	-	-	-	-	-	-	-	-	✓	-
213.	Kachamaranahalli Govt. Lake	-	-	-	✓	-	-	-	-	✓	-
214.	Kachamaranahalli kunte4	-	-	-	-	-	-	✓	-	✓	-
215.	Kachamaranahalli kunte6	✓	-	-	-	-	-	-	-	✓	-
216.	Kaikondanahalli kere	✓	-	-	-	-	-	-	-	✓	-
217.	Kasavanahalli kere	✓	-	-	-	-	-	-	-	✓	-
218.	Kodathi kunte1		-	-	-	-	-	-	-	✓	-
219.	Kodathi kere	✓	✓	✓	-	-	-	-	-	✓	-
220.	Kodathi Kunte6	-	-	-	-	-	-	-	-	✓	-
221.	Kodathi Kunte9	-	-	-	-	-	-	-	-	✓	-
222.	Kodathi Kunte10	-	-	-	-	-	-	-	-	✓	-
223.	Kodathi Kunte11	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
224.	Kodathi Kunte12	-	-	-	-	-	-	-	-	✓	-
225.	Malluru kunte	-	-	-	-	-	-	-	-	✓	-
226.	Mulluru kere	-	-	-	✓	-	-	-	-	✓	-
227.	Munekolalu kere	-	-	-	-	-	-	-	-	✓	-
228.	Panthuru kunte2	-	-	-	-	-	-	-	-	✓	-
229.	Panthuru kunte3	-	-	-	-	-	-	-	-	✓	-
230.	Panatthur kere	-	-	-	✓	-	-	-	-	✓	-
231.	Panthuru kunte4	-	-	-	-	-	-	-	-	✓	-
232.	Panattur Govt. Kere	✓	-	-	-	-	-	-	-	✓	-
233.	Hado shiddapura kere	-	-	-	-	-	-	✓	-	✓	-
234.	Hadosiddapura kunte	-	-	-	-	-	-	-	-	✓	-
235.	Siddapura Kunte6	-	-	-	-	-	-	-	-	✓	-
236.	Siddapura Kunte7	-	-	-	-	-	-	-	-	✓	-
237.	Siddapura kere	✓	-	-	-	-	-	-	-	✓	-
238.	Sorahunase kunte1	-	-	-	-	-	-	-	-	✓	-
239.	Otikere	-	-	-	-	-	-	-	-	✓	-
240.	Sulakunte kunte7	-	-	-	-	-	-	-	-	✓	-
241.	Devarakere	-	-	-	✓	-	-	-	-	✓	-
242.	Varthuru kunte1	-	-	-	-	-	-	-	-	✓	-
243.	Varthuru kunte7	-	-	-	-	-	-	-	-	✓	-
244.	Basavanapura kere	✓	-	-	-	-	-	-	✓	✓	-
245.	Benniganahalli Kere	✓	-	-	-	-	-	-	-	✓	-
246.	Byappanahalli kunte1	-	-	-	-	-	-	-	-	✓	-
247.	B.Narayanapura kere	✓	-	-	-	-	-	-	-	✓	-
248.	Byrasandra kere1	✓	-	-	-	-	-	-	-	✓	-
249.	Byrasandra kunte	✓	-	-	-	-	-	-	-	✓	-
250.	Byrasandra Melinakere	✓	-	-	-	-	-	-	✓	✓	-
251.	Chellakere kere	✓	-	-	-	-	-	-	-	✓	-
252.	Channasandra Kunte2	-	-	-	-	-	-	-	-	✓	-
253.	Chinnappanahalli kere2	-	-	-	-	-	-	-	-	✓	-

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		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
254.	Dyavasandra kere	✓	-	-	-	-	-	-	-	✓	-
255.	Doddanekundi kere2	✓	-	-	-	-	-	-	-	✓	-
256.	Hoodi kere	✓	-	-	-	-	-	-	-	✓	-
257.	Giddanakere	✓	-	-	-	-	-	-	-	✓	-
258.	Horamavu kere	✓	-	-	-	-	-	-	-	✓	-
259.	Kaggadasapura kere	✓	-	-	-	-	-	-	-	✓	-
260.	Kalkere Kere	✓	-	-	-	-	-	-	-	✓	-
261.	Kalkere kunte3	-	-	-	-	-	-	-	-	✓	-
262.	Kowdenahalli Kere	-	-	-	-	-	-	-	-	✓	-
263.	Vijinapura kere2	-	-	-	-	-	-	-	✓	✓	-
264.	Kodigehalli kunte1	-	-	-	-	-	-	-	-	✓	-
265.	Kodigehalli kunte4	-	-	-	-	-	-	-	-	✓	-
266.	Vengaiahanakere	✓	-	-	-	-	-	-	-	✓	-
267.	Krishnaraja puram kere-1	✓	-	-	-	-	-	-	-	✓	-
268.	Kundalahalli kere	✓	-	-	-	-	-	-	-	✓	-
269.	Garudacharplayakere	✓	-	-	-	-	-	-	-	✓	-
270.	Garudacharya palya lake (Goshala)	✓	-	-	-	-	-	-	-	✓	-
271.	Mahadevapura kere	✓	-	-	✓	-	-	-	-	✓	-
272.	Bande Mahadevapura kere	✓	-	-	-	-	-	-	-	✓	-
273.	Nagareshvara Nagenahalli Kere	-	-	-	-	-	-	-	-	✓	-
274.	Nagondanahalli Kunte	-	-	-	-	-	-	-	-	✓	-
275.	Nallurahallikere	✓	-	-	-	-	-	-	-	✓	-
276.	Nallurahallin kunte1	✓	-	-	-	-	-	-	-	✓	-
277.	Pattandur Agrahara kunte3	-	-	-	-	-	-	-	-	✓	-
278.	Pattandur Agrahara kunte7	-	-	-	-	-	-	-	-	✓	-
279.	Pattaduru Agrahara kere-1	-	-	-	-	-	-	-	-	✓	-
280.	Pattandur Agrahara kunte11	✓	-	-	-	-	-	-	-	✓	-
281.	Pattandur Agrahara kunte12	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
282.	Rachenahalli kere	✓	-	-	-	-	-	-	-	✓	-
283.	Sadaramangala lake	✓	-	-	-	-	-	-	✓	✓	-
284.	Shegehalli kere	✓	-	-	-	-	-	-	-	✓	-
285.	Sonnathimmanahalli kunte	✓	-	-	-	-	-	-	-	✓	-
286.	Sonnenahalli kere	-	-	-	-	-	-	-	-	✓	-
287.	Thannisandra kunte2	-	-	-	-	-	-	-	-	✓	-
288.	Vibhutipura kere	✓	-	-	-	-	-	-	-	✓	-
289.	Whitefield kere	-	-	-	-	-	-	-	-	✓	-
290.	Anagalapura kunte2	-	-	-	-	-	-	-	-	✓	-
291.	Bhattarahalli kere	-	-	✓	-	-	-	-	-	✓	-
292.	Bidarahalli kere	-	✓	✓	✓	-	-	-	-	✓	-
293.	Bidarena agrahara kere	-	✓	✓	-	-	-	-	-	✓	-
294.	Byappanahalli kere	-	✓	✓	✓	-	-	-	-	✓	-
295.	Bhairathi Kunte3	-	-	-	✓	-	-	-	-	✓	-
296.	Chimasandra Kere	✓	✓	✓	✓	-	-	-	-	✓	-
297.	Chikkabanahalli kere	✓	✓	✓	✓	-	-	-	-	✓	-
298.	Chikkabanahalli kunte	-	-	-	-	-	-	-	-	✓	-
299.	Chikkagubbi kere	-	✓	✓	✓	-	-	-	-	✓	-
300.	Doddabanahalli kunte1	-	-	-	-	-	-	-	-	✓	-
301.	Doddabanahalli kunte2	-	-	-	-	-	-	-	-	✓	-
302.	Doddagubbi kere	-	-	-	✓	-	-	-	-	✓	-
303.	Doddagubbi kunte1	-	-	-	-	-	-	-	-	✓	-
304.	Goravigere kunte2	-	✓	-	-	-	-	-	-	✓	-
305.	Goravigere kunte3	-	✓	✓	-	-	-	-	-	✓	-
306.	Hirandahalli Kunte 2	-	-	-	-	-	-	-	-	✓	-
307.	Hirandahalli Kunte 3	✓	✓	-	-	-	-	-	-	✓	-
308.	Hirandahalli Kunte 4	✓	-	-	-	-	-	-	-	✓	-
309.	Rampura Kere	-	-	✓	-	-	-	-	-	✓	-
310.	Kada Agrahara kunte	-	-	-	-	-	-	-	-	✓	-
311.	Kadugodi Kunte 2	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
312.	Khajisonnenahalli Kunte4	-	-	-	-	-	-	-	-	✓	-
313.	Khajisonnenahalli Kunte1	-	-	-	-	-	-	-	-	✓	-
314.	Khajisonnenahalli Kunte2	-	-	-	-	-	-	-	-	✓	-
315.	Khajisonnenahalli Kunte5	-	-	-	-	-	-	-	-	✓	-
316.	Khajisonnenahalli Kunte7	-	-	-	-	-	-	-	-	✓	-
317.	Khajisonnenahalli Kunte8	-	-	-	-	-	-	-	-	✓	-
318.	Khajisonnenahalli Kunte10	-	-	-	-	-	-	-	-	✓	-
319.	Kannamangala kere	-	✓	-	✓	-	-	-	-	✓	-
320.	Kannuru kere2	-	-	-	-	-	-	-	-	✓	-
321.	Katamnalluru Kere	-	-	-	-	-	-	-	-	✓	-
322.	Kithaganuru Kere	-	-	-	✓	-	-	-	-	✓	-
323.	Kithaganuru Kunte 5	-	-	-	-	-	-	-	-	✓	-
324.	Konadasapura kere	-	-	-	-	-	-	-	-	✓	-
325.	Kumbena agrahara Kunte	-	-	-	-	-	-	-	-	✓	-
326.	Medihalli Kunte4	✓	-	✓	-	-	-	-	-	✓	-
327.	Nimbekaipura Kere	-	-	-	-	-	-	-	-	✓	-
328.	Seegihalli kunte1	✓	-	✓	-	-	-	-	-	✓	-
329.	Seegihalli katte 1	✓	-	✓	-	-	-	-	-	✓	-
330.	JinkeTimmasandra Kere	✓	-	-	-	-	-	-	-	✓	-
331.	Yellamallappashetti Kere	✓	✓	-	-	-	-	-	-	✓	-
332.	Yarappanahalli Kere1	-	-	-	-	-	-	-	-	✓	-
333.	Yarappanahalli Kere2	-	-	-	-	-	-	-	-	✓	-
334.	Avalahalli Kunte-1	-	-	✓	-	-	-	-	-	✓	-
335.	Avalahalli kere	✓	-	✓	-	-	-	-	-	✓	-
336.	Chikkanagamangala Kunte-1	-	-	✓	-	-	-	-	-	✓	-
337.	Govt Gulimangalada lake	-	✓	✓	✓	-	-	-	-	✓	-
338.	Chikkanagamangala Govt. Kere	✓	✓	-	-	-	-	-	-	✓	-
339.	Chikkanekundi Lake land	-	-	-	-	-	-	✓	-	✓	-
340.	Chikkavaderapura Govt. Kunte-2	-	-	-	-	-	-	-	-	✓	-

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		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
341.	Chikkavaderapura Govt. Karabu Kunte	-	-	-	✓	-	-	-	-	✓	-
342.	Chokkasandra lake-1	-	-	-	-	-	-	-	-	✓	-
343.	Govt. Vaddakere-2	-	-	-	-	-	-	-	-	✓	-
344.	Choodasandra Govt Lake-3	✓	✓	✓	✓	-	-	-	-	✓	-
345.	Dommasandra Kunte-3	-	-	-	-	-	-	-	-	✓	-
346.	Dommasandra Govt Lake-1	✓	-	-	✓	-	-	-	-	✓	-
347.	Dommasandra Kunte-7	-	-	-	-	-	-	✓	-	✓	-
348.	Dommasandra Kunte-11	-	-	-	-	-	-	-	-	✓	-
349.	Dommasandra Govt. Lake-2	-	-	-	-	-	-	-	-	✓	-
350.	Gattihalli Govt. lake	-	-	-	-	-	-	-	-	✓	-
351.	Gottamaranahalli Govt. Lake	-	✓	-	✓	-		-	-	✓	-
352.	Gulimangala Kunte-1	-	-	-	-	-	-	-	-	✓	-
353.	Halasahalli Thippasandra Kunte-2	-	-	-	-	-	-	-	-	✓	-
354.	Halasahalli Thippasandra Kunte-3	-	-	-	-	-	-	-	-	✓	-
355.	Tippasandra lake	-	-	-	✓	-	-	-	-	✓	-
356.	Halasahalli Thippasandra Kunte-5	-	-	-	-	-	-	-	-	✓	-
357.	Harohalli Govt lake	✓	-	-	-	-	-	-	-	✓	-
358.	Heggondahalli Kunte-1	-	-	-	-	-	-	-	-	✓	-
359.	Heggondahalli Govt. lake	-	-	-	✓	-	-	-	-	✓	-
360.	Heggondahalli Kunte-4	-	-	-	-	-	-	-	-	✓	-
361.	Hosahalli Kunte-1	-	-	-	-	-	-	-	-	✓	-
362.	Hosahalli Kunte-2	-	-	-	-	-	-	-	-	✓	-
363.	Hosahalli Kunte-3	-	-	-	-	-	-	-	-	✓	-
364.	Hosahalli Govt. lake	-	-	-	✓	-	-	-	-	✓	-
365.	Hosahalli Kunte-5	-	-	-	-	-	-	-	-	✓	-
366.	Hosahalli Kunte-6	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
367.	Huskur Govt. Lake	-	✓	-	-	-	-	-	-	✓	-
368.	Madhagar Kunte	-	-	-	-	-	-	-	-	✓	-
369.	Huskuru Kunte-3	✓	-	-	-	-	-	-	-	✓	-
370.	Kada Agrahara Kere	-	-	-	-	-	-	-	-	✓	-
371.	Kagalipura Govt. Lake	-	-	-	-	-	-	-	-	✓	-
372.	Kommasandra Kunte-1	-	-	-	-	-	-	-	-	✓	-
373.	Kommasandra Kunte-2	-	✓	✓	-	-	-	-	-	✓	-
374.	Kommasandra Kunte-3	-	-	-	-	-	-	-	-	✓	-
375.	Rocherenvu	-	-	-	✓	-	-	-	-	✓	-
376.	Kommasandra Kunte-4	✓	-	-	-	-	-	-	-	✓	-
377.	Kommasandra Kunte-5	-	-	-	-	-	-	-	-	✓	-
378.	Kathriguppe Kunte-1	-	-	-	-	-	-	-	-	✓	-
379.	Kathriguppe Kunte-2	-	-	-	✓	-	-	-	-	✓	-
380.	Kodlu lake-1	✓	-	-	-	-	-	-	-	✓	-
381.	Kodlu Kere-2	✓	-	-	-	-	-	-	-	✓	-
382.	Nekkundi Dommasandra Kunte-1	-	-	-	-	-	-	-	-	✓	-
383.	Nekkundi Dommasandra Kunte-2	-	-	-	-	-	-	-	-	✓	-
384.	Ramanayakanahalli Govt. Kere-1	-	-	-	✓	-	-	-	-	✓	-
385.	Ramanayakanahalli Govt. Kere-2	-	-	-	✓	-	-	-	-	✓	-
386.	Ramanayakanahalli Kunte-1	-	-	-	-	-	-	-	-	✓	-
387.	Rayasandra Kunte-1	-	✓	✓	✓	-	-	-	-	✓	-
388.	Rayasandra Kunte-2	-	✓	✓	-	-	-	-	-	✓	-
389.	Rayasandra Kere	✓	-	-	-	-	-	-	-	✓	-
390.	Singena Agrahara Govt. Sanna kere	-	-	-	✓	-	-	-	-	-	-
391.	Singena Agrahara Kunte-1	-	-	-	-	-	-	-	-	✓	-
392.	Singena Agrahara Kunte-5	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
393.	Tigalara Chowddenahalli Govt. Karabukere	-	✓	✓	✓	-	-	-	-	✓	-
394.	Thigala Choudenahalli Kunte-2	-	-	-	-	-	-	-	-	✓	-
395.	Gollahalli Govt. Lake	✓	-	-	-	-	-	-	-	✓	-
396.	Uramundinakere	✓	-	-	-	-	-	-	-	✓	-
397.	Hebbagodi Govt. Attikere	✓	-	-	-	-	-	-	-	✓	-
398.	Veerasandra Govt. Kere-1	✓	-	✓	-	-	-	-	-	✓	-
399.	Veerasandra Govt. Kere-2	✓	-	✓	-	-	-	-	-	✓	-
400.	Veerasandra Govt. Kunte-1	✓	-	-	-	-	-	-	-	✓	-
401.	Bhujangadasana Amanikere Govt lake	-	-	-	✓	-	-	-	-	✓	-
402.	Bannerughatta kunte1	✓	-	-	-	-	-	-	-	✓	-
403.	Bannerughatta lake land	✓	✓	-	-	-	-	-	-	✓	-
404.	Kumbara kere	-	-	✓		-	-	-	-	✓	-
405.	Bannerughatta Kunte2	-	-	-	-	-	-	-	-	✓	-
406.	Bannerughatta kavalu kunte	-	-	-	-	-	-	-	-	✓	-
407.	Begihalli Govt. Kere	-	-	-	✓	-	-	-	-	-	-
408.	Bhuthanahalli Kunte-2	-	-	-	-	-	-	-	-	✓	-
409.	Bhuthanahalli Kunte-4	-	-	-	-	-	-	-	-	✓	-
410.	Bhutanahlli lake	-	✓	-	✓	-	-	-	-	✓	-
411.	Majarevaradahalli Kunte	-	-	-	-	-	-	-	-	✓	-
412.	Bilwaradahalli kere	-	✓	-	-	-	-	✓		✓	-
413.	Bilwaradahalli kunte	-	-	-	-	-	-	-	-	✓	-
414.	Bingipura lake	✓	-	-	-	-	-	-	-	✓	-
415.	Bingipura Kunte1	-	✓	-	-	-	-	✓	-	✓	-
416.	Govt Karabu katte	-	-	-	-	-	-	-	-	✓	-
417.	Govt. Kharabu kere	-	-	-	-	-	-	-	-	✓	-
418.	Honnashetti kere	-	-	-	-	-	-	-	-	✓	-
419.	Byrappanahalli Kunte 2	-	-	-	-	-	-	-	-	✓	-
420.	Gollahalli lake	✓	-	✓	-	-	-	-	-	✓	-

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		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
421.	Halesampigehalli Kunte	✓	-	-	-	-	-	-	-	✓	-
422.	Hulimangala katte	-	-	-	-	-	-	-	-	✓	
423.	Hulimangala kunte 2		-	-	-	-	-	-	-	✓	-
424.	Hulimangala Govt. Kodi Kere	-	-	-	-	-	-	-	-	✓	-
425.	Hulimangala Govt. kere	-	-	-	✓	-	-	-	-	✓	-
426.	Hulimangala kunte 6	-	-	-	-	-	-	-	-	✓	-
427.	Hullahalli Kharab Kere	-	✓	-	-	-	-	-	-	✓	-
428.	Hullahalli Kunte1	-	-	-	-	-	-	-	-	✓	-
429.	Matadakere	-	✓	-	✓	-	-	-	-	✓	-
430.	Hullahalli Kunte2	-	-	✓	✓	-	-	-	-	✓	-
431.	Govt. Kharabu Kattehonge kere	-	✓	-	-	-	-	-	-	✓	-
432.	Hullahalli Kere	-	✓	-	-	-	-	-	-	✓	-
433.	Kallakere lake land	✓	-	-	-	-	-	-	-	✓	-
434.	Kallukere kunte	-	-	-	-	-	-	-	-	✓	-
435.	Kannaikana Agrahara Kere	-	-	-	-	-	-	-	-	✓	-
436.	Lakshmipura lake	✓	-	-	-	-	-	-	-	✓	-
437.	Mantapada kere	-	-	-	✓	-	-	-	-	✓	-
438.	Mantapa kunte	-	-	-	✓	-	-	-	-	✓	-
439.	Govt Vadenakere	-	-	-	-	-	-	-	-	✓	-
440.	Addigenakere	-	✓	-	✓	-	-	-	-	✓	-
441.	Maragondanahalli kere	✓	-	-	-	-	-	-	-	✓	-
442.	Nanjapura lake	-	✓	-	✓	-	-	-	-	✓	-
443.	Nanjapura kunte	-	-	-	-	-	-	-	-	✓	-
444.	Bidarekere lake land	-	-	-	-	-	-	-	-	✓	-
445.	Sakalavara Govt. Kharabu lake	-	-	-	-	-	-	-	-	✓	-
446.	Sakalavara kunte	-	-	-	-	-	-	-	-	✓	-
447.	Vabasandra kunte1	-	-	-	-	-	-	-	-	✓	-
448.	Uramundinakere	-	✓	-	-	-	-	-	-	✓	-

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449.	Vabasandra kunte3	-	-	-	-	-	-	-	-	✓	-
450.	Vaderahalli Govt. lake	-	-	-	-	-	✓	-	-	✓	-
451.	Chanenahalli kunte 2	-	-	-	-	-	-	-	-	✓	-
452.	Bilnirkatte	✓	-	-	-	-	-	-	-	✓	-
453.	Chanenahalli kunte5	-	-	-	-	-	-	-	-	✓	-
454.	Chikkelluru Govt. Kere	-	✓	-	✓	-	-	-	-	✓	-
455.	Chikkelluru kunte 1	-	✓	-	-	-	-	-	-	✓	-
456.	Chikkelluru kunte 2	-	✓	-	-	-	-	-	-	✓	-
457.	Chikkelluru kere	-	✓	-	-	-	-	-	-	✓	-
458.	Mogi Kere	-	✓	-	-	-	-	-	-	-	-
459.	Chikkagowodana Kere	-	✓	-	✓	-	-	-	-	-	-
460.	Kethohalli kunte	-	✓	-	-	-	-	-	-	✓	-
461.	Kethohalli narasipura kunte	-	✓	-	✓	-	-	-	-	✓	-
462.	Koluru kunte 1	-	-	-	-	-	-	-	-	✓	-
463.	Hosa Kere	-	✓	-	✓	-	-	-	-	✓	-
464.	Gowdana Kere	-	✓	-	✓	-	-	-	-	✓	-
465.	Koluru Gururayanapura Kunte1	-	✓	-	-	-	-	-	-	✓	-
466.	Koluru Gururayanapura Kunte3	-	✓	-	-	-	-	-	-	✓	-
467.	Koluru Gururayanapura Kunte4	-	✓	-	-	-	-	-	-	✓	-
468.	Koluru Nanjunadapura Kunte	-	-	-	✓	-	-	-	-	✓	-
469.	Yelachaguppe kunte1	-	-	-	-	-	-	-	-	✓	-
470.	Cholana Katte	-	-	-	-	-	-	-	-	✓	-
471.	Keremare Katte	-	-	-	-	-	-	-	-	✓	
472.	Yelachaguppe kunte2	-	-	-	-	-	-	-	-	✓	-
473.	Yelachaguppe kunte3	-	-	-	-	-	-	-	-	✓	-
474.	Yelachagupperamapura Kere	✓	✓	-	✓	-	-	-	-	✓	-

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475.	Yelachaguppe karabu Katte	-	✓	-	-	-	-	-	-	✓	-
476.	Sarkaari katte	-	-	-	-	-	-	-	-	✓	-
477.	Agara kunte3	-	-	-	-	-	-	-	-	✓	-
478.	Chinnammanakere	✓	-	-	-	-	-	-	-	✓	-
479.	Agara kunte 4	-	-	-	-	-	-	-	-	✓	-
480.	Agara kunte 5	-	-	-	-	-	-	-	-	✓	-
481.	Agara kere	-	✓	-	-	-	-	-	-	✓	-
482.	Badavamavarthekavalu Kunte2	-	-	-	-	-	-	-	-	✓	-
483.	Badavamavarthekavalu Kunte4	-	-	-	-	-	-	-	-	✓	-
484.	Badavamavarthekavalu Kunte5	-	-	-	-	-	-	-	-	✓	-
485.	Hosakere	-	-	-	✓	-	-	-	-	✓	-
486.	Kuppareddy kere	-	-	-	✓	-	-	-	-	✓	-
487.	Vaderahalli lake	-	-	-	-	-	-	-	-	✓	-
488.	Badavamavarthekavalu Kunte7	-	-	-	-	-	-	-	-	✓	-
489.	Bhimmanakuppe Govt lake	-	-	-	✓	-	-	-	✓	✓	-
490.	Bheemanakuppe kere	-	✓	-	-	-	-	-	-	✓	-
491.	Bheemanakuppe Hosakere	-	-	-	-	-	-	-	-	✓	-
492.	Challagatta kunte1	-	-	-	-	-	-	-	-	✓	-
493.	Chinakurchi kunte2	-	✓	-	✓	-	-	-	-	✓	-
494.	Chinnakurchi kere-1	-	-	-	✓	-	-	-	-	✓	-
495.	Chinnakurchi kere-2	-	✓	✓	-	-	-	-	-	✓	-
496.	Govt. Gangashetty kere	✓	-	-	-	-	-	-	-	✓	-
497.	Deevatigeramanahalli kere	✓	-	-	-	-	-	-	-	✓	-
498.	Devagere kere	-	-	-	✓	-	-	-	-	✓	-
499.	Doddabele kunte2	✓	-	-	-	-	-	-	-	✓	-
500.	Gollahalli Govt Kere	-	-	-	-	-	-	-	-	✓	-
501.	Bheemana katte	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
502.	Halagevaderahalli kere-2	✓	-	-	-	-	-	-	-	✓	-
503.	Hemigepura kunte 3	-	-	-	-	-	-	-	-	✓	-
504.	Kambhipura Govt. Karabu kere-1	✓	-	-	-	-	-	-	-	✓	-
505.	Kambipura kunte1	✓	-	-	-	-	-	-	-	✓	-
506.	Kambhipura Govt. Karabu kere-2	-	-	-	-	-	-	-	-	✓	-
507.	Kanaminiki Govt. Katte	-	-	-	✓	-	-	-	-	✓	-
508.	Kanaminiki Govt. kere	✓	-	-	✓	-	-	-	-	✓	-
509.	Kaniminike Kunte4	✓	-	-	-	-	-	-	-	✓	-
510.	Kaniminike Kunte6	-	-	-	-	-	-	-	-	✓	-
511.	Kaniminike Kunte7	-	-	-	-	-	-	-	-	✓	-
512.	Kenchinahalli kere	✓	-	-	-	-	-	-	-	✓	-
513.	Kenchanapura kunte1	-	-	-	-	-	-	-	-	✓	-
514.	Kenchanapura Govt. Lake	-	-	-	✓	-	-	-	-	✓	-
515.	Kasaba Kengeri kere	✓	-	-	-	-	-	-	-	✓	-
516.	Gumaiahana Kere	-	-	✓	-	-	-	-	-	✓	-
517.	Kommaghatta Govt. Lake	✓	-	-	-	-	-	✓	-	✓	-
518.	Hosa Bairohalli	-	-	-	-	-	-	-	-	✓	-
519.	Kommaghatta Gokatte	-	-	-	-	-	-	-	-	✓	-
520.	Mallammana katte	-	-	-	✓	-	-	-	-	✓	-
521.	Kommaghatta krishnasagara kunte1	-	-	-	-	-	-	-	-	✓	-
522.	Kommaghatta krishnasagara kunte2	-	-	-	-	-	-	-	-	✓	-
523.	Govt. Maggekere	-	-	-	-	-	-	-	-	✓	-
524.	Chaluvekere	-	-	-	-	-	-	-	-	✓	-
525.	Govt. Gaddakere	-	-	-	-	-	-	-	-	✓	-
526.	Kumbalagodu Kunte6	-	-	-	-	-	-	-	-	✓	-
527.	K. Gollahalli kere	-	-	-	✓	✓	-	-	-	✓	-
528.	Kumbalagodu Gollahalli Kunte2	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
529.	Kumbalagodu Gollahalli Kunte3	-	✓	-	-	-	-	-	-	✓	-
530.	Konashetty kere	-	-	-	-	-	-	-	-	✓	-
531.	Maligondanahalli kunte1	-	-	-	-	-	-	-	-	✓	-
532.	Maligondanahalli Lake1	-	-	-	✓	-	-	-	-	✓	-
533.	Maligondanahalli Lake2	-	-	-	✓	-	-	-	-	-	-
534.	Mylasandra Lake-2	-	-	✓	-	-	-	-	-	✓	-
535.	Muppatu Kavalu Sakari (New)	-	-	-	✓	-	-	-	-	✓	-
536.	Maragondanahalli Govt. Lake	-	-	-	-	-	-	-	-	✓	-
537.	Hosa Katte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
538.	Mudukappana Katte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
539.	Kariyana kunte (Newly Created)	-	-	-	-	-	-	-	-	✓	-
540.	Govt karabu katte	-	-	-	-	-	-	-	-	✓	-
541.	Karab Kere	-	-	-	✓	-	-	-	-	✓	-
542.	Nayandanahalli kere	✓	-	-	-	-	-	-	-	✓	-
543.	Ranchanamadu kunte	-	-	-	-	-	-	-	-	✓	-
544.	Chikkakere	✓	-	-	-	-	-	-	-	✓	-
545.	Ramasandra Kere	-	-	-	✓	-	-	-	-	✓	-
546.	Ramohalli kunte 3	-	-	-	-	-	-	-	-	✓	-
547.	Ramohalli kunte 5	-	-	-	-	-	-	-	-	✓	-
548.	Kallapanakatte kere	-	-	-	-	-	-	-	-	✓	-
549.	Thimappanakere	✓	-	-	-	-	-	-	-	✓	-
550.	Ramohalli kere	-	-	-	✓	-	-	-	-	✓	-
551.	Sompura kunte 1	✓	-	-	-	-	-	-	-	✓	-
552.	Sompura Govt.lake	-	-	-	-	-	-	-	-	✓	-
553.	Sulikere kunte 1	-	-	-	-	-	-	-	-	✓	-
554.	Sulikere kunte 2	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
555.	Thagachikuppi kunte 2	-	-	-	-	-	-	-	-	✓	-
556.	Valagerehalli kere	✓	-	-	-	-	-	-	-	✓	-
557.	Bandimatta Hosa kere	✓	-	-	✓	-	-	-	-	✓	-
558.	Narasapanakere	-	-	-	-	-	-	-	✓	✓	-
559.	Alahalli Kere	✓	-	-	-	-	-	-	-	✓	-
560.	Arehalli Kere	✓	-	-	-	-	-	-	-	✓	-
561.	Arehalli kunte	✓	-	-	-	-	-	-	-	✓	-
562.	Devarakere	-	-	-	-	-	-	-	-	✓	-
563.	Byrasandra Kere	-	-	-	-	-	-	-	-	✓	-
564.	Chunchanaghatta Kere	✓	-	-	-	-	-	-	-	✓	-
565.	Doddakallasandra kere	✓	-	-	-	-	-	-	-	✓	-
566.	Subbedarana kere	-	-	-	-	-	-	-	-	✓	-
567.	Gottigere Kere	✓	-	-	-	-	-	-	-	✓	-
568.	Gottigere kunte2	-	-	-	-	-	-	-	-	✓	-
569.	Gottigere kunte3	-	-	-	-	-	-	-	-	✓	-
570.	Subarayanakere	✓	-	-	-	-	-	-	-	✓	-
571.	Gubbalal kere	✓	-	-	-	-	-	-	-	✓	-
572.	Hosahalli kunte	-	-	-	-	-	-	-	-	✓	-
573.	Hosakerehalli Kere	✓	-	-	-	-	-	-	-	✓	-
574.	Goudanakere	✓	-	-	-	-	-	-	-	✓	-
575.	Kembathahali kere	✓	-	-	-	-	-	-	-	✓	-
576.	Konanakunte kere	-	-	-	-	-	-	-	-	✓	-
577.	Krishna Nagar kere	✓	-	-	-	-	-	-	-	✓	-
578.	Jogi kere	✓	-	-	-	-	-	-	-	✓	-
579.	Puttenahalli Kere	✓	-	-	-	-	-	-	-	✓	-
580.	Sarrakki kere	✓	-	-	-	-	-	-	-	✓	-
581.	Gowdarakere	✓	-	-	-	-	-	-	-	✓	-
582.	Thippasandra kere	-	-	-	-	-	-	-	-	✓	-
583.	Thurahalli kunte	✓	-	-	-	-	-	-	-	✓	-
584.	Moge kere	✓	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
585.	Doraikere	-	-	-	-	-	-	-	-	✓	-
586.	Subramhanyapura kere	✓	-	-	-	-	-	-	-	✓	-
587.	U. Manavarthekaval kere	-	-	-	-	-	-	-	-	✓	-
588.	Uttarahalli Manavarthekaval kunte4	-	-	-	-	-	-	-	-	✓	-
589.	Uttarahalli Manavarthekaval kunte5	-	-	-	-	-	-	-	-	✓	-
590.	Vajarahalli kunte2	-	-	-	-	-	-	-	-	✓	-
591.	Muniyappana katte	✓	-	-	-	-	-	-	-	✓	-
592.	Vasanthapura katte	✓	-	✓	-	-	-	-	-	✓	-
593.	Janaradhan kere	✓	-	-	-	-	-	-	-	✓	-
594.	O.B.Chudahalli kunte2	-	-	-	-	-	-	-	-	✓	-
595.	Yediyur kere	-	-	-	-	-	-	-	-	✓	-
596.	Annamma kere	✓	-	-	-	-	-	-	-	✓	-
597.	Arekere Govt. lake	✓	-	-	-	-	-	-	-	✓	-
598.	Basapura lake	✓	-	-	-	-	-	-	-	✓	-
599.	Basapura Govt.lake	✓	-	-	-	-	-	-	-	✓	-
600.	Basavanapura Kere	✓	-	-	-	-	-	-	-	✓	-
601.	Chikkabegur kere	✓	-	-	-	-	-	-	-	✓	-
602.	Begur Lake1	-	-	-	-	-	-	-	-	✓	-
603.	Begur Lake2	-	-	-	✓	-	-	-	-	✓	-
604.	Subbedarana kere	✓	-	-	-	-	-	-	-	-	-
605.	Begur kunte4	-	-	-	-	-	-	-	-	✓	-
606.	Nyanappanahalli Kere	✓	-	-	-	-	-	-	-	✓	-
607.	Beratena Agrahara Lake	✓	-	-	-	-	-	-	-	✓	-
608.	Bettadasanapura kunte1	-	-	-	-	-	-	-	-	✓	-
609.	Bettadasanpura Govt. kere	-	-	-	✓	-	-	-	-	✓	-
610.	Doddatogur lake	✓	-	-	-	-	-	-	-	✓	-
611.	Doddatogur kunte 2	-	-	-	-	-	-	-	-	✓	-
612.	Chikkatogur kere	✓	-	-	-	-		-	-	✓	-
613.	Doddanagamangala	-	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
	Kunte3										
614.	Kythasandra Govt. Lake	✓	-	-	-	-	-	-	-	✓	-
615.	Hommedevanahalli Kere1	✓	-	-	-	-	-	-	-	-	-
616.	Hongasandra Govt. Lake	✓	-	-	-	-	-	-	-	✓	-
617.	Hulimavu Kere	✓	-	-	-	-	-	-	-	✓	-
618.	Ibbalur Govt. Lake	✓	-	-	-	-	-	-	-	✓	-
619.	Jakkasandra lake	-	-	-	-	-	-	-	-	✓	-
620.	Kalena Agrahara Govt. Lake	✓	-	-	-	-	-	-	-	-	-
621.	Kalena Agrahara kunte	-	-	-	-	-	-	-	-	✓	-
622.	Kammanahalli Govt. Lake	-	-	-	-	-	-	-	-	✓	-
623.	Kammanahalli Lake	✓	-	-	✓	-	-	-	-	✓	-
624.	Konappana Agrahara lake	✓	-	-	-	-	-	-	-	✓	-
625.	Konappana Agrahara Kunte 6	-	-	-	-	-	-	-	-	✓	-
626.	Koramangala kere2	✓	-	-	-	-	-	-	-	-	-
627.	Madivala Kere	✓	-	-	-	-	-	-	-	✓	-
628.	Mylasandra Buddagana katte	-	-	-	-	-	-	-	-	✓	-
629.	Mylasandra Urumundinakere	-	-	-	-	-	-	-	-	✓	-
630.	Sullu Kunte Kere	-	✓	-	✓	-	-	-	-	✓	-
631.	Mylasandra Illuvarajana Katte	-	-	-	-	-	-	-	-	✓	-
632.	Mylasandra Hosakere	-	-	-	-	-	-	-	-	✓	-
633.	Mylasandra Govt. Lake	-	-	-	-	-	-	-	-	✓	-
634.	Naganathapura kere	✓	-	-	-	-	-	-	-	✓	-
635.	Naganathapura kunte1	✓	-	-	-	-	-	-	-	✓	-
636.	Parapana Agahara Lake	✓	-	-	-	-	-	-	-	-	-
637.	Parappana Agrahara kunte5	-	-	-	-	-	-	-	-	✓	-
638.	Govt. Jungu Kere	✓	-	-	-	-	-	-	-	-	-
639.	Kodagi Singasandra kere	✓	-	-	-	-	-	-	-	✓	-

Sl No	Water body Name	Nonpoint source pollutants			Soil excavation	Sand mining	Sand washing	Religious Activity		weeds	Use of Fish Chemical
		Sewage Inflow	Agriculture runoff	Road runoff				Organic waste	Idol immersion		
640.	Tavarekere lake	-	-	-	-	-	-	-	-	✓	-
641.	Agara kere	-	-	-	-	-	-	-	-	-	-
642.	Vitasandra kunte2	-	-	-	-	-	-	-	-	✓	-
643.	Vitasandra Govt. Lake	-	-	-	-	-	-	-	-	-	-
644.	Yellakunte Govt. Lake	✓	-	-	-	-	-	-	-	✓	-
645.	Yelenahalli Lake	✓	-	-	-	-	-	-	-	✓	-
646.	Yelenahalli kunte 2	-	-	-	-	-	-	-	-	✓	-

Table-7.8. Documentation of the encroachment of lakes

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
1	BUBNBKhbl_kr1-34	Hebbal kere	192.19	Road & Nursery	South	10	Public & Private
2	BUBNBKkjk_kr2-41	Kajarakanahalli Lake	51.26	Temple, sheds, school, chruch, building & road	E, Southwest & North	50	Local People & Public
3	BUBNBKkpb_kr1-44	Kempambudhi lake	56.16 (MI)	Temple, Road, Houses, park & slum	N, E, S, SW & SE	20	Public & Govt
4	BUBNBKrjm_kr4-68	Sankey Tank	46.19 (SSLR)	Swimming pool, park, Shivaji Statute, Road, & vacant	SE, NW & NE	6	BBMP, Forest Dept
5	BUBNBKsmp_kr1-69	Sampinge Kere	35.13	Kanteerava Stadium	E,W,N & S	95	Government
6	BUBNBKupr_kr1-76	Lalbhagh kere	37.16	Road & RV. Teachers College	South	5	Public & Private
7	BUBNYPabg_kr1-78	Abbigere Kere	47.13	Road	East	0.1	Government
8	BUBNYPbgk_kr5-85	Bagalagunte Govt.Lake	13.31	Road, sheds, plantation & Building	NW, SE	2	Public, Govt
9	BUBNYPcbv_kr1-86	Chikkabanavara kere	105.15	Agri., sheds, market & Buildings	SW, SE & North	7	Farmers, wood traders & Public
10	BUBNYPgng_kr1-109	Ganigarahalli kere	34.26	Agriculture & Road	NW	2	Farmers & public
11	BUBNYPcho_kr1-93	Chokkasandra Lake	27.33	Sheds, Buildings & Road	SE, N, SW	5	Public, road
12	BUBNYPdbk_kr2-97	Doddabidarakallu lake	40.17	Houses	SW	0.1	Public
13	BUBNYPher_ku2-115	Herohalli kunte1	≈0.24	Teak plantation	West	50	Public
14	BUBNYPkan_kr1-129	Kannalli kere	68.09	Settlement & Agriculture	W, SW, North East	3	Public and farmers
15	BUBNYPkan_ku7-135	Parvatana katte	0.32	Residential area development	South west	5	layout
16	BUBNYPkan_ku8-136	Kannalli kunte-4	0.25	Layout development	West, S, N	9	Layout developer
17	BUBNYPkrv_kr1-140	Karihobanahalli kere	3.05	BBMP Office & Road	North	Nil	BBMP
18	BUBNYPlag_kr4-160	Laggeri Lake	6.29	Houses & Park	N, NE & W	25	Public & BBMP

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
19	BUBNYPlkp_kr2-166	Lakshmipura kere	10.06	Grave yard & Road	N, NE & SE	0.01	Public
20	BUBNYPlgd_kr3-169	Lingadheeranahalli Lake	5.32	Graveyard	North	2	Public
21	BUBNYPmlg_kr1-170	Malgalu lake	6.26	Road, Houses, Temple & Park	NE, SE & SW	80	Govt., Public, Pvt. & BBMP
22	BUBNYPmls_kr1-173	Mallasandra Lake-1	5.23	Road	West	0.1	Road
23	BUBNYPmls_kr6-178	Mallasandra Lake-2	11.28	Road	South	0.1	Road
24	BUBNYPmng_kr1-186	Haranakatte	6.22	SMV Layout & NICE road	West	30	BDA & NICE
25	BUBNYPmng_kr2-187	Badakukere	4.00	Road & Agri.	East & SW	5	NICE & Farmer
26	BUBNYPnlk_kr3-195	Nelagadiranahalli Hosakere	19.22	Sheds and houses	North	5	Public
27	BUBNYPsgk_kr6-225	Srigandhakavalu Karabu Katte	6.33	Building & Road	NE	0.1	Sri Amma Bhaghwan Dhyana Mandir & Public
28	BUBNYPulu_kr3-232	Ullalu lake-2	24.12	Road	West	0.1	Government
29	BUBNYHals_kr1-236	Allasandra Lake	41.23	Building, road, slum houses, graveyard & vacant land	NE & S	5	Govt.
30	BUBNYHamt_kr2-238	Amruthahalli Lake	24.36	Graveyard	N	1	Public
31	BUBNYHatu_kr2-243	Atturu kere	90.04	Road & houses	S	0.9	Govt. & public
32	BUBNYHbel_kr1-248	Bellihalli kere	18.32	Plantation	NW	5	Farmer
33	BUBNYHchk_gk1-255	Chokkanahalli Katte	2.14	Road	SE	1	Devloper
34	BUBNYHchk_kr3-257	Chokkanahalli lake	8.02	Graveyard	SE	5	Public
35	BUBNYHgtg_kr3-266	Gantiganahalli Kere	85.05	Agriculture	N & South	10	Farmers
36	BUBNYHhnn_kr3-276	Honnenahalli Govt Kere	9.26	Agriculture	Northwest	10	Farmers
37	BUBNYHjku_kr1-277	Jakkuru lake	164.07	Road	South	0.1	Road
38	BUBNYPjbk(4)_kr1-281	Jarakabandi Kaval kelge kere	7.35	Eucalyptus plantation & Fence	North, South	25	Private
39	BUBNYHlks_kr3-299	Lakshmisagara Kere	15.12	Agri	East & South	40	Farmer

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
40	BUBNYHmda_kr1-300	Medi Agrahara Kere	13.15	Agri	NE	1	farmer
41	BUBNYHmda_kr2-301	Thupinkere	13.10	Agriculture	North	2	Farmer
42	BUBNYHngd_kr1-302	Nagadasanahalli Kere	288.28	Agriculture	West	6	Farmers
43	BUBNYHnrp_kr1-303	Narasipura Lake-1	15.30	Fenced Vacant land	NE	1	Private
44	BUBNYHnrp_kr1-304	Narasipura Lake-2	9.07	Temple, buildings	NE	2	Public
45	BUBNYHrgh_kr3-314	Ramagondanahalli kere	36.26	Road	NE	0.8	Govt
46	BUBNYHsny_gk3-317	Singanayakanahalli katte 2	≈ 2.10	Road	NE	5	Govt.
47	BUBNYHsny_kr4-318	Singanayakayahalli Govt Gokatte	3.05	Agriculture	Nil	2	Farmers
48	BUBNYHsgp_kr1-319	Singapura lake	66.18	Slum Board	North East	5	Govt
49	BUBNYHsvn_kr1-321	Shivanahalli lake	18.39	Road & Railway track	NE, E & Central	25	Govt.
50	BUBNYHsrp_kr1-322	Srinivasapura lake	3.14	Houses, graveyard & mud road	SW & W	10	Public
51	BUBNJLbth_kr2-334	Bettahalsur kere	26.17	Agriculture & Graveyard	West, South	3	Farmer & Public
52	BUBNJLcgl_kr5-343	Chagalatti kere	29.26	Layout & waste dumping	NE & South	2	Private & Public
53	BUBNJLdyk_gk1-345	Dasanayakana halli kunte	1.16	Agriculture	North	1	Farmer
54	BUBNJLdyk_kr2-346	Dasanayakana halli kere	16.13	Agriculture & factory	North East & South	0.2	Farmers & industries
55	BUBNJLdyk_kr3-347	Dasanayakanahalli Doddukunte	3.27	Agriculture & plantation	N, E, W	1	Farmers
56	BUBNJLhsm_kr1-348	Kodatti Kere	33.06	Agriculture &Graveyard	NW, W & N	15	Farmers & Public
57	BUBNJLhsm_kr2-349	Hunasemaranahalli kere	22.24	NH & Agriculture	E, W & N W	10	NH Authority & Farmers
58	BUBNJLktn_kr1-351	Kattigenahalli karabu lake	25.28	Houses & road	North	4	Public & Govt
59	BUBNJLmrn_kr5-356	Marenahalli kere	21.14	Huts, graveyard, layout,	South East, S,	1.5	Public & farmer

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
				agriculture	W		
60	BUBNJLnkt_kr1-357	Nellakunte kere	26.33	Agriculture	NE, E & SE	5	Farmers
61	BUBNJLstn_kr4-361	Sathanur karabu 4	19.00	Road, Agriculture, Hallowbrick factory & Graveyard	N, NE & SE, NW	0.8	Govt, Farmers, private & public
62	BUBNJLstn_gk8-365	Sathanuru kunte 8	1.15	Inside Delhi Public School			
63	BUBNJLsug_kr1-368	Suggata kere	7.13	Agriculture & Road	N & S	5	Farmers & Government
64	BUBNJLsug_ku2-369	Suggatta kunte	≈ 0.07	Layout	North West	0.2	Local residents
65	BUBNJLtms_kr1-370	Thimmasandra kere	102.14	Agriculture	All direction	70	Farmers
66	BUBNHGblj_kr1-375	Bilijaji kere	30.31	Agriculture	S,W	0.2	Farmer
67	BUBNHGbyl_kr1-376	Byalakere Kere	13.10	Agriculture	E, W & S	2	Farmer
68	BUBNHGgna_kr1-378	Guniagrahara Kere 1	18.23	Agriculture	NE	1.5	Farmer
69	BUBNHGikp_kr1-383	Ivarakandapura Kere	141.16	Plantation	N & NW	1	Dept.Horticul.
70	BUBNHGitg_kr4-387	Ittagalapura lake 2	19.20	Road & Poultry farm	SW, SE & South	4.5	Public & Private
71	BUBNHGitg_kr5-388	Ittagalapura lake 3	10.21	Agriculture	South East	2.5	Farmer
72	BUBNHGktm_kr1-390	Kalatammanahalli Kere	18.31	Agriculture	N, NE	2	Farmers
73	BUBNHGkln_kr1-392	Kalenahalli Kere	19.00	Agriculture	SE, SW & NE	Nil	Farmer
74	BUBNHGkst_kr4-397	Kasagattapura Kere 3	10.30	Road, House & Plantation	W, S & SE	1	Govt, Public
75	BUBNHGkmp_ku2-399	Kempapura Kunte 2	≈0.05	Eucalyptus Plantation	S,W	35	Farmer
76	BUBNHGkmb_kr1-405	Kumbarahalli Kere	34.36	Agriculture	NE & East	1	Farmer
77	BUBNHGlgn_kr2-408	Linganahalli Kere	18.15	Agri., layout & road	N, SE, SW& S	Nil	Farmer, govt
78	BUBNHGmdp_kr1-413	Madappanahalli Kere 1	16.02	Agriculture, road	E & W	20	Farmer, Govt
79	BUBNHGmdp_kr5-417	Aralakunta	10.36	Agriculture	NE & S	30	Farmer
80	BUBNHGmdp_ku7-419	Madappanahalli Kunte 4	≈0.07	Developers	S,W	45	Layout
81	BUBNHGmdp_ku8-420	Madappanahalli Kunte 5	≈0.07	AG Land	E,S & W	60	Former

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
82	BUBNHGmvp_kr1-422	Mavallipura Karabu Lake	22.02	Agri., Houses & road	E,S	25	Farmer, Public & Govt
83	BUBNHGmvp_kr5-426	Mavallipura Kere 3	20.14	Brick factory	N & SW	2.5	Private
84	BUBNHGmvp_kr6-427	Mavallipura Kere 4	65.15	Agriculture	NE, SE & N	15	Farmer
85	BUBNHGmyp_kr1-432	Mylappanahalli kere 1	13.38	Agriculture	East	0.5	Farmer
86	BUBNHGmyp_kr2-433	Mylappanahalli Kere 2	20.25	Road	N	1	Govt.
87	BUBNHGrjk_gk1-434	Kallakatte	1.24	Ambedkar bhavan	NW	0.5	Govt.
88	BUBNDPakm_gk1-454	Adikamaranahalli Kunte	1.34 1/2	Layout	North-East	30	Layout developer
89	BUBNDPalu_kr1-455	Alur kere	76.20	Agriculture & layout	W, E & SW	2	Farmers
90	BUBNDPbyd_kr2-458	Byandahalli kere	4.23	Mudroad	NW	0.1	Government
91	BUBNDPdsp_kr2-462	Dasanapura kunte-2	3.09	Building & layout	South West	4	Private
92	BUBNDPdsp_kr3-463	Dasanapura kere	44.33	Agriculture	North West	2	Farmers
93	BUBNDPggd_kr4-468	Gangondanahalli kere	63.30	Nice road	East	15	NICE
94	BUBNDPhrk_kr2-473	Harokyathanahalli kere	18.24	Compound wall	North East	0.5	Private
95	BUBNDPhgd_kr1-477	Heggadaevanapura kere-1	7.11	Fence	West	1	Farmer
96	BUBNDPkch_kr1-480	Kachohalli Kere-1	63.01	Layout	North	2	Layout developer
97	BUBNDPkch_kr2-481	Kachohalli Kere-2	9.17	Agriculture	South	15	Farmers
98	BUBNDPkud_kr1-485	Kuduregere kere	30.15	Agriculture, road	E, N &central	3.5	Farmer & Govt.
99	BUBNDPlkn_kr3-489	Lakkenahalli kere	15.16	Agri. & Eucalyptus	East	10	Farmer
100	BUBNDPlkp_kr1-490	Lakshmipura Kere	22.02	Agriculture	East	35	Farmers
101	BUBNDPmch_kr1-491	Machohalli kere	29.25	Road	East	0.5	Public
102	BUBNDPmdv_kr1-493	Madavara Kere	71.30	Hospital, Road & Layout	SW & East	12	Jindal Organisation & Government
103	BUBNDPnrp_ku1-494	Narasipura Kunte-1	0.09	Road, Over Head Tank, Drinking Water plant, Temple	SW, NW	10	Govt. & Public
104	BUBEVRbda_kr1-510	Bellandur Amanikere	919.38	Agriculture & Road	S & E	2	Farmer & Govt.

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
105	BUBEVRbda_kr2-511	Varthur Amanikere	445.14	House & Agriculture	SE, S & N	2	Public & Farmer
106	BUBEVRbhg_kr2-515	Bhoganahalli kere	12.24	Eucalyptus plantation & houses	SE & NE	2	Private
107	BUBEVRckb_kr1-522	Chikkabellanduru kere	75.21	Plantation, Temple & Road	South	9	Farmer & Public
108	BUBEVRguj_kr4-542	Gunjur Kere-1	65.39	Temple	NW	0.01	Public
109	BUBEVRguj_ku8-546	Gunjuru kunte5	0.29(GIS)	Brick factory, sheds & coconut plantation	NW & NE	5	Private
110	BUBEVRguj_ku12-550	Gunjuru kunte9	1.00	Eucalyptus plantation	S, SE & SW	30	Farmer
111	BUBEVRhly_kr1-551	Halanayakanahalli kere1	79.25	Road & agriculture	N,NE,E & S	7	Govt.& Farmer
112	BUBEVRhrl_kr2-554	Haraluru kere	34.07	Road	NE	1	Govt.
113	BUBEVRkcm_ku1-556	Kachamaranahalli kunte1	0.14	Eucalyptus plantation	South & North	20	Farmer
114	BUBEVRkcm_kr3-558	Kachamaranahalli Govt. Lake	18.01	Agri. land, Pl., Vl & Graveyard	South West & SE	40	Farmers & Public
115	BUBEVRkcm_ku7-562	Kachamaranahalli kunte6	0.25	Houses	East	25	Private
116	BUBEVRkkd_kr1-565	Kaikondanahalli kere	48.23	Road & sheds	NW & NE	0.2	Govt. & private
117	BUBEVRksv_kr4-569	Kasavanahalli kere	55.08	Plantation	NE & W	0.01	Public
118	BUBEVRkdt_kr3-575	Kodathi kere	78.01	Road & agriculture land	S &NE	2	Govt. & Private
119	BUBEVRkdt_ku7-579	Kodathi Kunte6	0.09 (SSLR)	Coconut plant.	East	40	Farmer
120	BUBEVRkdt_gk13-585	Kodathi Kunte12	2.22	Shed & Agriculture	N & E	90	Private
121	BUBEVRpnt_kr7-612	Panattur Govt. Kere	27.17	Road, graveyard & Railway Track	SW, E & lake Centre	10	GovT. & Private
122	BUBEVRsdp_kr8-625	Siddapura kere	27.35	Agriculture	NE & SE	10	Farmer
123	BUBEVRslk_kr5-634	Otikere	21.27	Agriculture	SE	1	Farmer
124	BUBEVRslk_kr9-638	Devarakere	12.36	Agriculture	E & S	2	Farmer
125	BUBEVRvrt_gk7-648	Varthuru kunte7	1.18	Eucalyptus plantation &	W, S & SE	80	Farmer & Private

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
			(SSLR)	brick factory			
126	BUBEKRbsp_kr1-666	Basavanapura kere	14.07	Compound wall, Road & temple	S,SE,W,NW & N	15	Private, Public & Govt.
127	BUBEKRbgn_kr1-668	Benniganahalli Kere	45.39	Railway track & houses	NE, NW & W	4	Central Govern. & private
128	BUBEKRbnp_kr1-674	B.Narayanapura kere	15.06	Outer ring road	lake Center	10	Government
129	BUBEKRbys_ku2-677	Byrasandra kunte	0.25	Road	South	30	Government
130	BUBEKRbys_kr3-678	Byrasandra kere2	14.19	Road	NE	6	Government
131	BUBEKRclk_kr1-679	Chellakere kere	38.05	Houses, Road & play ground	NW, W & S	30	Public & Govt.
132	BUBEKRcnp_kr2-683	Chinnappanahalli kere2	11.33	Apartment & house	E & SE	8	Private
133	BUBEKRdvs_kr1-684	Dyavasandra kere	16.08	Railway track & house	South	4	Central Govt. & private.
134	BUBEKRddk_kr6-691	Doddanekundi kere2	135.30	Temple	S-E	1	Public
135	BUBEKRhod_kr1-695	Hoodi kere	15.10	Graveyard	SE	3	Public
136	BUBEKRhrm_kr1-708	Horamavu kere	37.14	Houses	South	30	Private
137	BUBEKRhma_kr1-709	Gramadakere	51.34	Road & houses	W & S	4	Govt & Pvt.
138	BUBEKRkgd_kr1-710	Kaggadasapura kere	50.18	Shed	South East	3	Pvt
139	BUBEKRklk_kr1-711	Kalkere Kere	194.06	House & layout	N & W	5	Pvt.
140	BUBEKRkwd_kr1-716	Kowdenahalli Kere	67.39	Houses, Shed & School	NW & W	45	Public & Pvt.
141	BUBEKRkwd_kr2-717	Vijinapura kere2	11.28	Houses, School hostel & shed	SW & S	0.1	Public, Govt
142	BUBEKRkrp_kr2-727	Krishnaraja puram kere-1	21.27	Shed, Houses	E, S& NE	20	Public
143	BUBEKRmvp_kr1-732	Garudacharplayakere	5.36	Road	SE	2	Govt.
144	BUBEKRmvp_kr2-733	Garudacharya palya lake (Goshala)	5.14	Waste seggr. shed	NW	0.01	Private
145	BUBEKRmvp_kr3-734	Mahadevapura kere	26.23	IT Company & Road	SE & SW	0.1	Pvt. & Govt.
146	BUBEKRmvp_kr4-735	Bande Mahadevapura	13.11	Outer ring road	lake Centre	10	Government

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
		kere					
147	BUBEKRngn_kr1-736	Nagareshvara Nagenahalli Kere	11.08	Apartment & Houses	NW & SE	1	Private
148	BUBEKRnlr_kr1-739	Nallurahallikere	54.29	Shed & Road	NE & West	10	Public & Govt
149	BUBEKRpta_kr8-749	Pattaduru Agrahara kere-1	12.37	Plantation	All direction	90	Private
150	BUBEKRpta_kr12-753	Pattandur Agrahara kunte11	16.35	Graveyard	NW	0.1	Public
151	BUBEKRrch_kr2-757	Rachenahalli kere	131.06	Institutions-JNCASR, MGIRED, Rd. & house	North & NW	10	Govt. & Public
152	BUBEKRsdm_kr1-758	Sadaramangala lake	52.21	Compound wall	East	3	Private
153	BUBEKRseg_kr1-759	Shegehalli kere	31.13	Houses & Graveyard	West & SE	11.5	Private & Public
154	BUBEKRstm_ku1-760	Sonnathimmanahalli kunte	0.09	Houses & Road	S,W & NW	70	Pvt. & Govt.
155	BUBEKRvbp_kr3-776	Vibhutipura kere	45.18	Houses & Graveyard	S & SW	2	Public
156	BUBEKRwhf_kr5-788	Whitefield kere	19.32	Houses & compound wall	W & S	18	Private
157	BUBEBDbtr_kr1-800	Bhattarahalli kere	18.10	Garden city College & Rd.	West	4	Private & Public
158	BUBEBDbdr_kr1-802	Bidarahalli kere	96.26	Agriculture	NE	2	Farmer
159	BUBEBDbda_kr2-804	Bidarena agrahara kere	16.09	Eucalyptus Plantation	North	5	Farmers
160	BUBEBDbyp_kr1-808	Byappanahalli kere	43.33	Agriculture	North East	30	Farmers
161	BUBEBDcms_kr2-817	Chimasandra Kere	26.20	Road	South West	3	Govt.
162	BUBEBDckb_kr1-818	Chikkabanahalli kere	37.09	Houses	North West	15	Public
163	BUBEBDcgb_kr1-820	Chikkagubbi kere	21.11	Agriculture	W, N, SW & W	15	Farmers
164	BUBEBDddb_ku1-821	Doddabanahalli kunte1	≈0.20	Coconut & Eucalyptus Plant.	E & S	20	Farmers
165	BUBEBDdgb_kr1-825	Doddagubbi kere	132.12	Agriculture	South East	4	Farmers
166	BUBEBDhuv_kr2-839	Rampura Kere	187.31	Agriculture	South	0.01	Farmers
167	BUBEBDkdg_ku2-844	Kadugodi Kunte 2	0.10	Agriculture	South	30	Farmers
168	BUBEBDktg_kr1-875	Kithaganuru Kere	25.27	Road	NW & SW	4	Govt.

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
169	BUBEBDkdp_kr5-887	Konadasapura kere	8.23 (GIS)	Reserved to construct Apartment	NW & WS	5	Nites Estate Buildes
170	BUBEBDnbk_kr2-897	Nimbekaipura Kere	18.27	Agriculture & Graveyard	W & SE	5	Farmer & Public
171	BUBEBDver_kr1-908	Yellamallappashetti Kere	490.15	Road, BWSSB office, Pvt. School ground, Bulidings, Graveyard, Agri. & Eucalyptus plant.	SW, SE, N, NW & NE	4	Govt., Pvt. & Public
172	BUAKSPavl_kr5-917	Avalahalli kere	10.22	Central Govt.	lake Center	10	Railway track
173	BUAKSPckm_kr3-920	Govt Gulimangalada lake	46.19	Ag land	N-W	1	Farmers
174	BUAKSPckk_kr1-924	Chikkanekundi Lake land	43.11	AG Land, Eucalyptus plants, temple, Main road, agriculture	NE, South, S-E, NW	15	Farmer & Govt.
175	BUAKSPcdp_gk3-927	Chikkavaderapura Govt. Karabu Kunte	1.13	Eucalyptus Plantation	North	25	Nil
176	BUAKSPcks_kr1-929	Chokkasandra lake-1	15.32	Ag Land	SE	2	Farmer
177	BUAKSPcho_kr4-933	Choodasandra Govt Lake-3	20.16	AG land	SW	5	Farmers
178	BUAKSPdms_kr7-941	Dommasandra Govt Lake-1	39.19	AG land, graveyard	WS	3	farmer
179	BUAKSPdms_ku12-946	Dommasandra Kunte-11	0.20	Ag Land & Mango Plantation	West, North	5	Farmer
180	BUAKSPdms_kr17-951	Dommasandra Govt. Lake-2	3.29	Road, houses	E & W	9	Govt, public
181	BUAKSPgth_kr3-954	Gattihalli Govt. lake	72.39	Agriculture & road	N, S	2	Farmer, public & Govt
182	BUAKSPgot_kr1-955	Gottamaranahalli Govt. Lake	37.23	Agriculture	SE, SW, W	6	farmer
183	BUAKSPhgd_ku1-965	Heggondahalli Kunte-1	0.06	AG land	N-E, E-S, S-W	75	Farmers

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
184	BUAKSPhgd_kr3-967	Heggondahalli Govt. lake	13.15	Houses & agriculture	NE, S	7	Public & farmer
185	BUAKSPhsh_ku3-972	Hosahalli Kunte-3	0.16	Ag land	N-W, W-S	60	Farmer
186	BUAKSPhku_kr1-977	Huskur Govt. Lake	122.28	Railway track, agriculture	West, East	25	Govt, farmer
187	BUAKSPhku_ku2-978	Madhagar Kunte	0.14	Houses & AG Land	N-W & N-E	10	Villagers & Farmers
188	BUAKSPhku_gk4-980	Huskuru Kere	1.24	Ag land & OHT	S-W	10	Farmers & Govt
189	BUAKSPhku_ku5-981	Huskuru Kunte-3	0.21	AG land	N-E	10	Farmer
190	BUAKSPkag_kr2-983	Kada Agrahara Kere	14.38	Agriculture & layout	SW,NE,SE	1.5	Farmer & Private
191	BUAKSPkgp_kr1-985	Kagalipura Govt. Lake	14.13	Ag.land	N,NE	5	Farmar
192	BUAKSPkms_kr5-991	Rocherenvu	12.27	Agriculture & Road	North, NW	6	Farmer & Govt
193	BUAKSPkms_gk6-992	Kommasandra Kunte-4	2.17	Road & Eucalyptus Plants	E, North, NW	5	Govt. & Farmer
194	BUAKSPklu_kr4-1104	Kodlu Kere-2	13.05	Road, Temple, Apartment & Houses	NE, SE, West	5	Govt., Public & Private
195	BUAKSPnkd_ku1-1005	Nekkundi Dommasandra Kunte-1	0.33	Road	W-S	1	Govt.
196	BUAKSPrny_kr1-1008	Ramanayakanahalli Govt. Kere-1	28.02	AG land	West, SE	5	Farmers
197	BUAKABglh_kr2-1029	Gollahalli Govt. Lake	17.01	Road	East	5	Pvt
198	BUAKABhbg_kr1-1030	Uramundinakere	32.13	Houses	S, SW	1.5	Public
199	BUAKABvrs_kr1-1034	Veerasandra Govt. Kere-1	14.02	Vacant land, Building	West, N-E	6	Developer
200	BUAKABvrs_kr2-1035	Veerasandra Govt. Kere-2	17.06	Building	North	5	Developer
201	BUAKJGabj_kr1-1038	Bhujangadasana Amanikere Govt lake	54.02	vacant, Agriculture	NW, NE, SE	1	Farmer
202	BUAKJGbng_kr1-1039	Bannerughatta kunte1	3.21	Graveyard	SW, W	10	Public
203	BUAKJGbhu_gk4-1050	Bhuthanahalli Kunte-4	1.30	Road	West	2	Govt.
204	BUAKJGbhu_kr6-1052	Bhutanahlli lake	7.18	AG land	East	10	Farmer

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
205	BUAKJGbin_kr1-1057	Bingipura lake	28.01	Agriculture & Plantation	NW, S	6	Farmer
206	BUAKJGbin_ku2-1058	Bingipura Kunte1	0.16	Road & Agriculture	NE, SW	5	Govt. & Farmer
207	BUAKJGbin_kr6-1062	Govt. Kharabu kere	8.13	Vacant	SE	0.01	Public
208	BUAKJGglh_kr1-1067	Gollahalli lake	5.31	KEB Transform, office	North	40	Govt
209	BUAKJGhlm_kr7-1076	Hulimangala Govt. kere	67.07	AG land & Eucalyptus plantation	East, NW	5	Farmer
210	BUAKJGhlm_ku9-1078	Hulimangala kunte6	0.33	Eucalyptus plantation & Road	NE, East	10	Farmer & Govt.
211	BUAKJGhul_gk2-1081	Hullahalli Kunte1	2.26	Vacant land	North	2	Farmer
212	BUAKJGhul_kr3-1082	Matadakere	20.2	AG land, Graveyard, temple, Layout	NW, NE	6	Formar, public, Developers
213	BUAKJGhul_gk4-1083	Hullahalli Kunte2	2.35	Vacant land & Road	NE, East, South	5	Public & Govt.
214	BUAKJGhul_kr6-1085	Govt. Kharabu Kattehonge kere	4.04	Vacant Land	NW, WS	10	Public
215	BUAKJGhul_kr7-1086	Hullahalli Kere	17.17	Graveyard, Plantation & Layout	E & W	0.9	Public, Farmer & Developers
216	BUAKJGklk_kr2-1088	Kallakere lake land	4.08	Layout & compound	SE	3	Developer
217	BUAKJGklk_gk3-1089	Kallukere kunte	1.23	Located inside the Union Bank Compound and Not Allowed to visit			
218	BUAKJGlkp_kr2-1093	Lakshmipura lake	14.37	Temple, shed	SE, NW	1	public
219	BUAKJGmtp_kr1-1095	Mantapada kere	42.14	Vacant land & Graveyard	SE	2	public
220	BUAKJGmtp_ku2-1096	Mantapa kunte	0.32	Vacant land & Layout	North & W	1	Pvt.
221	BUAKJGmrg_kr1-1099	Maragondanahalli kere	18.39	Coconut plantation, Houses & Govt. School	North, East	10	public, Govt
222	BUAKJGnjp_kr1-1101	Nanjapura lake	18.09	AG land	SE	1	Farmer
223	BUAKJGnjp_gk2-1102	Nanjapura kunte	1.21	Eucalyp. plants, Meenakshi Resort, Temple, Road	North, SE, South, West	30	Farmer, Pvt, Govt
224	BUAKJGskv_gk2-1105	Sakalavara kunte	2.16	Vacant land	North	5	Farmer
225	BUAKJGvbs_gk1-1106	Vabasandra kunte1	1.06	AG land	South	50	Farmer
226	BUAKJGvbs_kr2-1107	Uramundinakere	8.38	AG land, Eucalyptus plants	NE, SE	2	Farmer
227	BUAKJGvbs_ku4-1109	Vabasandra kunte3	≈0.27	Agricuture	SE	15	Farmer

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
228	BUAKJGvdh_kr1-1111	Vaderahalli Govt. lake	4.15	Eucalyptus Plantation	North	0.1	Farmer
229	BUBSTKchn_gk6-1117	Bilnirkatte	≈1.20	Agriculture	South	2	Farmers
230	BUBSTKckl_gk4-1123	Chikkelluru kere	2.26	Agriculture, layout & road	NE, West & lake center	50	Farmers, Private & Govt.
231	BUBSTKkth_kr1-1126	Mogi Kere	4.25	Road	South	4	Government
232	BUBSTKkth_kr2-1127	Chikkagowodana Kere	5.12	Agriculture	NW	2	Farmer
233	BUBSTKklr_kr4-1133	Hosa Kere	24.11	Mango plantat.	South	1	Farmer
234	BUBSTKklr_kr5-1134	Gowdana Kere	8.37	Road,Vacant land	South	10	Government
235	BUBSTKkgp_gk1-1136	Koluru Gururayanapura Kunte1	1.10	Coconut plantation	North	20	Farmer
236	BUBSTKknp_ku1-1140	Koluru Nanjunadapura Kunte	1.00	Mango plant. & graveyard	South, East & West	20	Farmers & Public
237	BUBSTKylg_kr7-1147	Yelachagupperamapura Kere	21.43	Agriculture, Coconut & Mango plantation	E, SE	5	Farmer
238	BUBSTKylg_kr8-1148	Yelachaguppe karabu Katte	7.35	Agriculture & Road	SW	15	Farmer & Govt.
239	BUBSKGagr_ku3-1152	Agara kunte3	0.30	Located inside the The Art of Living International Center			
240	BUBSKGagr_kr4-1153	Chinnammanakere	3.29	Houses & Road	SE & E	3	Public & Govt.
241	BUBSKGagr_ku5-1154	Agara kunte 4	0.27	House	NW	No	Private
242	BUBSKGagr_kr7-1156	Agara kere	13.25	Agri. &Temple	NE & NW	2	Farmer & Public
243	BUBSKGbvk_kr1-1160	Badavamavarthekavalu Hosakere-1	≈5.20	Layout	SW	2	Developer
244	BUBSKGbvk_ku5-1164	Badavamavarthekavalu Kunte4	≈0.03	Agriculture	North	30	Farmer
245	BUBSKGbvk_kr9-1168	Kuppareddy kere	16.21	Road	W	6	Government
246	BUBSKGbhm_kr3-1173	Bheemanakuppe kere	5.24	Road, Grave Yard, Plant. & Agri.	SE & S	30	Govt., Public & Farmer

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
247	BUBSKGcnk_kr4-1180	Chinnakurchi kere-2	6.12	Road & Agri.	E, S & NE	3	Govt. & Farmer
248	BUBSKGcwp_kr1-1181	Govt. Gangashetty kere	37.14	Road & Vacant	E & SE	2	Private & Govt.
249	BUBSKGdvg_kr2-1185	Devagere kere	10.03	Agriculture	NE	2	Farmer
250	BUBSKGglh_kr1-1190	Gollahalli Govt Kere	19.26	Agriculture & road	S & N	6	Pvt. & Govt.
251	BUBSKGhgv_kr3-1194	Halagevaderahalli kere-2	17.10	Houses & road	E,S,SE,SW,W	20	Pvt. & Govt.
252	BUBSKGkmp_kr1-1198	Kambhipura Govt. Karabu kere-1	3.18	Sand storage, Compund wall & Road	SE, E & N	8	Pvt. & Govt.
253	BUBSKGkmp_kr3-1200	Kambhipura Govt. Karabu kere-2	5.13	Road	NE & E	2	Government
254	BUBSKGknk_kr1-1203	Kanaminiki Govt. Katte	5.21	House	NW	0.01	Public
255	BUBSKGknc_kr1-1214	Kenchinahalli kere	1	Agriculture	East	1	Farmer
256	BUBSKGkcp_kr3-1217	Kenchanapura Govt. Lake	17.20	Plantation	NW & SW	25	Farmer
257	BUBSKGkng_kr1-1220	Kasaba Kengeri kere	32.16	Road & compound wall	E & W	3	Govt. & Pvt.
258	BUBSKGkng_kr3-1222	Gumaiahana Kere	12.26	Road	West	5	Govt.
259	BUBSKGkom_kr5-1238	Kommaghatta Gokatte	5.21	Plantation	N, NW & SW	25	Farmer
260	BUBSKGkum_kr1-1242	Govt. Maggekere	5.32	Railway track & vacant land	West	20	Govt. & Pvt.
261	BUBSKGkgl_kr2-1255	K. Gollahalli kere	12.17	Agriculture	W	2	Farmer
262	BUBSKGlgd_kr1-1258	Konashetty kere	5.22	Road	North	1	Govt.
263	BUBSKGmlg_ku1-1259	Maligondanahalli kunte1	0.23	Coconut plant. & agri.	W & S	10	Farmer
264	BUBSKGmlg_kr2-1260	Maligondanahalli Lake1	6.30	Agriculture & Coconut plantation	SW	1	Farmer
265	BUBSKGmlg_kr4-1262	Maligondanahalli Lake2	17.10	Agriculture	S,N & NE	10	Farmer
266	BUBSKGmls_kr1-1263	Mylasandra Lake-2	16.02	Layout Road & Temple	W,SW	8	Private & Public
267	BUBSKGmks_gk1-1270	Govt karabu katte	2.16	Agri. Land & eucalyptus plant.	W, SW & S	5	Farmers

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
268	BUBSKGmks_kr2-1271	Karab Kere	3.06	Agriculcture land	South	2	Farmers
269	BUBSKGnyn_kr1-1274	Nayandanahalli kere	15.18	Railway track	NW	1	Govt.
270	BUBSKGrms_kr1-1278	Chikkakere	7.06	NICE & Local Road	NW, SW & SE	10	Public
271	BUBSKGsmp_ku1-1296	Sompura kunte 1	0.37	Agriculture	North	0.5	Farmers
272	BUBSKGvlg_kr1-1306	Valagerehalli kere	24.35	Plant., Graveyard, Mud road, Hollow Block factory & House	NW & ES	11	Farmer, Public & Private
273	BUBSKGvlg_kr3-1308	Bandimatta Hosa kere	54.14	Houses, Temple	E, SE & SW	8	Private & Public
274	BUBSKGvrs_kr1-1309	Narasapanakere	17.20	NICE Road	NE & SE	40	NICE
275	BUBSUHalh_kr1-1313	Alahalli Kere	21.25	House	SE	0.01	Public
276	BUBSUHarh_kr1-1314	Arehalli Kere	7.10	Sheds & Road	SW, NW	30	Public & Govt.
277	BUBSUHbys_kr1-1320	Byrasandra Kere	15.11	Graveyard & Houses	NE, SE, SW	8	Public & BDA
278	BUBSUHcuk_kr1-1323	Chunchanaghatta Kere	22.31	Road & Houses	SW & W	1	Govt. & Private
279	BUBSUHdks_kr1-1325	Doddakallasandra kere	21.16	Buildings & temple	NE & SE	10	Public
280	BUBSUHglh_kr1-1328	Subbedarana kere	19.10	NICE road	North	5	NICE
281	BUBSUHgtg_kr2-1330	Gottigere Kere	37.13	NICE road	South	5	NICE
282	BUBSUHgtg_kr5-1333	Subarayanakere	5.10	Road, Temple	NE, SE, SW	10	Govt. & Pvt.
283	BUBSUHgbl_kr2-1335	Gubbalal kere	8.10	layout & coconut plantation	SW & E	5	BDA
284	BUBSUHhsh_ku1-1338	Hosahalli kunte	0.12	House	South	0.01	Public
285	BUBSUHhkr_kr1-1339	Hosakerehalli Kere	59.26	Road, Factory, Houses	NW,SE	3	NICE & Private
286	BUBSUHkdr_kr1-1343	Goudanakere	9.30	Houses	N,NE,SW,W	20	Private
287	BUBSUHkbt_kr1-1347	Kembathahali kere	5.18	Temple & road	South, NE	2	public
288	BUBSUHknk_kr1-1349	Konanakunte kere	9.18	Road, Factory, graveyard Temple	E, S & NW	4	Govt. & Private
289	BUBSUHkot_kr1-1351	Krishna nagar kere	18.09	Buildings & Road	E & NW	1.5	Govt. & Private
290	BUBSUHmls_kr3-1355	Jogi kere	3.02	Road & Layout	E & SW	2	Govt. & Private
291	BUBSUHput_kr1-1358	Puttenahalli Kere	13.25	Road & houses	E & SE	4	Govt. & Private

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
292	BUBSUHskk_kr1-1363	Sarrakki kere	82.24	Temple, Buliding & school	All side of the lake	10	Govt., Public & Private
293	BUBSUHtlg_kr1-1364	Gowdarakere	19.16	Houses & layout	SE & SW	15	Private
294	BUBSUHtps_gk1-1367	Thippasandra kere	2.32	Road & Park	NE,S,W	25	Government
295	BUBSUHtur_gk1-1368	Thurahalli kunte	2.02	Houses, Road & Vacant land	NE, South, SW	5	Public & Govt.
296	BUBSUHuth_kr1-1369	Moge kere	15.16	Houses	N & E	3	Private
297	BUBSUHuth_kr3-1371	Doraikere	28.23	Sheds	SE	0.5	Private
298	BUBSUHuth_kr4-1372	Subramhanyapura kere	18.06	Houses	NW,NE,SW	30	Private
299	BUBSUHumk_gk6-1378	Uttarahalli Manavarthekaval kunte5	1.24	Agriculture land	North	2	KSSRDI
300	BUBSUHvjr_ku2-1381	Vajarahalli kunte2	1.00	Graveyard & Road	SW & W	3	Public
301	BUBSUHvjr_gk3-1382	Muniyappana katte	2.31	Coconut plantation & road	N & W	2	Private & Govt.
302	BUBSUHvsp_gk1-1383	Vasanthapura katte	1.33	Road & Arya Vaisnya Kalyana mantapa	North, NW	5	Govt. & Public
303	BUBSUHvsp_kr2-1384	Janaradhan kere	7.10	Buildings & roads	NE, S, W & NW	30	Private
304	BUBSUHydy_kr1-1388	Yediyur kere	18.02	Apartment, Samudya Bhavan & Settlement	E, SW & N	30	Private & Govt.
305	BUBSUHylc_kr2-1391	Annamma kere	7.32	Temple, Buliding & school	N,NW	10	Govt., Public & Private
306	BUBSBGark_kr1-1399	Arekere Govt. lake	37.21	Houses & Road	SE & N	4	Public & Govt.
307	BUBSBGbsp_kr1-1400	Basapura lake	11.02	Houses	S & SE	4	Private
308	BUBSBGbsp_kr3-1402	Basapura Govt.lake	10.29	Graveyard, road	North, SW	0.1	Public & Govt.
309	BUBSBGbvp_kr1-1403	Basavanapura Kere	7.34	House, Rd., Temple & Eucalyptus Plant.	W, NW, S	1	Public, Govt & farmer
310	BUBSBGbgu_kr2-1405	Chikkabegur kere	42.16	Houses & Road	NW,N & NE, E	8	Public & Govt.

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
311	BUBSBGbgu_kr3-1406	Begur Lake1	137.24	Agriculture & Nice Road, road, Houses & graveyard	S, NW,E	1	Farmer, Govt. & Public
312	BUBSBGbgu_kr6-1409	Begur Lake2	23.27	Layout & Agri.	S & W	0.5	Pvt. & Farmer
313	BUBSBGbgu_kr7-1410	Subbedarana kere	6.05	Road	SE	0.01	NICE
314	BUBSBGbgu_gk8-1411	Begur kunte4	1.01	Vacant land	NE	1	Private
315	BUBSBGbag_kr1-1417	Beratena Agrahara Lake	11.18	Small Church, Mud Road	SW	2	Public
316	BUBSBGbdp_gk3-1420	Govt. kere	2.30	Road & Vacant land	NE, South	5	Govt. & Public
317	BUBSBGcsp_kr1-1425	Gudde Lake	9.05	Abandoned buildings	NE	3	Private
318	BUBSBGcsp_kr2-1426	Chandrashekarapura Govt. lake	3.16	Houses, Mud road & vacant	N,W & SW	12	Public
319	BUBSBGddt_kr1-1428	Doddatogur lake	52.22	Graveyard, houses, road & agriculture, NICE Road	SW, S & N	10	Public, Farmers & Govt.
320	BUBSBGddt_gk3-1430	Doddatogur kunte 2	1.04	Villas	West, South	50	Concorde group
321	BUBSBGddt_kr4-1431	Chikkatogur kere	12.39	Road	West & South	0.1	Govt.
322	BUBSBGdnm_ku3-1434	Doddanagamangala Kunte3	0.22	Road	NE	5	Govt.
323	BUBSBGhrk_kr5-1440	Kythasandra Govt. Lake	16.29	Temple	NW	0.01	Public
324	BUBSBGhgs_kr1-1446	Hongasandra Govt. Lake	18.04	Road & Houses	SE	2	Govt. & Public
325	BUBSBGhum_kr1-1448	Hulimavu Kere	130.17	Buildings, Layout, Park, Vacant land, Agri. land, Road, Govt. School & Temple	S, SW, W & NW	10	Public, Farmer & Govt.
326	BUBSBGiba_kr2-1450	Ibbalur Govt. Lake	18.06	Road, temple & Graveyard	N , E, S & W	15	Govt & Public
327	BUBSBGjks_kr1-1451	Jakkasandra lake	11.21	Buildings	West	10	Govt.
328	BUBSBGkla_kr1-1454	Kalena Agrahara Govt. Lake	7.30	Settlement, road	NE, West	2.5	Public

Sl. No.	EMPRI Water Body Code	Waterbody Name	Extent (A-G)	Encroachment for	Direction of Encroachm.	Approx. % of encroach.	Encroached by
329	BUBSBGkmn_kr1-1456	Kammanahalli Govt. Lake	18.37	Road	South	3	NICE Road
330	BUBSBGkmn_kr3-1458	Kammanahalli Lake	7.11	House, Road	SW, NE, NW	0.5	Private, Govt
331	BUBSBGkpa_kr1-1460	Konappana Agrahara lake	28.10	Settlement, Graveyard & Road	S, E	20	Public
332	BUBSBGkrm_kr3-1472	Koramangala kere2	99.02	Houses, NDRI	N,S, W	90	Public, Govt.
333	BUBSBGmdw_kr1-1473	Madivala Kere	276.28	Road & Houses	NW	1	Govt. & Public
334	BUBSBGmyl_kr1-1474	Mylasandra Buddagana katte	4.29	Layout & Agriculture	W & E	4	Pvt. & Farmer
335	BUBSBGmyl_kr2-1475	Mylasandra Urumundinakere	5.25	Road & Houses	N & W	2	Govt & Pvt.
336	BUBSBGmyl_kr3-1476	Sullu Kunte Kere	8.33	Layout, Agriculture	NE, SE & E	5	Pvt. & Farmer
337	Eucalyptus Plantation & agriculture	Mylasandra Govt. Lake	14.36	Eucalyptus Plantation & agriculture	W	3	Farmer
338	BUBSBGngp_kr1-1481	Naganathapura kere	5.17	Compound wall & Houses	NW, South & SE	0.9	Central Jail & Public
339	BUBSBGsgs_kr2-1497	Govt. Jungu Kere	11.08	Road	North	0.8	Govt.
340	BUBSBGtvk_kr1-1503	Tavarekere lake	20.12	Park & Ground	All sides	50	Government
341	BUBSBGvkk_kr1-1507	Agara kere	142.29	Houses & Road	S, W, E, NE	15	BDA
342	BUBSBGvts_ku2-1509	Vitasandra kunte2	0.18	Mango Plantat.	West	10	Farmer
343	BUBSBGvts_kr3-1510	Vitasandra Govt. Lake	19.12	Layout	West, south	2	Private
344	BUBSBGylk_kr3-1513	Yellakunte Govt. Lake	7.29	House	North	0.8	Public
345	BUBSBGyln_kr2-1515	Yelenahalli Lake	4.39	Layout Compound wall	NE, South	2	Private

Table-7.9. Details of weightage factor assigned for parameters to priroritise the lakes for conservation

S.No.	Parameters	Assigned value
Lake Area		
1.	3.01 – 4 Acres	4
2.	4.01 – 5 Acres	5
3.	5.01 – 10 Acres	6
4.	10.01 – 20 Acres	7
5.	20.01 – 50 Acres	8
6.	50.01 – 75 Acres	9
7.	Above 75 Acres	10
Water Retention Period		
8.	1 Month	1
9.	2 Month	2
10.	3 Month	3
11.	4 Month	4
12.	5 Month	5
13.	6 Month	6
14.	7 Month	7
15.	8 Month	8
16.	9 Month	9
17.	Above 9 Months	10
Usage of Lake		
18.	Drinking	4
19.	Bathing+Swimming	1
20.	Fishing	2
21.	Irrigation	1
22.	Cattle Feeding	1
23.	Washing	1
24.	Groundwater Recharge	1
25.	Recreational Activity	1
26.	Cultural Activity	1
Biota Value in Lake		
27.	Fish	2
28.	Amphibia	1
29.	Reptiles	0.5
30.	Benthos	1
31.	Butterflies	1
32.	Odonates	1
33.	Birds	1
34.	Insects	0.5
35.	Aquatic Plant	1
36.	Herbs & Shrubs	1
Water Quality of Lake		
37.	Class-A	4
38.	Class-B	2
39.	Class-C	1
40.	Class-D	-1
41.	Class-E	-2
42.	Below Class-E	-4
43.	Dry	0
Encroachment on Lake		
44.	Very Small Area (upto 9.9%)	-2
45.	Small Area (10-19.9%)	-4
46.	Large Area (20-39.9%)	-6
47.	Largest Area (40-59.9%)	-8
48.	Huge Area (Above 60%)	-10
Indirect Point Source Pollution in Lakes		
49.	Sewage	-4
50.	Effluent	-6
51.	Agri. Runoff	-1
52.	Road Runoff	-2
Issues		
53.	Soil excavation	-2
54.	Sand washing	-2
55.	Washing	-3
56.	Religious practice	-2
57.	Weed infestation	-1

Table-7.10. List of Black Alert lakes that needs immediate revival

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
1	Ajjegowdana katte	4	2	1	3	0	0	-6	-3	-2	-1
2	Lakshmipura kere	7	3	1	3	-2	-1	-8	-4	-3	-4
3	Seegehalli kere	7	4	2	1	-1	0	-12	-1	-2	-2
4	Gantiganahalli Kere	10	3	5	3	-1	-4	-12	-5	-2	-3
5	Honnenahalli Govt Kere	6	4	6	1	-2	-4	-8	-1	-2	0
6	Lakshmisagara Kere	7	2	4	3	-1	-8	-10	0	-2	-5
7	Singanayakayahalli Govt. Gokatte	4	1	2	1	-1	-1	-6	-1	-2	-3
8	Srinivasapura lake	4	1	0	1	0	-4	-2	0	0	0
9	Vaderahalli kere	6	2	1	2	-2	0	-6	0	-3	0
10	Suggata kere	6	3	1	3	-1	-2	-6	-3	-2	-1
11	Thimmasandra kere	10	2	1	1	-1	-10	0	-1	-2	0
12	Kasagattapura Kere 3	7	3	1	2	-1	-1	-10	-5	-2	-6
13	Lakshmipura Kere	8	4	3	3	-1	-6	-12	-1	-2	-4
14	Bhoganahalli kere	7	2	1	3	-2	-1	-6	-4	-1	-1
15	Basavanapura kere	7	3	2	4	-1	-4	-9	-4	-2	-4
16	B.Narayanapura kere	7	4	0	4	0	-4	-7	-4	0	0
17	Horamavu kere	8	6	1	4	-2	-6	-6	-4	-1	0
18	Bande Mahadevapura kere	7	5	0	4	-2	-4	-6	-4	0	0
19	Pattaduru Agrahara kere-1	7	7	0	3	0	-10	-6	0	-1	0
20	Byappanahalli kere	8	6	1	2	0	-6	-7	-3	-2	-1
21	Dommasandra Govt. Lake-2	4	2	0	3	-2	-2	-6	0	-1	-2
22	Gollahalli lake	6	5	1	5	-2	-8	-4	-6	-1	-4
23	Kanaminiki Govt. kere	7	4	0	3	0	0	-12	-4	-2	-4
24	Doddakallasandra kere	8	4	1	3	-4	-4	-6	-4	0	-2
25	Janaradhan kere	6	7	0	3	-2	-6	-4	-4	0	0
26	Koramangala kere2	10	5	0	3	0	-10	-7	-4	0	-3

Table-7.11. List of Red Alert lakes that require immediate action

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
1	Kajarakanahalli Lake	9	3	0	4	0	-8	-6	0	-1	1
2	Kempambudhi lake	9	6	1	4	0	-6	-4	-4	0	6
3	Sampinge Kere	8	10	1	2	-2	-10	-1	-2	-2	4
4	Abbigere Kere	8	6	4	5	-2	-1	-8	-4	0	8
5	Bagalagunte Govt.Lake	7	10	1	4	-2	-2	-8	-4	0	6
6	Ganigarahalli kere	8	10	4	3	-1	0	-18	-2	-2	2
7	Herohalli Thotadakere	5	10	0	5	-3	0	0	-10	0	7
8	Karihobanahalli kere	4	1	0	4	0	0	0	0	-2	7
9	Laggeri Lake	6	6	0	5	0	-6	-4	-4	-1	2
10	Malgalu lake	6	3	1	3	0	-10	0	-2	0	1
11	Mallasandra Lake-1	6	2	0	2	-2	-1	-5	0	0	2
12	Mallasandra Lake-2	7	2	1	5	0	-1	-12	0	0	2
13	Atturu kere	10	2	0	5	0	-1	-4	-4	-1	7
14	Jarakabandi Kaval kelge kere	6	1	0	1	0	-6	0	0	0	2
15	Krishnasagara Kere	7	2	6	5	-1	0	-5	-6	-2	6
16	Medi Agrahara Kere	7	4	3	2	-1	-1	-7	-1	-2	4
17	Shivanahalli lake	7	2	1	3	0	-6	-2	0	-1	4
18	Thirumenahalli lake	6	2	2	6	-1	0	-4	-4	0	7
19	Veerasagara kere	8	3	1	5	0	0	-6	-4	-4	3
20	Venkateshapura lake	6	1	3	3	-2	0	-5	0	0	6
21	Bettahalsur kere	8	5	1	2	-2	-1	-4	-4	-2	3
22	Chagalatti kere	8	3	1	2	-1	-1	-6	-1	-2	3
23	Dasanayakanahalli Doddukunte	4	2	0	2	0	-1	-2	-1	-2	2
24	Kodatti Kere	8	5	5	5	-2	-4	-6	-5	-2	4
25	Hunasemaranahalli kere	8	5	5	5	-1	-4	-5	-3	-2	8
26	Sathanur karabu 4	7	6	5	3	-2	-1	-8	-1	-2	7
27	Byalakere Kere	7	10	1	4	-2	-1	-6	-5	-2	6
28	Guniagrahara Kere 1	7	10	1	3	-1	-1	-6	-5	-2	6
29	Ittagalapura lake 2	7	4	1	5	-1	-1	-4	-1	-2	8
30	Kalenahalli Kere	7	2	1	3	-4	0	-3	0	-2	4
31	Krishnarajapura Karabu katte	4	1	1	1	-2	0	0	0	0	5
32	Kumbarahalli Kere	8	6	1	4	-2	-1	-6	-1	-2	7
33	Madappanahalli Kere 1	7	2	1	3	-1	-6	0	-1	-3	2

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution		Issues	Total
								Point Source	Indirect Point Source		
34	Aralakunta	7	4	1	4	-1	-6	0	-1	0	8
35	Mavallipura Karabu Lake	8	10	1	2	-2	-6	-5	-5	0	3
36	Mylappanahalli Kere 2	8	3	1	3	-1	-1	-7	-1	-2	3
37	Alur katte	6	3	2	2	-1	0	-3	-1	-2	6
38	Dasanapura kunte-2	4	1	1	2	0	-1	-4	0	-2	1
39	Hanumanthasagara Kere	6	4	2	3	-1	0	-4	-2	-2	6
40	Harokyathanahalli kere	7	2	2	3	-2	-1	-4	-3	-2	2
41	Heggadaevanapura kere-1	6	7	2	1	-1	-1	-7	-1	0	6
42	Kachohalli Kere-1	9	8	2	2	0	-2	-10	-1	-2	6
43	Kachohalli Kere-2	6	7	1	1	-1	-4	-2	-1	-1	6
44	Kuduregere kere	8	3	2	3	-1	-1	-6	0	-2	6
45	Ambalipura kere	7	4	0	3	-2	0	-4	-4	0	4
46	Bellandur Amanikere	10	3	3	7	-2	-1	-9	-4	0	7
47	Devarabisanahalli kere	7	4	0	4	-1	0	-6	-4	0	4
48	Doddakanneli kere	7	2	0	3	-2	0	0	-4	0	6
49	Bellandure Gramadakere	9	4	1	4	-2	0	-4	-4	-1	7
50	Gunjuruplaya kere	8	3	1	3	0	0	-8	-4	0	3
51	Gunjur Kelaginakere	6	3	1	4	-2	0	-6	0	0	6
52	Junnasandra Kere	8	2	0	3	0	0	-4	0	-1	8
53	Kachamaranahalli Govt. Lake	7	2	2	3	0	-8	-1	0	-2	3
54	Kaikondanahalli kere	8	5	0	4	-1	-1	-6	-4	0	5
55	Mulluru kere	8	2	2	4	0	0	-6	0	-2	8
56	Panatthur kere	6	4	2	3	-1	0	-6	0	-2	6
57	Panattur Govt. Kere	8	3	0	4	-2	-4	-4	-4	0	1
58	Siddapura kere	8	3	1	6	-1	-4	-2	-4	0	7
59	Byrasandra kere1	7	4	2	5	-1	0	-6	-4	0	7
60	Byrasandra kere2	7	4	0	4	-2	-2	-4	-4	-2	1
61	Chellakere kere	8	5	2	3	0	-6	-6	-4	0	2
62	Doddanekundi kere2	10	3	1	4	-1	-1	-6	-4	0	6
63	Hoodi kere	7	4	0	4	-2	-1	-5	-4	-1	2
64	Kaggadasapura kere	9	5	1	4	-2	-1	-4	-4	0	8
65	Kowdenahalli Kere	9	6	2	5	-2	-8	-6	0	0	6
66	Vijinapura kere2	7	7	0	3	-2	-1	-4	0	-2	8
67	Krishnaraja puram kere-1	8	6	3	4	-2	-6	-4	-4	0	5
68	Garudacharplayakere	6	7	0	4	-2	-1	-4	-4	0	6

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution		Issues	Total
								Point Source	Indirect Point Source		
69	Garudacharya palya lake (Goshala)	6	7	1	4	-2	-1	-6	-4	0	5
70	Mahadevapura kere	8	6	2	4	-1	-1	-5	-4	-2	7
71	Nallurahalli kere	9	6	2	4	-1	-4	-7	-4	0	5
72	Pattandur Agrahara kunte11	7	7	1	0	-1	-1	-8	-4	0	1
73	Bhattarahalli kere	7	6	0	1	-1	-1	-8	-2	0	2
74	Bidarahalli kere	10	3	1	5	0	-1	-8	-3	-2	5
75	Bidarena agrahara kere	7	5	4	1	-2	-2	-8	-3	0	2
76	Chimasandra Kere	8	5	2	6	-1	-1	-4	-7	-2	6
77	Chikkabanahalli kere	8	4	2	5	-1	-4	-4	-7	-2	1
78	Chikkagubbi kere	8	6	2	5	0	-4	-4	-3	-2	8
79	Khajisonnenahalli Kunte7	4	6	0	0	-2	0	0	0	0	8
80	Kannamangala kere	7	6	2	5	-2	0	-7	-1	-2	8
81	Katamnalluru Kere	7	4	1	1	-2	0	-4	0	0	7
82	Kithaganuru Kere	8	4	1	4	-2	-1	-8	-2	-2	2
83	JinkeTimmasandra Kere	6	3	4	3	-2	0	-4	-4	0	6
84	Avalahalli kere	7	4	1	4	-1	-4	-3	-6	0	2
85	Govt Gulimangalada lake	8	4	2	2	-1	-1	-2	-3	-2	7
86	Chikkanagamangala Govt. Kere	7	5	0	4	-2	0	-2	-5	0	7
87	Govt. Vaddakere-2	5	2	0	1	-1	0	-6	0	0	1
88	Choodasandra Govt Lake-3	8	5	0	5	0	-2	-6	-3	-2	5
89	Dommasandra Govt Lake-1	8	5	2	5	-1	-1	-4	-4	-2	8
90	Tippasandra lake	7	4	2	6	-1	0	-8	0	-2	8
91	Harohalli Govt lake	7	4	2	5	-2	0	-8	-4	0	4
92	Heggondahalli Govt. lake	7	4	1	4	-1	-2	-3	0	-2	8
93	Kodlu Kere-2	7	6	0	3	-1	-1	-4	-4	0	6
94	Ramanayakanahalli Govt. Kere-2	7	3	0	4	-1	0	-4	0	-2	7
95	Tigalara Chowddenahalli Govt. Karabukere	8	4	1	5	-1	0	-6	-3	-2	6
96	Gollahalli Govt. Lake	7	7	1	5	-2	-1	-6	-4	0	7
97	Veerasandra Govt. Kere-1	7	9	0	5	-2	-2	-6	-6	-1	4
98	Veerasandra Govt. Kere-2	7	10	0	5	-2	-1	-6	-6	-1	6
99	Bannerughatta kunte1	4	5	1	5	-2	-4	-2	-4	0	3

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
100	Bhutanahlli lake	6	5	1	4	-1	-4	-1	-1	-2	7
101	Bingipura lake	8	5	0	4	-1	-2	-2	-6	0	6
102	Honnashetti kere	5	5	1	3	-1	0	-6	-1	0	6
103	Matadakere	8	3	2	3	-1	-2	-2	-1	-2	8
104	Govt. Kharabu Kattehonge kere	5	5	1	3	-2	-4	-2	-1	0	5
105	Kalkere Sarkari Kunte	4	2	0	1	0	0	0	0	0	7
106	Kallakere lake land	5	5	2	5	-2	-1	-4	-4	0	6
107	Lakshmipura lake	7	4	1	5	-2	-1	-6	-4	0	4
108	Maragondanahalli kere	7	5	0	5	-2	-4	-6	-4	0	1
109	Nanjapura lake	7	4	1	3	-2	-1	-2	-1	-2	7
110	Vaderahalli Govt. lake	5	2	1	4	-1	-1	-4	0	-2	4
111	Hosa Kere	8	2	1	3	0	-1	-2	-1	-2	8
112	Gowdana Kere	6	4	0	5	-1	-4	0	-1	-2	7
113	Yelachagupperamapura Kere	8	2	1	3	0	-1	0	-5	-2	6
114	Yelachaguppe karabu Katte	6	2	1	4	0	-4	-4	-1	0	4
115	Agara Chinnammanakere	4	5	1	4	-1	-2	-6	-4	0	1
116	Kuppareddy kere	7	5	0	5	0	-2	-12	0	-2	1
117	Badavamavarthekavalu Kunte7	4	3	0	0	0	0	0	0	0	7
118	Bheemanakuppe kere	6	4	0	5	0	-6	-6	-1	0	2
119	Deevatigeramanahalli kere	6	3	0	4	-1	0	-2	-4	-2	4
120	Halagevaderahalli kere-2	7	6	1	4	0	-6	-4	-4	0	4
121	Kambhipura Govt. Karabu kere-1	4	6	1	5	0	-2	-5	-4	0	5
122	Kambipura kunte1	4	5	0	2	-1	0	-3	-4	0	3
123	Kambhipura Govt. Karabu kere-2	6	4	0	5	0	-1	-6	0	0	8
124	Kenchinahalli kere	5	5	1	4	-2	-1	-4	-4	0	4
125	Kenchanapura Govt. Lake	7	3	1	3	0	-6	-2	0	-2	4
126	Kommaghatta Gokatte	6	3	0	3	0	-6	0	0	0	6
127	Govt. Maggekere	6	5	0	4	-2	-6	0	0	0	7
128	K. Gollahalli kere	7	3	0	5	0	-1	-2	0	-4	8
129	Maligondanahalli Lake1	6	6	1	4	-1	-1	-8	0	-2	5
130	Maligondanahalli Lake2	7	4	0	4	0	-4	-4	0	-2	5

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution Point Source	Pollution Indirect Point Source	Pollution Issues	Total
131	Nayandanahalli kere	7	6	1	3	0	-1	-4	-4	0	8
132	Ramasandra Chikkakere	6	5	1	4	-1	-4	-6	-4	0	1
133	Kallapanakatte kere	6	4	1	5	-2	0	-6	0	0	8
134	Thimappanakere	4	6	1	4	-2	0	-4	-4	-1	4
135	Valagerehalli kere	8	5	2	5	-1	-4	-6	-4	0	5
136	Bandimatta Hosa kere	9	10	0	4	-6	-2	-7	-4	-3	1
137	Narasapanakere	7	6	1	4	-4	-8	0	0	-2	4
138	Alahalli Kere	8	7	0	3	-1	-1	-4	-4	0	8
139	Arehalli Kere	6	10	0	4	-4	-6	-4	-4	0	2
140	Chunchanaghatta Kere	8	5	1	3	-2	-1	-4	-4	0	6
141	Subbedarana kere	8	3	0	4	-2	-1	-6	0	-1	5
142	Gottigere Kere	8	6	3	3	-2	-1	-6	-4	0	7
143	Subarayanakere	6	7	1	3	-2	-4	-4	-4	0	3
144	Gubbalal kere	6	5	0	3	-2	-1	-4	-4	0	3
145	Goudanakere	6	5	3	5	0	-6	-6	-4	-1	2
146	Kembathahali kere	6	3	1	3	0	-1	-6	-4	0	2
147	Konanakunte kere	6	6	1	3	-2	-1	-6	0	-1	6
148	Puttenahalli Kere	7	8	1	3	-1	-1	-6	-4	0	7
149	Sarrakki kere	10	10	0	3	-1	-4	-6	-4	-1	7
150	Gowdarakere	7	8	0	3	-2	-4	-4	-4	0	4
151	Subramhanyapura kere	7	10	1	3	0	-6	-4	-4	-1	6
152	Annamma kere	6	10	1	3	0	-4	-8	-4	0	4
153	Arekere Govt. lake	8	4	0	3	-1	-1	-5	-4	0	4
154	Basapura Govt.lake	7	5	1	2	-1	-1	-2	-4	0	7
155	Basavanapura Kere	6	4	0	5	-2	-1	-6	-4	0	2
156	Chikkabegur kere	8	7	1	3	-2	-2	-7	-4	0	4
157	Subbedarana kere	6	6	1	3	-2	-1	-1	-4	0	8
158	Beratena Agrahara Lake	7	5	0	4	0	-1	-6	-4	0	5
159	Chandrashekarapura Govt. lake	4	3	0	2	0	-4	0	0	-2	3
160	Doddatogur lake	9	7	2	4	-2	-4	-7	-4	0	5
161	Chikkatogur kere	7	7	1	4	-4	-1	-7	-4	0	3
162	Kythasandra Govt. Lake	7	8	0	3	-1	-1	-6	-4	0	6
163	Hommedevanahalli Kere1	4	5	0	3	-2	-1	0	-4	0	7
164	Hongasandra Govt. Lake	7	6	0	5	-2	-1	-6	-4	0	5

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
165	Ibbalur Govt. Lake	8	6	0	3	-2	-4	-4	-4	0	3
166	Kalena Agrahara Govt. Lake	6	5	0	3	-1	-1	-6	-4	0	2
167	Kammanahalli Lake	6	5	0	5	-1	-1	-5	-4	-2	3
168	Konappana Agrahara lake	8	7	1	4	-2	-6	-6	-4	0	2
169	Naganathapura kere	6	6	0	5	-1	-1	-4	-4	0	7
170	Kodagi Singasandra kere	7	5	2	3	0	0	-7	-4	0	6
171	Tavarekere lake	8	3	0	3	0	-8	0	0	0	6
172	Yellakunte Govt. Lake	6	6	0	4	0	-1	-7	-4	0	4
173	Yelenahalli Lake	5	5	1	5	1	-1	-6	-4	0	6

Table-7.12. List of Yellow Alert lakes that require conservation

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
1	Rajamahal Kere (Newly Created)	5	10	0	4	-2	0	0	-2	0	15
2	Chikkabanavara kere	10	10	4	3	-2	-2	-6	-8	0	9
3	Chokkasandra Lake	8	10	2	5	-1	-2	-6	0	0	16
4	Doddabidarakallu lake	8	10	0	4	-2	-1	-4	-4	-1	10
5	Andhrahalli Lake	7	10	1	4	-2	0	-4	0	0	16
6	Herohalli Lake	8	10	1	6	-1	0	-4	-4	0	16
7	Kammagondanahalli lake	8	6	1	2	0	0	-2	-4	-2	9
8	Kannalli kere	9	10	2	6	-1	-2	-12	-1	-2	9
9	Kodigehalli kere	6	10	1	3	-1	0	0	-4	-1	14
10	Lingadheeranahalli Karabu Katte	5	3	1	4	0	0	0	0	0	13
11	Lingadheeranahalli Lake	6	3	1	4	0	-2	0	0	0	12
12	Mallathahalli Lake	9	10	2	6	-1	0	-6	-4	0	16
13	Haranakatte	6	10	2	3	-4	-6	0	0	0	11
14	Badakukere	4	10	2	3	-2	-2	-2	-4	0	9
15	Nagarabhavi Kere	5	7	0	5	-2	0	0	-4	0	11
16	Nelagadiranahalli Lake	6	10	0	5	-2	0	-6	-4	0	9
17	Nelagadiranahalli Hosakere	7	10	0	5	-2	-2	0	-4	0	14
18	Narasahalli Lake	9	10	0	3	-2	0	0	-4	0	16
19	Srigandhakavalu Karabu Katte	6	3	1	6	0	-1	-6	0	0	9
20	Ullalu lake-2	8	10	2	6	-1	-1	-8	-4	0	12
21	Allasandra Lake	8	10	1	3	-1	-2	0	-4	0	15
22	Amruthahalli Lake	8	10	1	5	-2	-1	-6	-4	0	11
23	Avalahalli Kere	7	2	1	2	-2	0	0	-1	0	9
24	Bellihalli kere	7	4	1	3	-1	-2	0	0	-1	11
25	Chokkanahalli lake	7	10	0	3	-1	-2	0	-4	0	13
26	Dodda Bommasandra Lake	10	5	0	5	0	0	0	-4	0	16
27	Harohalli kere	9	2	3	5	-1	0	0	-6	-1	11
28	Thupinkere	7	4	6	4	-1	-1	-6	-1	-2	10
29	Nagadasanahalli Kere	10	10	4	4	-2	-2	-10	-1	-2	11
30	Narasipura Lake-1	7	6	2	5	-1	-1	0	-4	0	14
31	Narasipura Lake-2	7	6	0	5	-2	-2	0	-4	0	10

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution: Point Source	Pollution: Indirect Point Source	Issues	Total
32	Puttenahalli Lake	8	10	0	3	-2	0	-4	-4	-1	10
33	Ramagondanahalli kere	8	5	1	3	-2	-1	-2	-1	-2	9
34	Singapura lake	9	7	4	3	-1	-2	0	-4	0	16
35	Dasanayakana halli kere	7	2	2	2	0	-1	0	0	0	12
36	Kattigenahalli karabu lake	8	6	2	7	-2	-1	-4	-4	0	12
37	Marenahalli kere	8	10	2	3	-2	-1	-2	-3	-2	13
38	Nellakunte kere	8	3	1	4	-2	-2	0	-1	-2	9
39	Bilijaji kere	8	10	1	3	-1	-1	-4	-1	-2	13
40	Byalakere Govt Kere	7	10	1	3	-1	0	-6	-1	-2	11
41	Huralichikkanahalli Kere	8	4	1	4	-2	0	0	-1	-2	12
42	Ivarakandapura Kere	10	5	1	4	-1	-1	-4	-1	-2	11
43	Ittagalapura lake 1	5	3	1	3	-2	0	0	0	-1	9
44	Ittagalapura lake 3	7	3	5	2	-1	-1	-2	-1	0	12
45	Kalatammanahalli Kere	7	5	2	3	-1	-1	0	-1	0	14
46	Kasagattapura Kere 2	7	10	1	3	-1	0	-4	-1	-2	13
47	Linganahalli Kere	7	5	1	3	-1	0	0	-1	-2	12
48	Lingarajapura kere	6	4	1	4	-1	0	-4	-1	0	9
49	Mavallipura Kunte 1	4	3	1	2	0	0	0	0	0	10
50	Mavallipura Kere 3	8	4	1	2	-1	-1	-2	0	-2	9
51	Mavallipura Kere 4	9	3	1	4	-1	-4	0	-1	-2	9
52	Mylappanahalli kere 1	7	4	1	3	-1	-1	-2	0	-2	9
53	Byandahalli kere	5	4	1	5	-2	-1	0	-3	0	9
54	Dasanapura kere	8	10	0	2	-2	-1	-1	-1	0	15
55	Lakkenahalli kere	7	7	4	4	-2	-4	0	0	0	16
56	Ambalipura Kelaginakere	6	3	0	6	-2	0	0	0	0	13
57	Varthur Amanikere	10	10	3	6	-1	-1	-6	-4	0	17
58	Chikkabellanduru kere	10	4	1	4	0	-2	-6	0	-2	9
59	Gunjur Kere-1	9	4	2	4	0	-1	-6	-1	-2	9
60	Halanayakanahalli kere1	10	3	2	4	0	-1	-6	0	-2	10
61	Haraluru kere	8	4	2	5	-1	-1	-4	0	0	13
62	Kodathi kere	10	4	2	3	0	-1	0	-7	0	11
63	Munekolalu kere	7	4	1	6	-2	0	0	0	0	16
64	Hado shiddapura kere	8	3	3	4	-2	0	0	0	-2	14
65	Otikere	8	2	2	4	0	-1	-2	0	0	13
66	Devarakere	7	4	2	4	0	-1	-2	0	-2	12

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution Point Source	Pollution Indirect Point Source	Issues	Total
67	Benniganahalli Kere	8	10	1	4	0	-2	-3	-4	-1	13
68	Chinnappanahalli kere2	7	6	0	5	-1	-2	0	0	0	15
69	Dyavasandra kere	7	5	2	4	0	-2	-6	0	0	10
70	Giddanakere	8	5	2	4	-1	0	-4	-4	0	10
71	Gramadakere	9	5	0	5	-2	-1	-7	0	0	9
72	Kalkere Kere	10	8	1	3	-2	-1	0	-4	0	15
73	Vengaiahanakere	9	10	1	4	-1	0	-6	-4	0	13
74	Kundalahalli kere	8	5	1	6	0	0	-6	-4	0	10
75	Nagareshvara Nagenahalli Kere	7	5	2	5	-2	-1	-7	0	0	9
76	Rachenahalli kere	10	10	3	7	-1	-4	-7	-4	0	14
77	Shegehalli kere	8	6	2	4	-2	-4	4	-4	0	14
78	Vibhutipura kere	8	7	1	4	-2	-1	-4	-4	0	9
79	Whitefield kere	7	10	2	5	-2	-4	-6	0	0	12
80	Kada Agrahara kunte	5	6	1	5	0	0	-1	0	0	16
81	Konadasapura kere	6	5	2	4	-1	-2	-2	0	0	12
82	Nimbekaipura Kere	7	3	2	3	0	-2	0	0	0	13
83	Yellamallappashetti Kere	10	10	3	2	-1	-1	-7	-5	0	11
84	Yarappanahalli Kere1	7	5	2	4	-2	0	-6	0	0	10
85	Yarappanahalli Kere2	7	10	1	0	0	0	0	0	-2	16
86	Chikkanekundi Lake land	8	5	3	5	-2	-4	-3	0	-2	10
87	Chokkasandra lake-1	7	3	1	4	2	-1	-5	0	-1	10
88	Gottamaranahalli Govt. Lake	8	7	1	5	-1	-2	0	-1	-3	14
89	Hosahalli Govt. lake	7	5	3	4	-2	0	-2	0	-2	13
90	Huskur Govt. Lake	10	6	3	7	-2	-6	0	-1	-1	16
91	Kada Agrahara Kere	7	4	2	5	-2	-1	-2	0	0	13
92	Kagalipura Govt. Lake	7	3	2	5	-1	-1	-6	0	0	9
93	Rocherenvu	7	4	2	4	0	-2	-2	0	-2	11
94	Kodlu lake-1	8	10	0	4	-2	0	-2	-4	0	14
95	Ramanayakanahalli Govt. Kere-1	8	4	2	4	-2	-1	0	0	-2	13
96	Singena Agrahara Govt. Sanna kere	10	4	2	5	-2	0	0	0	-2	17
97	Uramundinakere	8	10	0	5	-2	-1	-7	-4	0	9
98	Hebbagodi Govt. Attikere	7	10	0	5	-2	0	-6	-4	0	10

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution: Point Source	Pollution: Indirect Point Source	Pollution: Issues	Total
99	Bhujangadasana Amanikere Govt lake	9	5	1	5	-2	-1	-4	0	-2	11
100	Bannerughatta lake land	8	5	1	5	-2	0	0	-6	0	11
101	Kumbarakere	5	4	2	5	-1	0	-2	-2	0	11
102	Begihalli Govt. Kere	6	5	0	4	4	0	0	0	-2	17
103	Byatarayanadoddi kere	7	6	5	4	1	0	-8	-2	0	13
104	Bilwaradahalli kere	6	6	4	7	-1	0	-4	-1	-2	15
105	Bilwaradahalli Hosakere	7	10	3	3	-2	0	0	-4	0	17
106	Govt. Kharabu kere	6	2	0	4	0	-1	0	0	-1	10
107	Hulimangala katte	7	4	1	5	-1	0	0	0	0	16
108	Hulimangala Govt. Kodi Kere	4	4	2	4	-2	0	0	0	0	12
109	Hulimangala Govt. kere	9	5	2	4	-2	-1	-2	0	-2	13
110	Hullahalli Kharab Kere	6	4	1	4	-1	0	-3	-1	0	10
111	Hullahalli Kere	7	5	0	6	0	-1	-1	-1	0	15
112	Kannaikana Agrahara Kere	4	4	0	3	2	0	0	0	0	13
113	Mantapada kere	8	4	2	5	-1	-1	0	0	-2	15
114	Govt Vadenakere	5	4	1	4	-1	0	0	0	0	13
115	Addigenakere	6	5	1	5	-1	0	0	-1	-2	13
116	Bidarekere lake land	10	6	2	4	-1	0	-9	0	0	12
117	Sakalavara Govt. Kharabu lake	8	4	1	5	-2	0	0	0	0	16
118	Uramundinakere	6	4	1	5	-1	-1	0	-1	0	13
119	Channenahalli Govt. kere	6	5	0	4	2	0	0	0	0	17
120	Chikkelluru Govt. Kere	7	3	1	5	0	0	0	-1	-2	13
121	Chikkagowodana Kere	5	3	1	5	0	-1	0	-1	-2	10
122	Agara kere	7	4	5	4	-1	-1	0	-1	0	17
123	Badamanavarthakaval Hosakere-1	6	5	1	3	1	-2	0	0	0	14
124	Badamanavarthakaval Hosakere-2	8	7	2	5	-1	0	-2	0	-2	17
125	Bhimmanakuppe Govt lake	7	4	1	5	-1	0	0	0	-4	12
126	Chinnakurchi kere-1	9	5	0	5	-4	0	0	0	-2	13
127	Chinnakurchi kere-2	6	3	1	5	1	-1	0	-3	0	12
128	Govt. Gangashetty kere	8	10	2	4	-4	0	0	-4	0	16
129	Devagere kere	7	4	0	5	0	-1	-2	0	-2	11

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution: Point Source	Pollution: Indirect Point Source	Pollution: Issues	Total
130	Gollahalli Govt Kere	7	5	0	3	1	-2	0	0	0	14
131	Kanaminiki Govt. Katte	6	5	1	5	0	-1	-4	0	-2	10
132	Kasaba Kengeri kere	8	7	2	4	0	-1	-6	-4	0	10
133	Gumaiahana Kere	7	4	0	5	-2	-1	0	-2	0	11
134	Kommaghatta Govt. Lake	8	10	2	5	-1	0	0	-4	-2	18
135	Konashetty kere	6	3	0	4	0	-1	0	0	0	12
136	Mylasandra Lake-2	7	5	1	5	0	-2	0	-2	0	14
137	Muppatu Kavalu Sakari	8	6	2	5	-1	0	-4	0	-2	14
138	Maragondanahalli Govt. Lake	6	4	0	5	-1	0	0	0	0	14
139	Karab Kere	4	4	1	5	0	-1	0	0	-2	11
140	Ramasandra Kere	10	7	1	5	0	0	-6	0	-2	15
141	Ramohalli kere	9	3	0	4	1	0	-6	0	-2	9
142	Sompura Govt.lake	7	5	1	3	1	0	0	0	0	17
143	Devarakere	6	6	1	3	-1	0	-4	0	0	11
144	Byrasandra Kere	7	6	2	5	-2	-2	-4	0	0	12
145	Hosakerehalli Kere	9	5	4	3	0	-1	-6	-4	-1	9
146	Krishna Nagar kere	7	5	4	3	-1	-1	-4	-4	0	9
147	Jogi kere	4	3	3	5	4	-1	0	-4	-1	13
148	Moge kere	7	6	1	3	-1	-1	0	-4	0	11
149	Doraikere	8	10	2	3	-1	-1	0	-4	0	17
150	U. Manavarthekaval kere	7	5	0	4	0	0	0	0	0	16
151	Yediyur kere	7	10	1	3	-1	-6	0	0	0	14
152	Basapura lake	7	5	0	5	-2	-1	0	-4	0	10
153	Begur Lake2	8	5	3	3	-1	-1	0	0	-2	15
154	Nyanappanahalli Kere	6	6	0	5	1	0	-2	-4	0	12
155	Gudde Lake	6	4	1	5	-2	-1	0	0	0	13
156	Hulimavu Kere	10	7	4	7	-1	-4	-7	-4	0	12
157	Jakkasandra lake	7	5	0	4	0	-4	0	0	0	12
158	Mylasandra Buddagana katte	5	3	1	3	4	-1	-2	0	0	13
159	Mylasandra Urumundinakere	6	3	2	6	1	-1	-6	0	0	11
160	Sullu Kunte Kere	6	6	0	5	3	-1	0	-1	-2	16
161	Mylasandra Hosakere	5	5	1	5	2	0	-5	0	0	13
162	Parapana Agahara Lake	7	7	0	3	1	0	-4	-4	0	10

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
163	Govt. Jungu Kere	7	7	2	7	-1	-1	0	-4	0	17
164	Agara kere	10	8	0	5	-1	-4	-6	0	0	12
165	Vitasandra Govt. Lake	7	5	4	5	-1	-1	-2	0	0	17

Table-7.13. List of Green Alert lakes that require action

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
1	Hebbal kere	10	10	3	5	-1	-2	0	-6	0	19
2	Mattikere Kere	10	10	1	7	-2	0	0	-4	0	22
3	Sankey Tank	8	10	1	5	-1	-2	-1	-2	0	18
4	Ulsoor Lake	10	10	2	6	1	0	0	-4	0	25
5	Lalbhagh kere	8	10	1	5	-1	-2	0	0	0	21
6	Agrahara Lake	7	10	0	3	-2	0	0	0	0	18
7	Kasaba Amanikere	10	10	2	6	-1	0	-2	-4	0	21
8	Kogilu kere	10	10	0	4	-1	0	-4	0	0	19
9	Kattigenahalli lake	8	10	3	7	-2	0	-2	-6	0	18
10	Alur kere	10	10	2	2	-1	-1	0	-1	0	21
11	Gangondanahalli kere	9	10	3	4	-2	-4	-1	0	0	19
12	Machohalli kere	8	7	4	3	-2	-1	0	0	0	19
13	Madavara Kere	9	10	0	5	-2	-4	0	0	0	18
14	Kasavanahalli kere	9	10	3	5	-2	-1	-2	-4	0	18
15	Doddagubbi kere	10	5	4	5	0	-1	-2	0	-2	19
16	Sadaramangala lake	9	7	2	4	-1	-1	0	0	-2	18
17	Sonnenahalli kere	8	10	3	4	-1	0	-5	0	0	19
18	Rampura Kere	10	10	0	6	-1	-1	0	-2	-1	21
19	Kannuru kere2	9	5	2	5	-2	0	0	0	0	19
20	Rayasandra Kere	10	10	3	5	-1	0	-4	-4	0	19
21	Mogi Kere	5	10	2	5	-1	-1	0	-1	0	19
22	Vaderahalli lake	8	7	3	5	-1	0	0	0	0	22
23	Bheemanakuppe Hosakere	10	7	2	5	-1	0	0	0	0	23
24	Govt. Gaddakere	7	4	1	7	0	0	0	0	0	19
25	Begur Lake1	10	7	5	5	-1	-1	-2	0	0	23
26	Kammanahalli Govt. Lake	7	6	5	7	-1	-1	-5	0	0	18
27	Madivala Kere	10	10	5	7	-1	-1	-5	-4	0	21
28	Mylasandra Govt. Lake	7	5	2	5	1	-1	-1	0	0	18

Table-7.14. List of Blue Alert Water bodies that require future preservation

Sl No.	Name of lakes	Size	Water Retention	Water Usage	Biota Value	Water Quality	Encroachment	Pollution			Total
								Point Source	Indirect Point Source	Issues	
1	Nagawara Lake	10	10	2	7	-1	0	0	0	0	28
2	Jakkuru lake	10	10	3	5	-1	-1	0	0	0	26
3	Gattihalli Govt. lake	9	10	5	7	-2	-1	-2	0	0	26

CHAPTER

8

MANUAL FOR INVENTORISATION OF WATER BODIES

Chapter-8: Manual for Inventorisation of Water bodies

8.1. Introduction:

Inventory of the water bodies would mean the summary of all the basic hydrological data in the specific area or jurisdiction. Inventorisation of all types of water bodies such as *Kere*, *Gokatte* and *Kunte*; whether it is existing or disused, that will be useful for decision makers to conserve the lentic water sources. The inventorisation involves the identification of water bodies in the maps and also physical verification. Inventorisation of water bodies in the urban area is one of the hardest task for the limnologist as well as for the ecologist because the water bodies have lost its characteristics due to development.

The manual will be used as a guide for the inventorisation of the water bodies in other urban areas of the Karnataka State. Inventorisation of the existing water bodies is easiest when compared to the disused water bodies, predominantly minor water bodies. Most of the small water bodies such as the *Gokatte* and *Kunte* in the urban area have disused due to the greed of the people on the water body land (encroachment), in the name of development and to provide the facilities to the urban people. As the urban population has the greater percentage of migrating and floating population, the urban people are unable to help in the inventorisation of the water bodies. Therefore the only way is to inventorise the water bodies based on the available secondary data with the help of technology like Remote Sensing and GIS.

8.2. Materials Needed:

i. GPS instrument to locate water bodies & its elevation

ii. Camera for photographs

iii. Measuring tape to measure the thickness of water body bund

iv. Field Datasheet to note the field data

v. Village & taluk map for verification in the field

vi. Lake map (if available) for cross verification in the field

vii. KML file of village map superimposed on Google imagery with mark of water bodies to inventorise water bodies with ease

8.3. Guidelines:

The guidelines for the inventorisation has been developed to inventorise the water bodies in other urban areas of Karnataka State based on the experience in inventorisation of water bodies in BMA, Mysuru and Nanjangud Local Planning Area (LPA). There are three steps in inventorising the water bodies in the urban area: preliminary, inventorisation and confirmation step. The flow chart for the inventorisation of water bodies in the urban area is shown in Figure-8.1.

8.3.1. Preliminary Step:

Preliminary work should be carried out in office before the inventorisation of the water bodies, which is called as deskwork. The first step for inventorisation of the water bodies should be demarcation of the water bodies inventorisation area, it may be the corporation area or planning area of any Authority of even KLCDA jurisdiction area (include municipal corporation administrative and planning area). After demarcation of the inventorisation area, the names of the villages that falls under the demarked area should be listed out for village (micro-) level inventorisation of the water bodies. Superimpose the village maps on the demarked area to create the base map for the inventorisation of the water bodies.

The other preliminary work for the inventorisation of water bodies is collection of maps such as the administrative area map, planning area map, master plan, Comprehensive Development Plan (CDP), village maps, digitized village maps, .KML format of village maps, taluk maps, toposheet, MI tank maps, SSLR surveyed lake maps. Apart from maps the available secondary data viz… Detailed Project Report (DPR), list of lakes under custodian, list of rejuvenated lakes, name and role of stakeholder should be collected from the lake custodian, administrative and planning Authorities.

8.3.2. Inventorisation:

Inventorisation of the water bodies in the demarked area should be done by two steps such as deskwork (planning) and verification (field) based on the collected secondary data and maps as follows;

A. Planning for physical inventory

Planning is one of the important steps in the inventorisation of water bodies in the demarked area. Planning is done as the deskwork in the office by scrutinizing the collected secondary data and maps for the water bodies. There are three stages in planning, which should be carried out correspondingly to know the location and number of water bodies.

i. ***Inventorise water bodies from the collected maps*** such as counting the number of water bodies with approximate size from the village maps and cross verification with the toposheet and the MI tank maps. Prepare the list of water bodies in the demarked area as per the village maps.

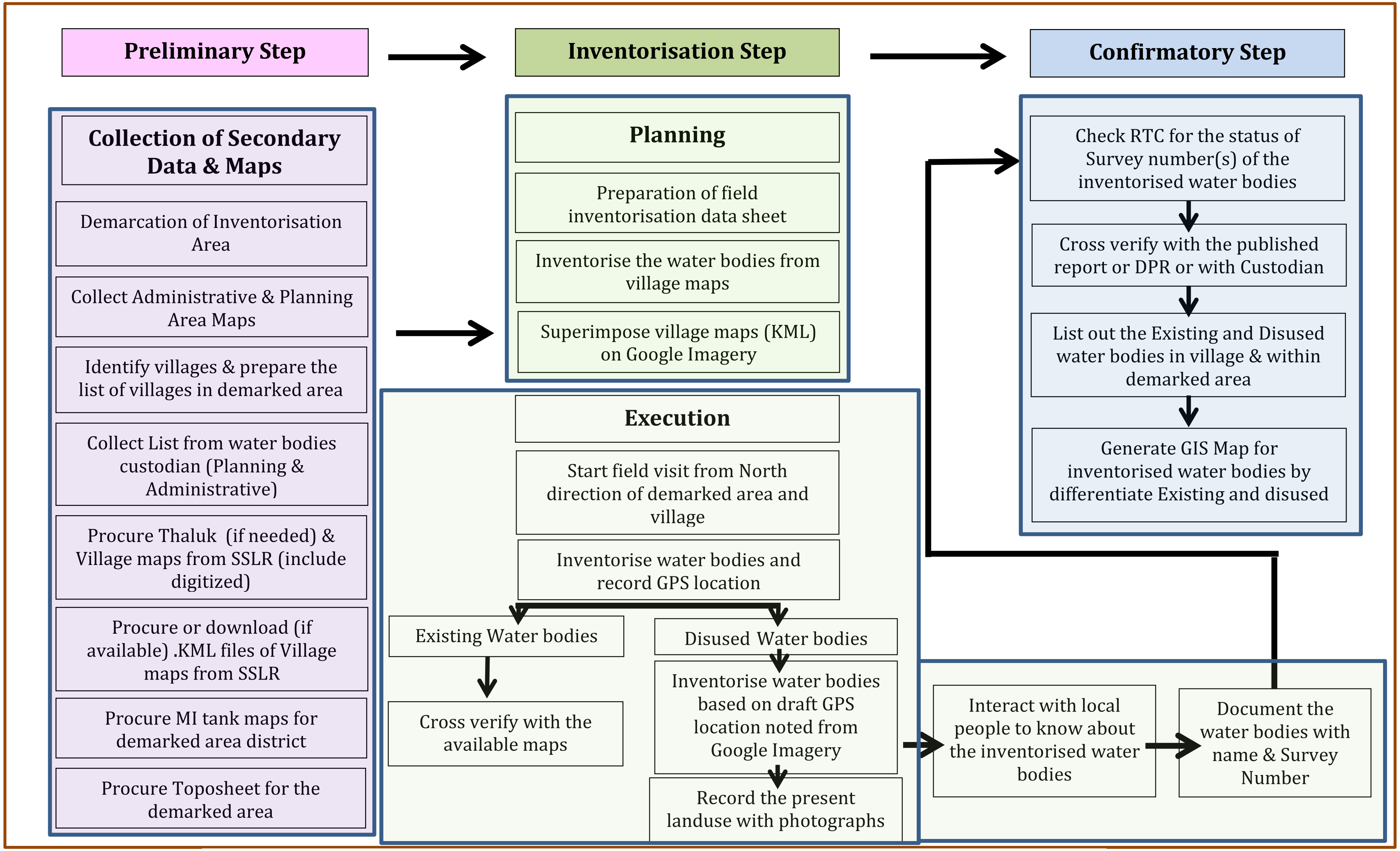


Figure-8.1. Flow chart for the inventorisation of the water bodies in the urban area

ii. ***Prepare the physical inventory field data sheet*** to record the observed data in the field during the physical verification of the water bodies. Field data sheet shall be designed based on the data needed for the inventorisation Authority. Field data sheet designed by CLC team of EMPRI, which has been used during the inventorisation of the water bodies in BMA is annexed in **Annexure-1**.

iii. ***Superimpose .KML village maps on satellite imagery*** to verify the lakes spread over on two to more villages. Superimpose on the satellite imagery has been done on the freely available Google imagery and this work will help to reduce the duplication of lake counts i.e. one lake spread over in three villages will be counted as three lakes.

B. Execution:

Execution of plan for inventorisation of the water bodies in the demarked area is the verification of the water bodies in the field. The important works that carried out in the field are following;

i. ***Organising the water bodies verification team*** to verify the present usage of the water bodies in the field. The team must have at least two members and they should be trained to use the GPS instrument and inventorisation of the water bodies.

ii. ***Start field visits from Northern direction*** of demarked area or one end of area, but not from the centre of the demarked area. If two or more teams are working in the inventorisation of the water bodies, then the area of inventorisation should be segregated based on the administrative or planning zones and taluk. Within the village also, the inventorisation should start from the Northern direction and inventorisation of water bodies should be clock-wise direction as thumb rule. To inventorise the disused water body, the approximate GPS point collected from the Google imagery shall be utilised.

iii. ***Record GPS location*** of the inventorised water bodies from the bund. Measuring tape can used to measure the width of the bund, because most of the lake bunds have been used as roads. When the inventorised water body is existing, then the water body should be cross verified with the available maps for the possibilities of encroachment. If the inventorised water body is disused, then the present landuse should be documented using camera.

Interact with the local people to collect the more details about the water bodies such as present usage of water bodies, if any pollutants and encroachment, type of water body as perennial or seasonal. If it is disused water body then when, who convert water body and who gave permission for conversion of water body landuse can be collected from the local people. After physical inventorisation of the water bodies, the list on inventorised water bodies should be prepared with the survey number of the village map, custodian, location, etc.

8.3.3. Confirmation:

The inventorised water body should be confirmed based on the authenticated data such as cross verification with RTC of the water body survey number, with the SSLR surveyed water body map, DPR or with custodian. Verified and confirmed water bodies should be segregated into existing and disused water bodies and shall be used to generate database. Water body database shall also be used to generate the water bodies map for the demarked area using the GIS.

8.4. Identification of Challenges and Solutions:

The methodological problems in the comprehensive inventory of the water bodies are identified based on the specified methodology by Szesztay (1966) and the technical challenges are identified through the experiences learnt during the study. The challenges and the identified technical problems are solved using the authenticated data as well as with the massive deskwork. The challenges and the identified technical problems with the solution will be helpful as manual in prospect to inventories the water bodies in other areas of the Karnataka State.

EMPRI team has overcome several difficulties from the starting of deskwork including the verification of secondary data to the finalization of the water bodies in the study area. The technical challenges are discussed in details in this chapter.

8.5. Lessons Learnt during the Study:

There are 32 technical challenges, which are overcome by EMPRI team during the study period. Within the technical challenges, eight challenges are raised in the village maps when delineating the study area.

8.5.1. Challenge-1: Overlap of Villages in Two different Planning Authorities:

The four villages namely Ajjagondanahalli, Gulakayipura, Thimmandahalli and Thirumala Shettyhalli of Anugondanahalli hobli in Hoskote taluk, Bengaluru Rural district in the BDA area overlap with the HPA (Hoskote Planning Authority) Master plan. The four villages located in the Hoskote taluk have been given back to the HPA through the order GO. No. in UDD 364 BMR 2009, dated: 26.09.2012 (HPA, 2013). These four villages are not part of the BDA planning area and accordingly, these villages are excluded from the study area.

8.5.2. Challenge-2: Two Villages have same Names are Under the Two Different Planning Authorities:

Ganakallu is the name of two villages located in the hobli's of Tavarekere as well as in the Kengeri, Bengaluru South taluk (Figure-8.1a). There is one *Kere* and two *Kunte's* in the Ganakallu village of Tavarekere hobli but there was no water body in the Ganakallu village of Kengeri hobli. Even the data provided by the KLCDA for verifying the lake has one *Kere*, which lead to the confusion for selecting the study area village.

Two villages named Vadarapalya (Figure-8.2a) have been located in the Uttarahalli hobli of Bengaluru South taluk. One village has three lakes and another village has one lake. Even KLCDA lake data mentioned that the village having three lakes has been considered within the BDA limit. So there is confusion for selection of the Vadarapalya village.

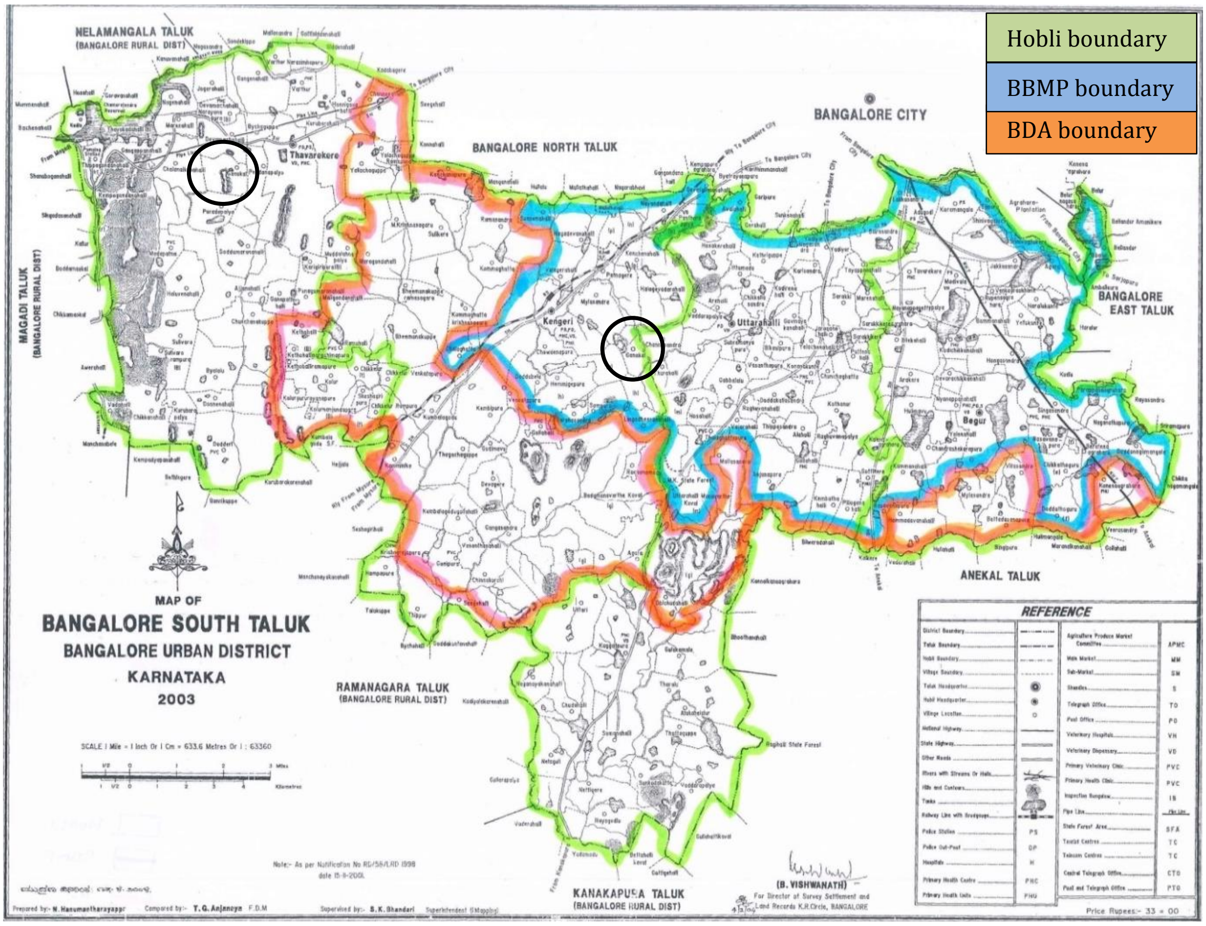
As per the BDA jurisdiction, Ganakallu village in the Kengeri hobli is in the study area. It is verified through the surrounding villages such as Channasandra, Hamingepura, Budamanavarthi Kavalu and Mallasandra. Ganakallu village in the Tavarekere hobli (Figure-8.1b) come under the jurisdiction of MPA (Magadi Planning Authority). Accordingly, the Ganakallu village of the Kengeri hobli (Figure-8.1c) has been included in the study area and the Ganakallu village in the Taverekere hobli was excluded from the study area.

Vadarapalya village, which has only one lake is the village that come under the jurisdiction of BBMP (Figure-8.2b) is included in the study area. It is surrounded by Arehalli, Kasaba Uttarahalli, Channasandra and Halagevaderahalli villages. Another Vadarapalya (Majre) village (Figure-8.2c) with the three lakes comes under the jurisdiction of KPA (Kanakapura Planning Authority).

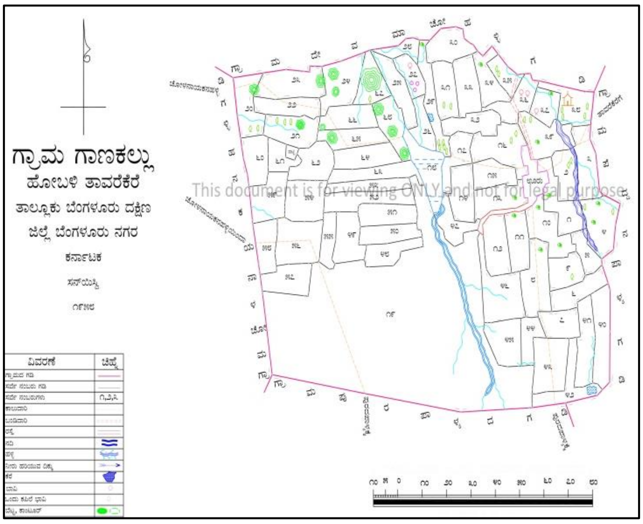
8.5.3. Challenge-3: No Maps for the Old Bengaluru City:

The maps for the old (Kasaba) Bengaluru City and the Civil station are not available. There are two legendary tanks called Darmabudhi and Karanji, these *Kere* are located in the Kasaba Bengaluru. Further, the part of the Millers tank, Ulsoor tank and Sampangie tank are located in the Civil Station area.

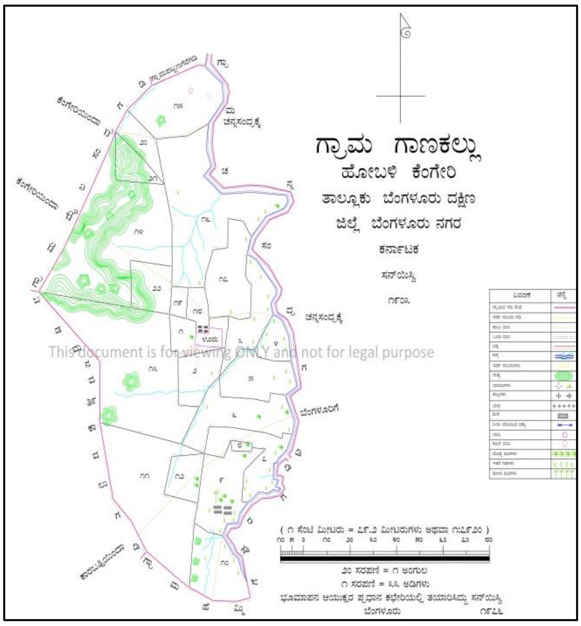
CLC team of EMPRI has delineated the boundary of the surrounding villages of the missing 1924's map (Figure-8.3). The surrounding villages of the Kasaba Bengaluru are Dodda Baikhanahalli, Hanumanthapura, Lalbagh, Sampangiehalli, Baragimudenahalli, Kempepura Agrahara, Thimmasandra, Kempabudhi and Jakkasandra. Whereas, the Civil station area are surrounded by the villages namely Doddakunte, Dandupparahalli, Byadarahalli, Halasuru, Binnamangala, Kasaba Bengaluru, Kuppasandra and Akkithimmanahalli.



a) Bengaluru South Taluk Map with the location of Ganakallu villages

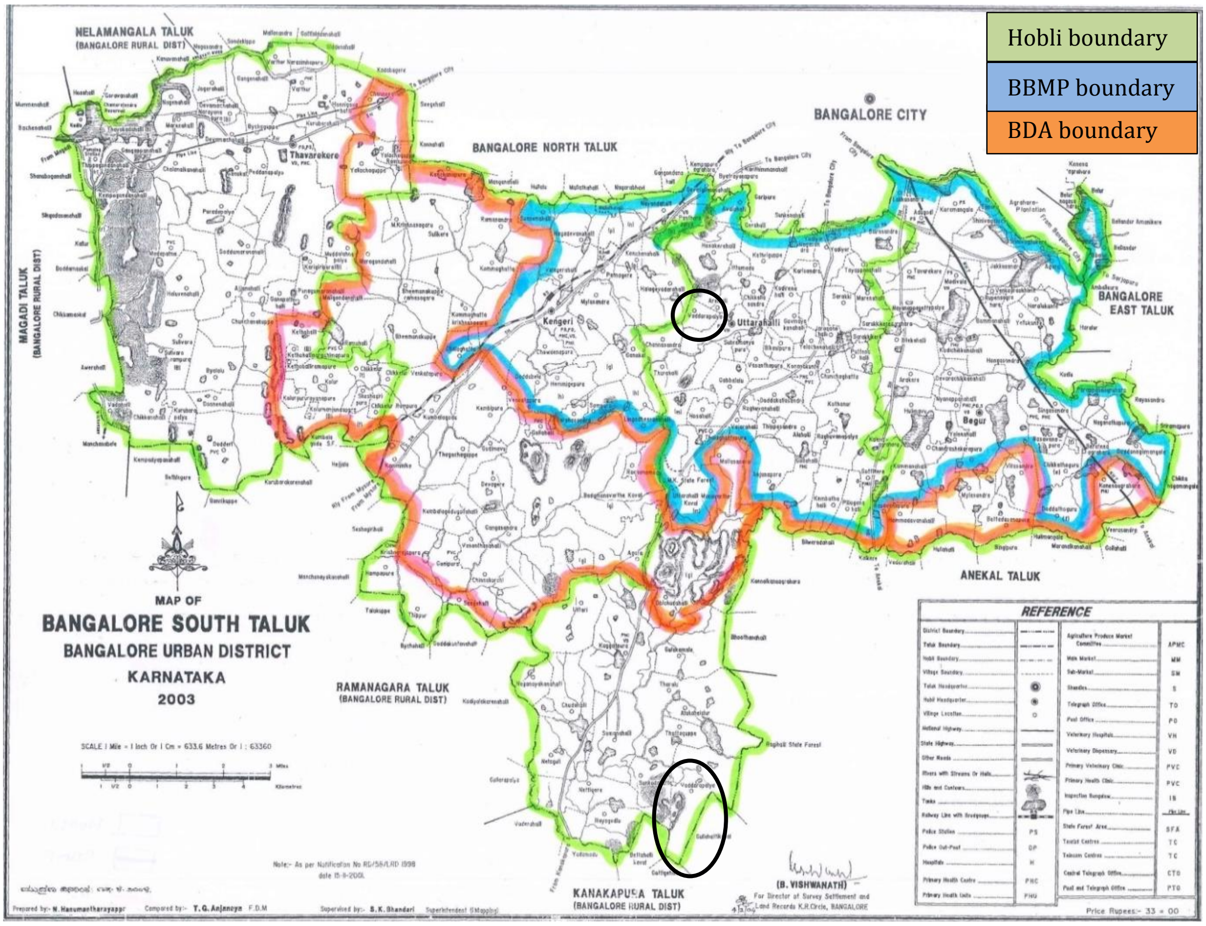


b) Ganakallu village map of Tavarakere hobli

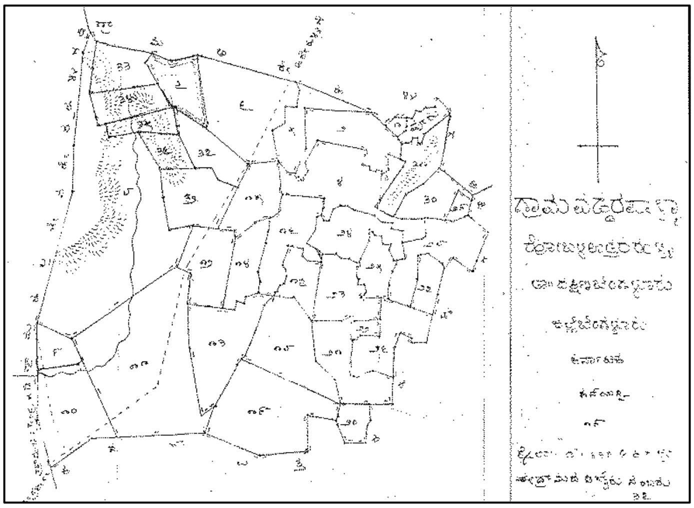


c) Ganakallu village map of Kengeri hobli (Study area)

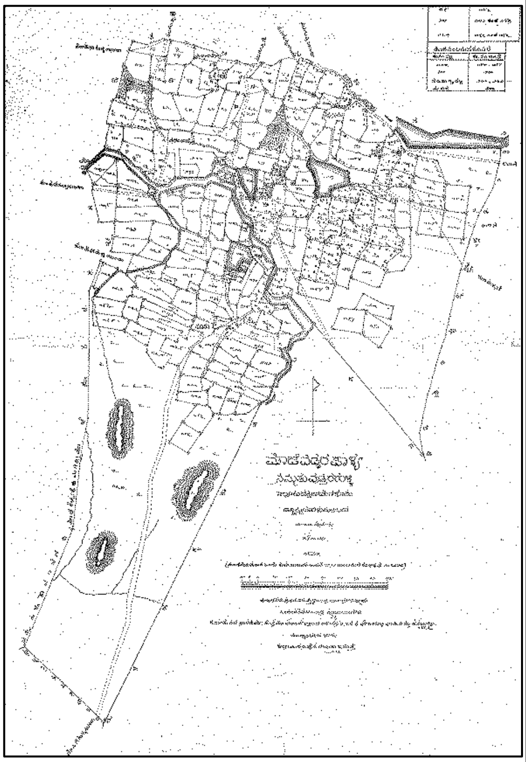
Figure-8.1. Ganakallu villages in Bengaluru South taluk



a) Vadarapalya villages in Uttarahalli hobli of Bengaluru South Taluk

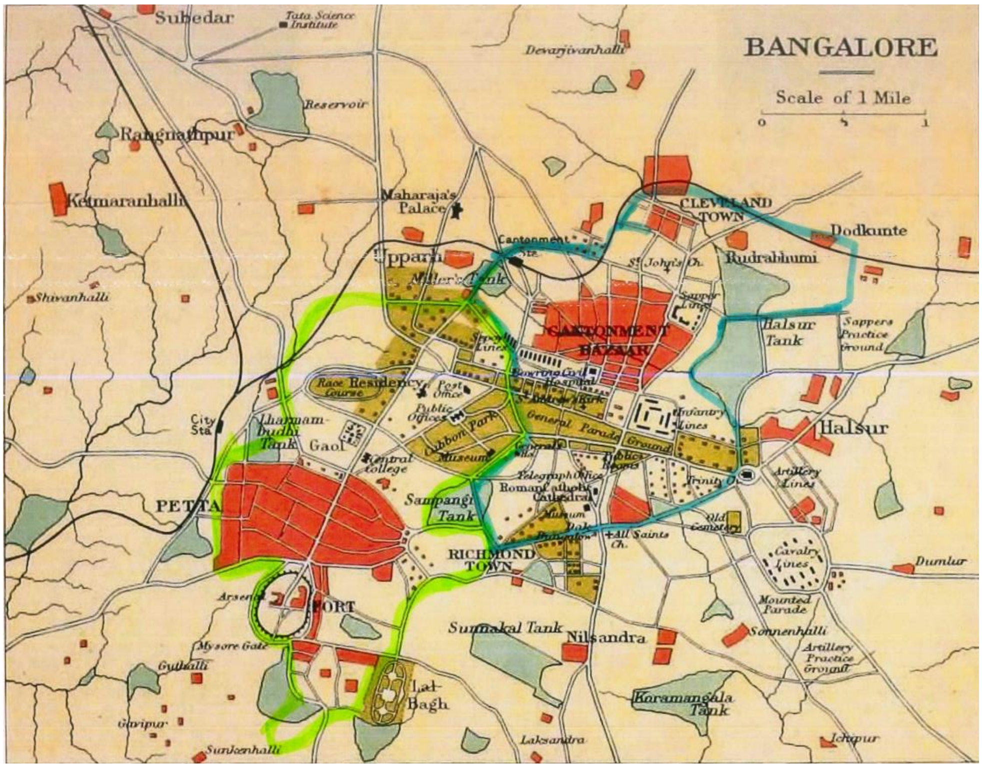


b) Vadarapalya village map coming under BBMP jurisdiction (Study area)



c) Vadarapalya village map coming under KPA jurisdiction

Figure-8.2. Vadarapalya villages in Uttrahalli hobli of Bengaluru South taluk



Source: https://eksparsh.wordpress.com/tag/old-bangalore/

Figure-8.3. Delineated Kasaba Bengaluru and Civil station areas in 1924 Map

8.5.4. Challenge-4: Partitioned Village Map:

Jarkabande Kavalu village in Bengaluru North taluk has two maps with four parts (Figure-8.4a). Part-1 & 4 in one part of combined map (Figure-8.4b) and Part-2 & 3 as another part of village map (Figure-8.4c). Whereas the three parts are in the Yelahanka hobli and one part (Part-1) is in the Yeshwanthpur hobli. The four parts identified in the taluk map have created the confusion that there are four villages in the same name.

The four parts of the Jarkabande Kavalu village (Figure-8.4d) are verified through the surrounding villages such as Peenya, Kasaba Yeshwanthpura and Malagalu SF for the part-1 village in the Yeshwanthpur hobli. The surrounding villages for the part-2 Jarkabande Kavalu village are Abbigere, Singapura, Ramachandrapura, Kammagondanahalli, Dodda Bommasandra and Peenya plantation. Part-3 village are surrounded by Chikka Bettahalli, Narasipura, Singapura and Ramachandrapura and the surrounding villages for the part-4 village are Lingarajapura, Mavallipura, Bylakere, Ramagondanahalli, Kempanahalli, Veerasagara and Shaymrajapura. Within the three parts in the Yelahanka hobli, two parts are (Part-2 & 3) comes under the BBMP jurisdiction and the Part-4 is come under the BDA jurisdiction.

Apart from the Jarkabande Kavalu village, seven villages in the study area have more than two parts of the map. Bagaluru village in Jala hobli of Bengaluru North taluk; Bellandur Amanikere in Varthur hobli of Bengaluru East taluk; Bannerghatta, Bilvardhahalli and Bingipura in Jigini hobli of Anekal taluk; and Badamanavarthe Kaval and Hemmigepura villages in Kengeri hobli of Bengaluru South taluk. Only the Bagaluru village has two partitions in one map itself and for other villages, the parts are in the separate map. Whereas the Badamanavarthe Kaval (Figure-8.5) village has three parts and each part has the water bodies. There are nine waterbodies (three *Kere* and six *Kunte*) in part-1; two *Kere* in the part-2; and one *Kunte* in part-3 of the Badamanavarthe Kaval village. So if any part of the village has been missed, then the number of water bodies will also be reduced or missed.

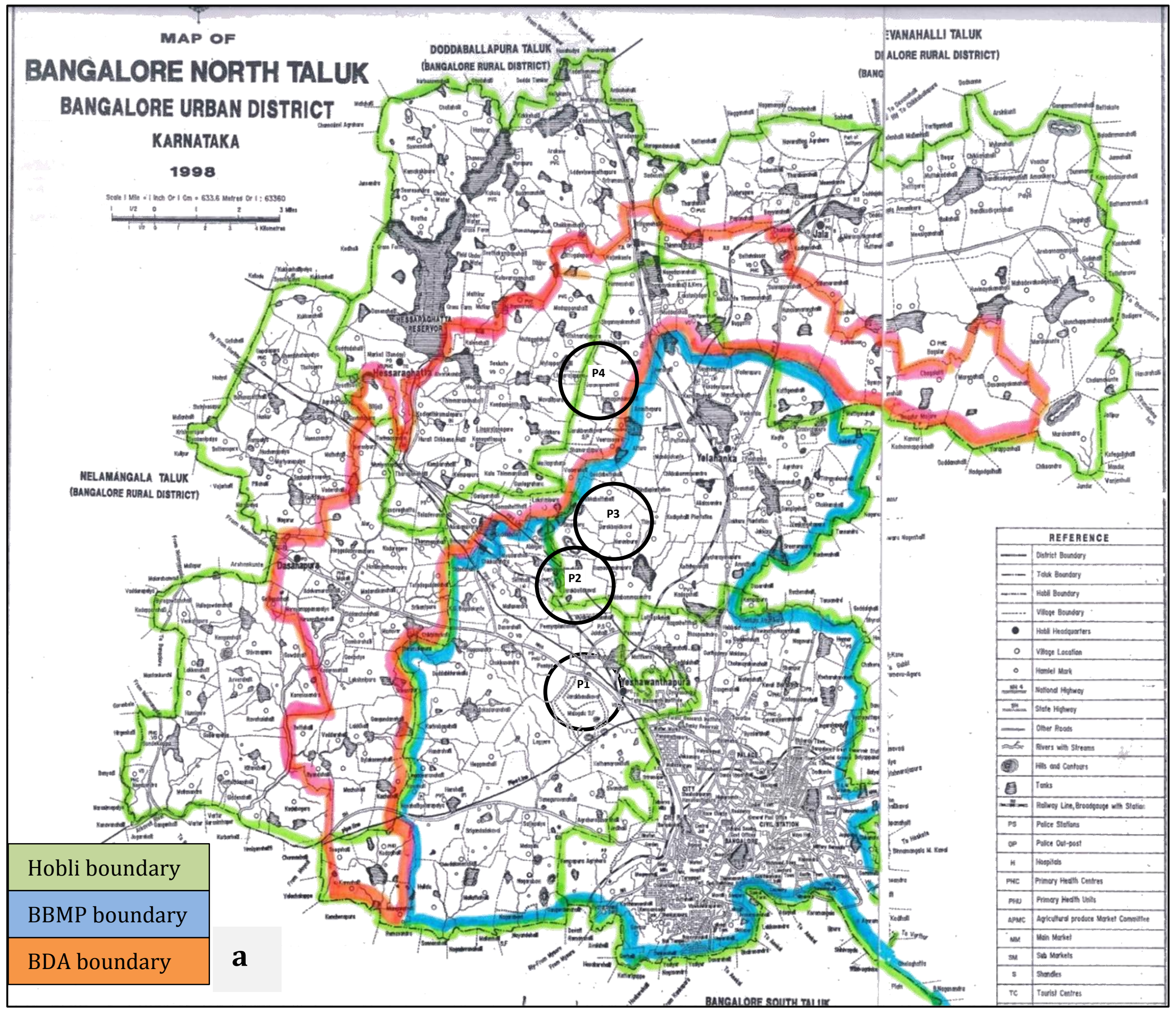
8.5.5. Challenge-5: Combined Village Maps:

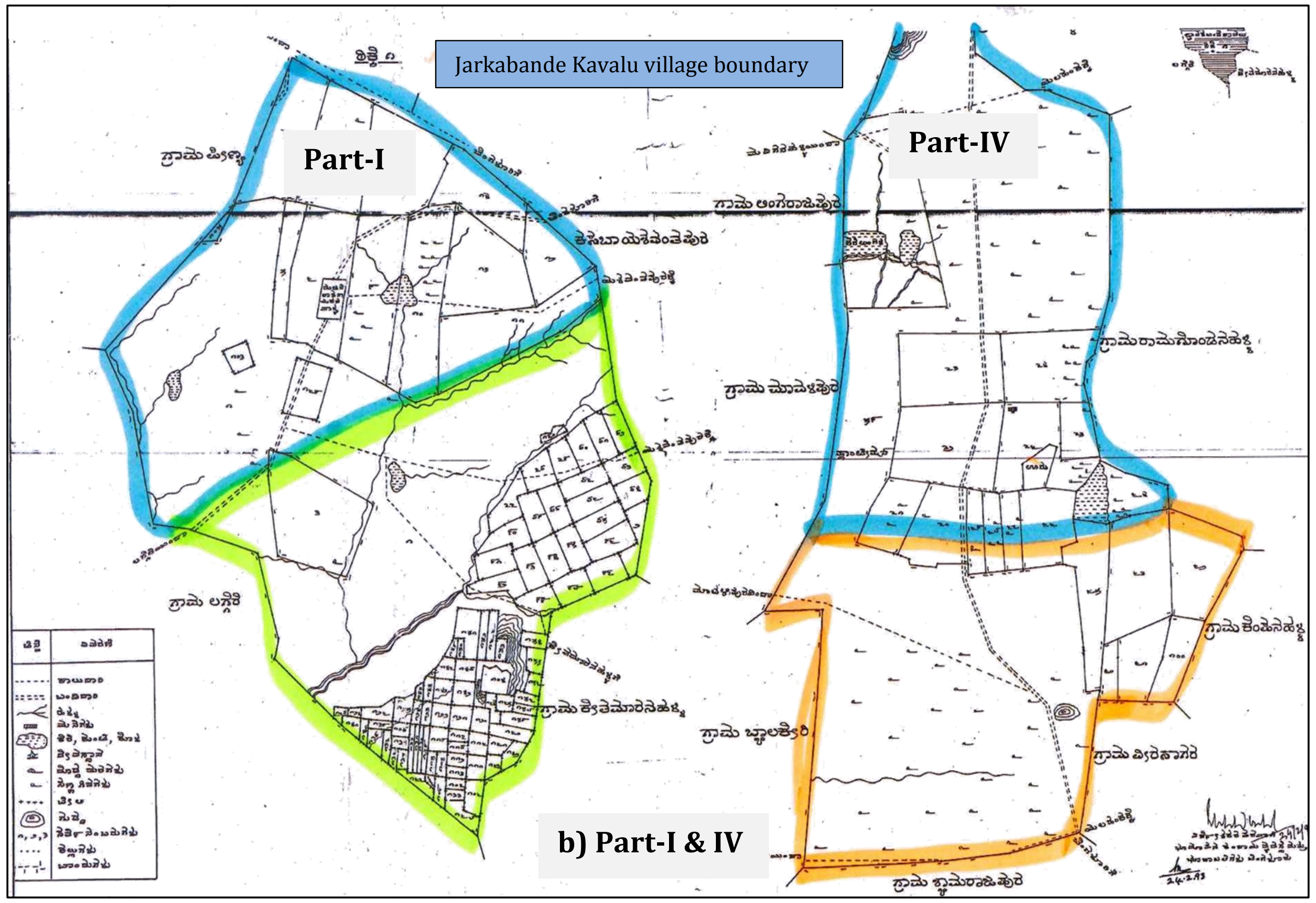
During initiation of the project work, only the Byappanahalli village (Figure-8.6a) map was available and the Vimanapura village map was missing. So the Vimanapura village (Figure-8.6b) map was collected from the SSLR. But the village maps for the Byappanahalli and the Vimanapura villages are same, which lead to the confusion that there is no map for the Vimanapura village.

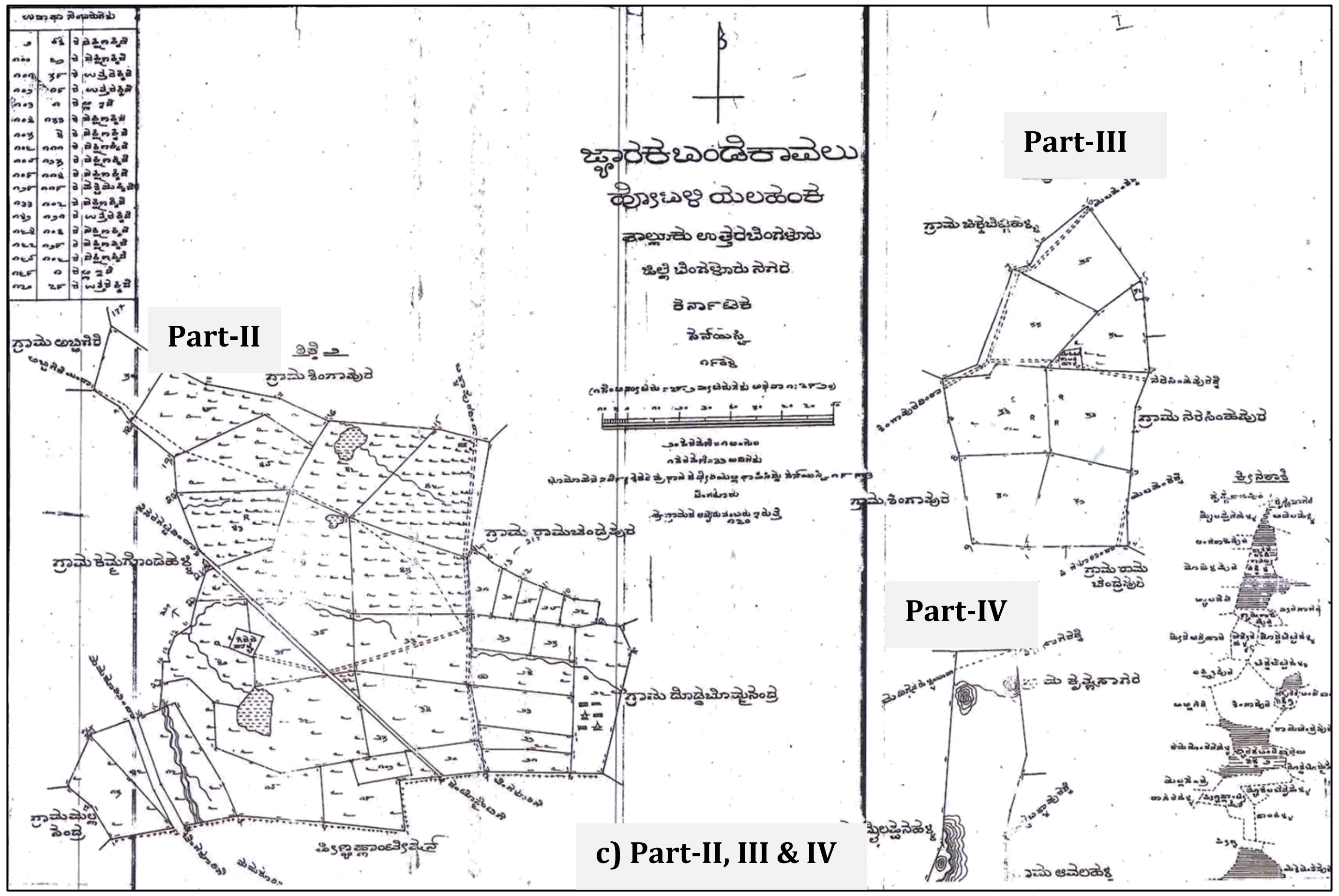
After the verification of village map with the surrounding village map located in the Krishnarajapuram (KR Puram) hobli of Bengaluru East taluk (Figure-8.6c) map, the Vimanapura village map was traced. The surrounding villages of the Vimanapura village are Banaswadi, Byataguttepalya, Binnamangala, Binnamangala Manavarthakaval, Sreenivasapura, Bendiganahalli and Byappanahalli. It is also found that the Vimanapura village map was compiled with the Byappanahalli village map into one single village map (Figure-8.6d). These also revealed that there was no water body in the Vimanapura village and then two water bodies in the Byappanahalli village.

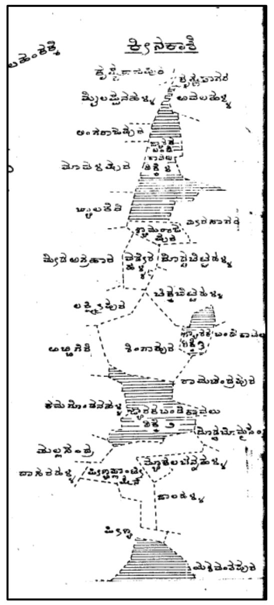
Similarly, the Malagulu SF (State Forest) and Jarkabande Kavalu SF village maps of Yelahanka hobli (Figure-8.7a) in Bengaluru North taluk couldn't be traced. But with the help of taluk and surrounding village maps, the Malagulu SF and Jarkabande Kavalu SF village (Figure-8.7b) maps have been traced and found that the maps were combined with the Jarkabande Kavalu village map of part-1 and part-4 respectively.

The confirmed Vimanapura village in the Byappanahalli village map has created the confusion because of Survey numbers, which are continued from the Byappanahalli village to the Vimanapura village. During RTC verification in the Bhoomi website, there is only the Byappanahalli village with the continuity of Survey numbers in the Vimanapura village.









d) Location of Four Parts of the Village maps

Figure-8.4. Four partitions of Jarkabande Kavalu village map in Yelahanka hobli of Bengaluru North taluk

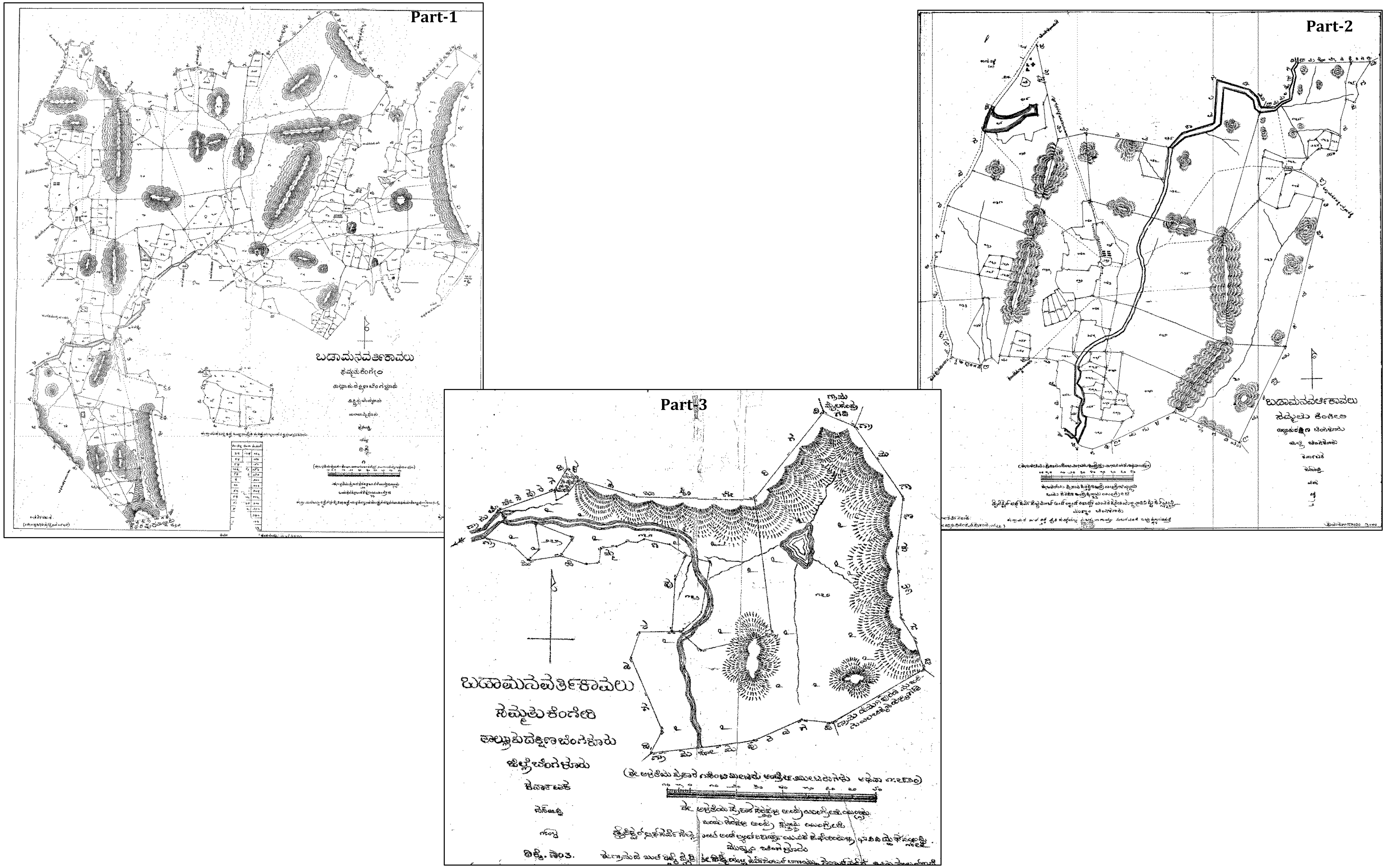


Figure-8.5. Three maps as part of the Badamanavarthe Kaval village in Kengeri hobli of Bengaluru South taluk

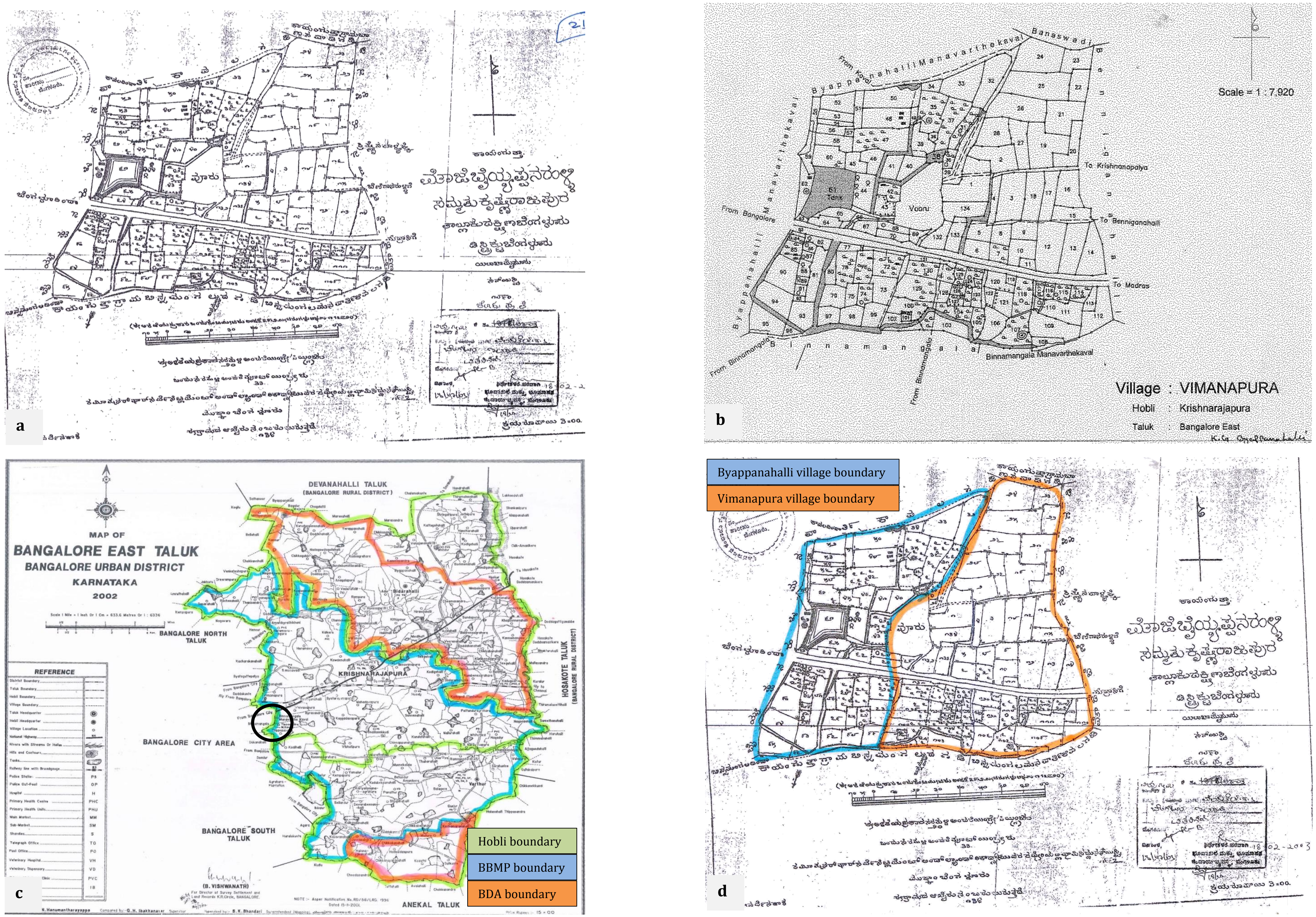
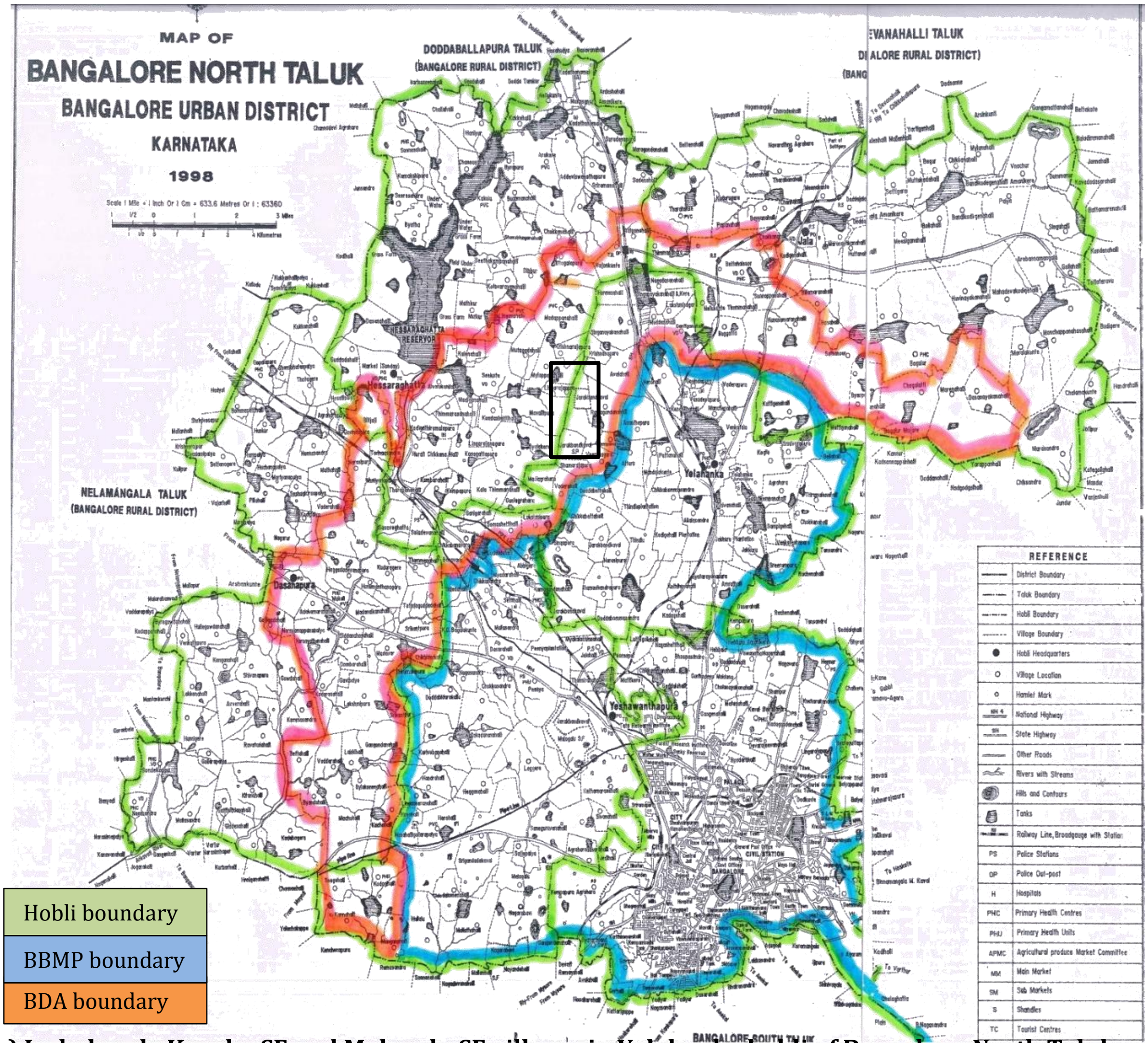
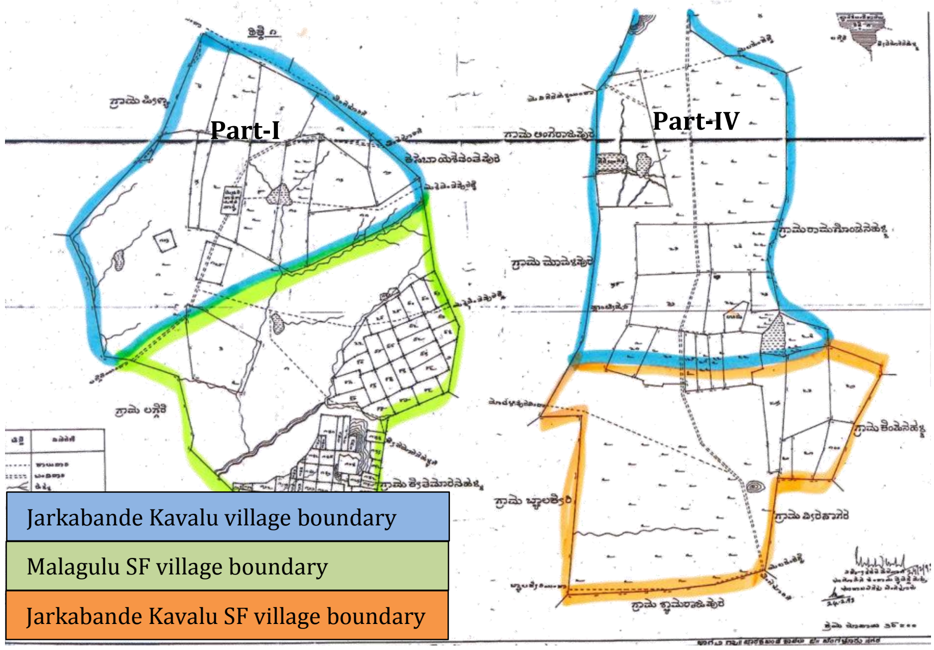


Figure-8.6. Comprised village map for Byappanahalli village and Vimanapura village in Krishnarajapura hobli of Bengaluru East taluk



a) Jarkabande Kavalu, SF and Malagulu SF villages in Yelahanka hobli of Bengaluru North Taluk



b) Location of Jarkabande Kavalu, Jarkabande Kavalu SF and Malagulu villages

Figure-8.7. Jarkabande Kavalu villages in Yelahanka hobli of Bengaluru North taluk

8.5.6. Challenge-6: Updated village maps:

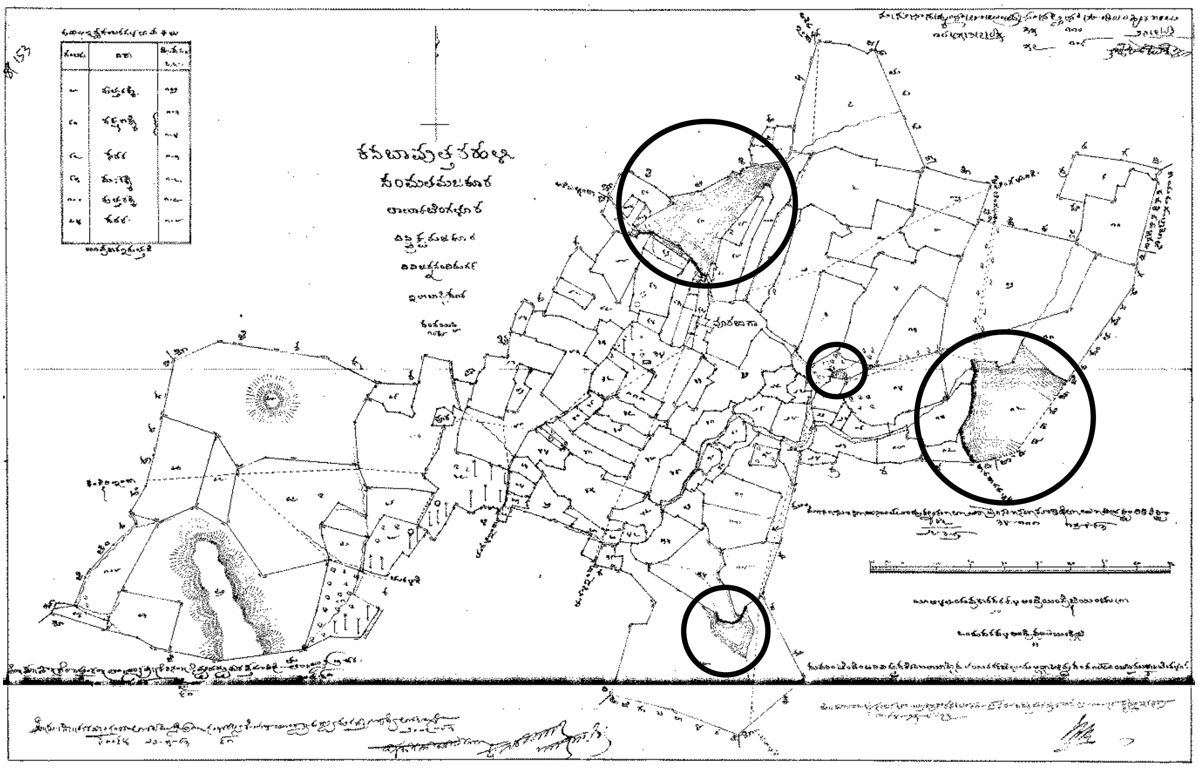
Gubbalalu village of the Uttarahalli hobli in the Bengaluru South taluk have four water bodies (three *Kere* & one *Kunte*). Gubbalal *Kere*, Dasanakatte-2 and Gubbalal *Kunte* are located in the Survey no.22 and 38 correspondingly as the village maps were prepared in the year 1886. But the RTC of these lakes showed that these lakes are located in the Survey no. of 25, 43 and 56 respectively. The same issue was also observed in the Uttarahalli village also, i.e. Moge *Kere*, Uttarahalli *Kunte*, Doraikere and Subramhanyapura *Kere* are located in the Survey no. of 91, 20, 16 and 58 (Figure-8.8a). The differences in the survey no. between the village map and the RTC have lead to the confusion in the identification of exact survey numbers of these water bodies.

The updated digitized village maps have been identified from the SSLR website and found that the Gubbalalu village map prepared on 1886 was updated in year 1994 and the Uttarahalli village map prepared in 1869 was updated in the year 1904. During the update of the village maps, the survey no. of the water bodies have been changed, which are reflected in the RTC survey numbers. Accordingly, the recent digitized village maps have been considered for the study and the water bodies survey numbers have been verified with the SSLR water body sketch. In the new digitized village maps, the water bodies are located in the Survey no. of 25, 43 and 56 of the Gubbalalu village and Survey no. of 111, 27, 22 and 64 of the Uttarahalli village (Figure-8.8b) respectively.

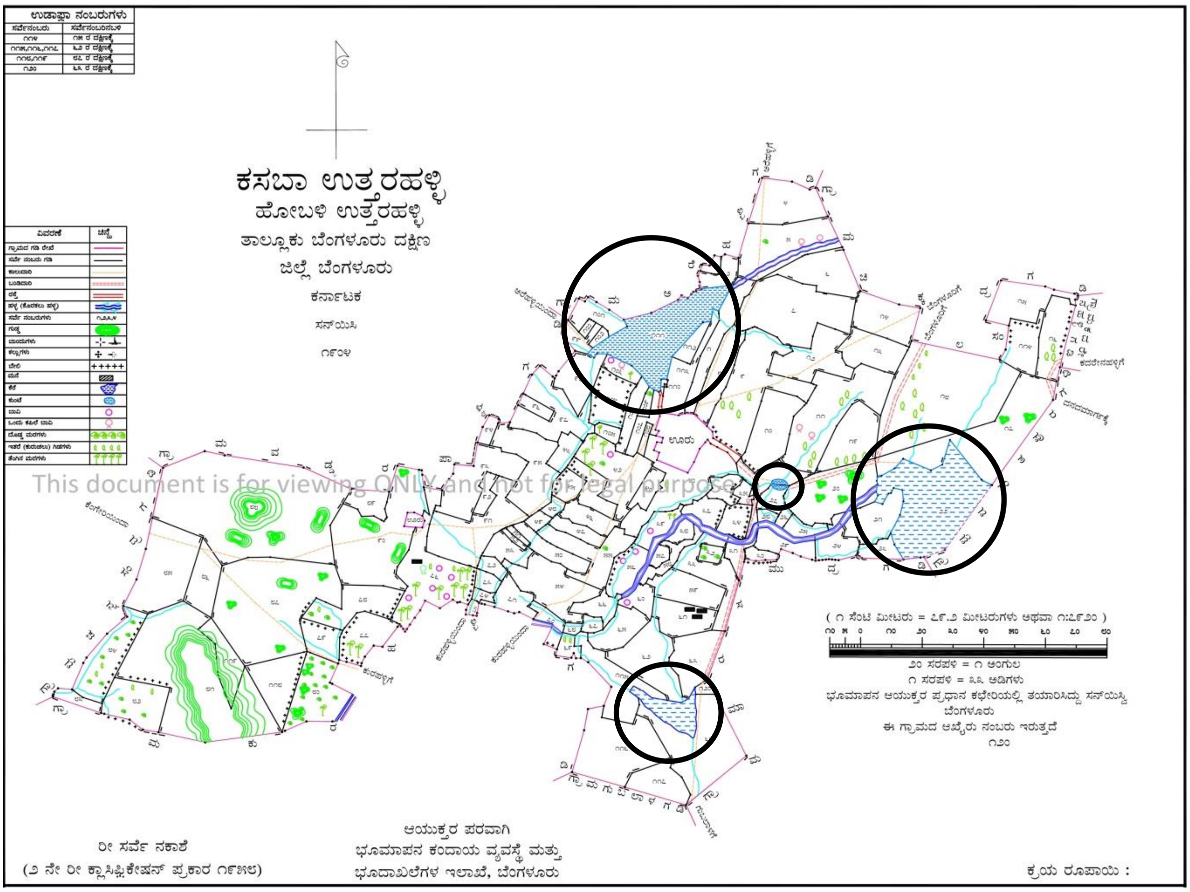
8.5.7. Challenge-7: Intersecting Administrative Boundaries:

The 11 villages under the BBMP administrative jurisdiction also retained as the Grama Panchayat by the Rural Development & Panchayat Raj Department (http://panchamitra.kar.nic.in/displayDistTal.aspx?context=districtMap&distCode=1502&tlCode=). The retained Grama panchayats are Soma Shettyhalli village in Yeshwanthapura Hobli and Kadigehalli village in the Yelahanka hobli of the Bengaluru North taluk; Seegehalli in the KR Puram hobli and Avalahalli, Bidarahalli, Doddabanahalli, Doddagubbi (Srigubbi) and Kithiganur villages in the Bidarahalli hobli of the Bengaluru East taluk; Gollahalli village in Uttrahalli hobli, and Dodda Thoguru and Konappana Agrahara villages in the Begur hobli of the Bengaluru South taluk. Overlapping of Grama Panchayats and BBMP as the administrative Authorities in BMA has created the misperception during the demarcation of the BBMP boundary.

After the meticulous scrutiny, the CLC team found that the few BBMP jurisdiction villages (but not all) retained as Grama panchayat has the administrative control on the villages located in the fringes of BBMP area. The challenge was resolved by including these 11 villages in the BBMP area as per the ward zonation map.



a) Uttarahalli village map prepared in the year 1869



b) Digitized Uttarahalli village map re-prepared in the year 1904

Figure-8.8. Water bodies in the Uttarahalli village map, Bengaluru South taluk

Apart from the villages, there is also confusion to identify the custodian of lake or water bodies, particularly in the BDA area. The custodian of the water bodies were identified through the secondary data from the Authorities viz… KLCDA, BBMP, BDA, Karnataka Forest Department, etc. and found that the selected major lakes are under the BDA custody for the rejuvenation of lakes with in the BMA. BDA also take-up lake rejuvenation within the BBMP jurisdiction and the rejuvenated lakes were handover to BBMP for maintenance. In the BDA jurisdiction, only few major lakes (not *Gokatte* and *Kunte*) are under the BDA custody and other lakes are under the Zilla Panchayat custody. Whereas, most of the *Gokatte* and *Kunte* are under the custody of Grama Panchayat.

8.5.8. Challenge-8: Village has two habitations:

There are eight water bodies in the Bhuthanahalli village, Jigani hobli of the Anekal taluk. This village is also called as Majarevaradahalli, which led to the confusion in the village name as well as in the water bodies name.

The challenge was solved after the field verification. During field verification, the interaction with the local people had revealed that the village has the two habitations in the name of Bhuthanahalli and Majarevaradahalli (Figure-8.9). Within the eight water bodies, only Kunte named as Venkaiana Katte is located in Majarevaradahalli habitation.

8.5.9. Challenge-9: Ulsoor lake is not mentioned in the village map:

Ulsoor lake was not shown in the village map (Figure-8.10a), which was generated during the year 1903. The village map showed that there was only one Kunte and there is no lake. The existing Ulsoor lake was also not mentioned in other surrounding villages and there is no Survey no. for the lake. This has created the confusion that the Ulsoor lake had established earlier before the generation of the village map. There are 10 water bodies in the Hulimangala village, Jigani hobli of Anekal taluk; within that the Hulimangala *Katte*, which are located in the survey no. 298 was not mentioned as the lake in the village map (Figure-8.11).

Ulsoor lake was found in the Old Bangalore map generated in the year 1900 (Figure-8.10b). The reason was unknown for the exclusion of the Ulsoor tank in the village map. The Survey no. and extent of the Ulsoor lake was documented from the SSLR surveyed lake map as well as from the Koliwad Legislative Committee report. Hulimangala *Katte* located in the survey no. 298 with the extent of 13.14 A-G has been verified with the availability of the RTC.

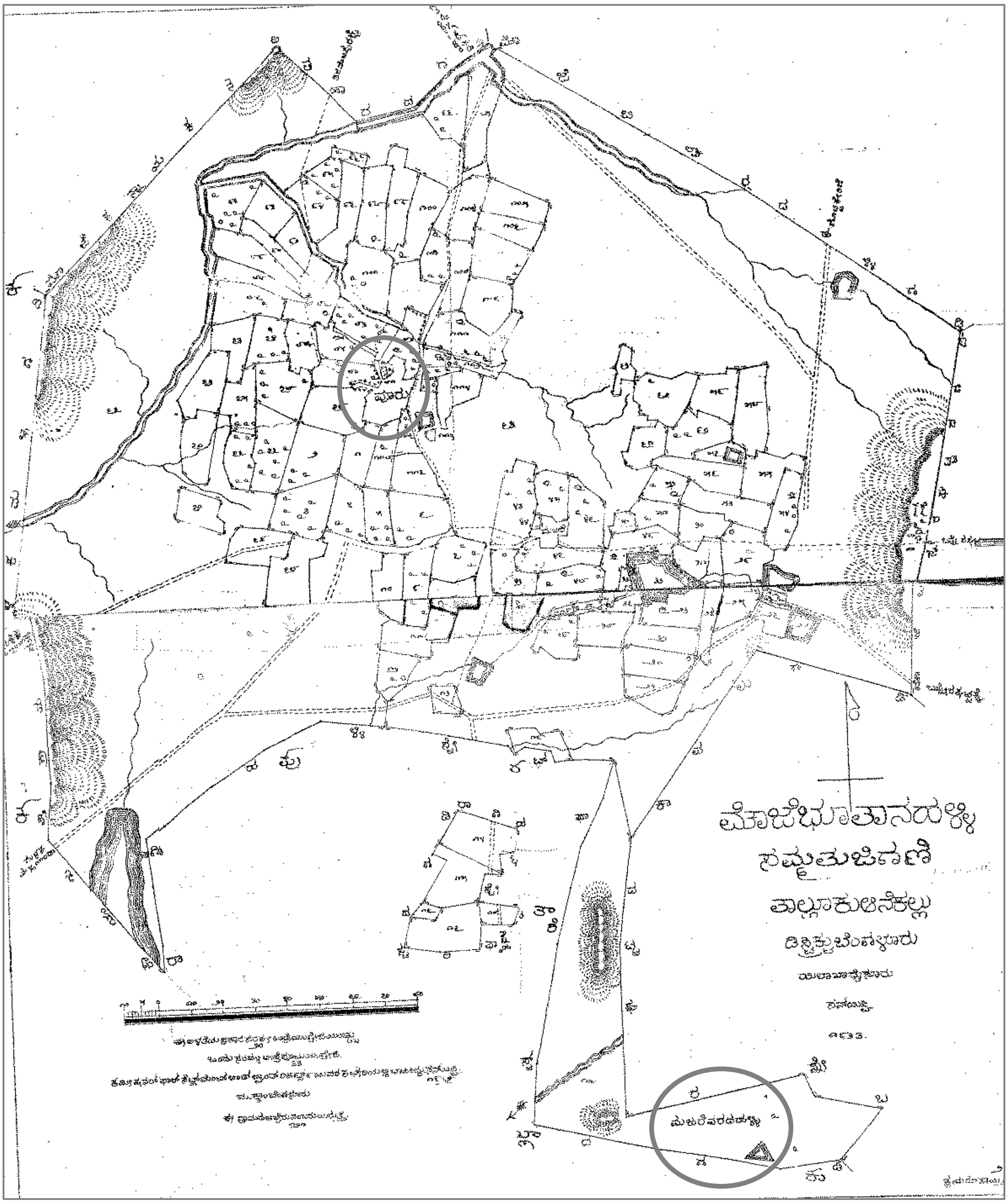
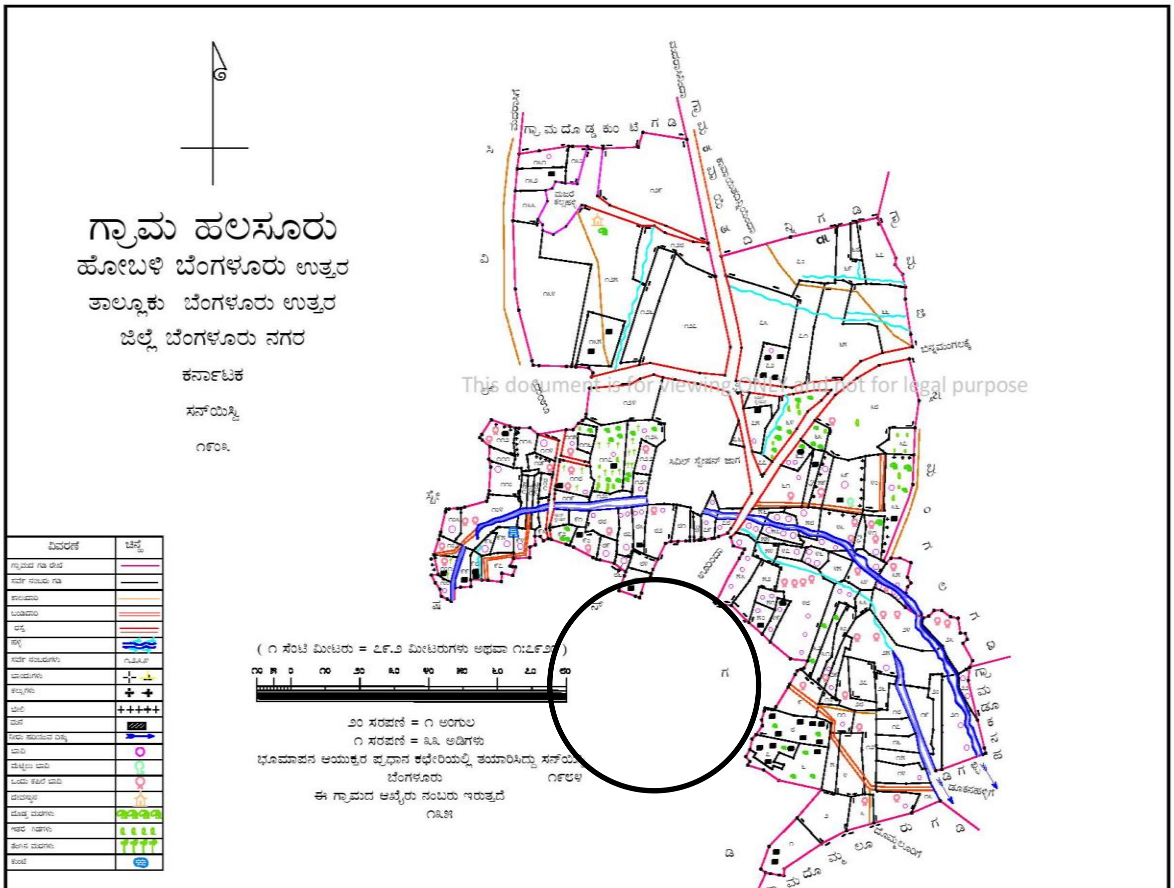
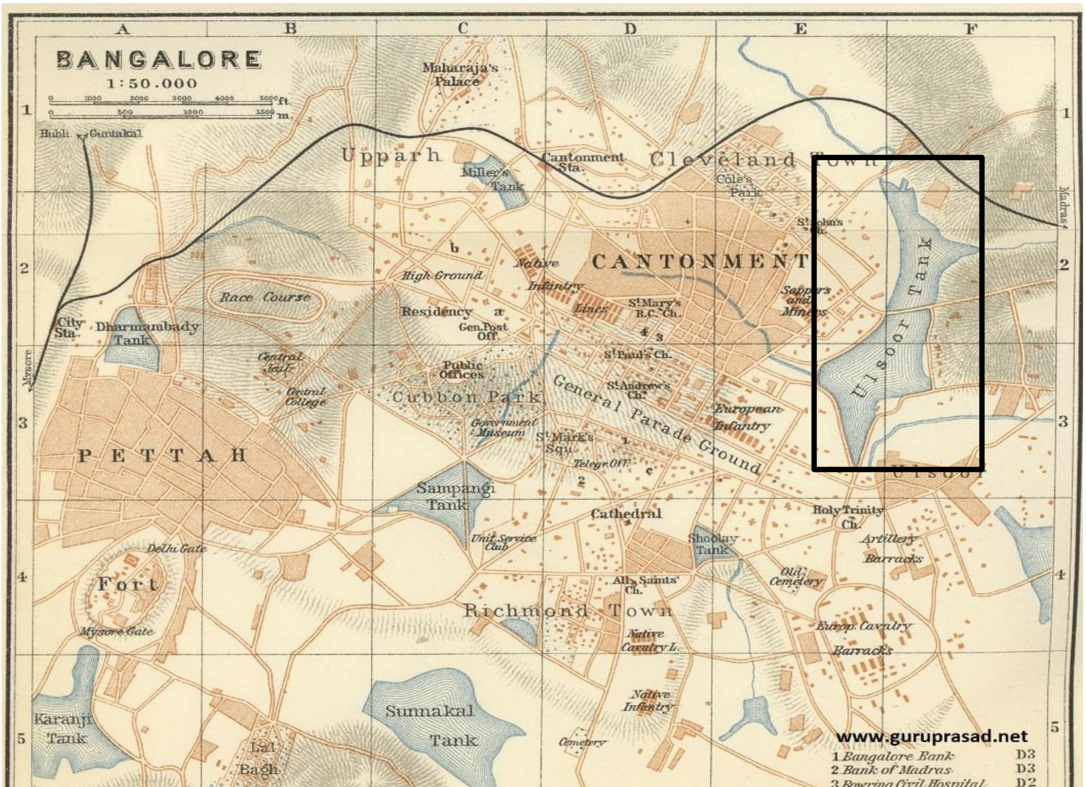


Figure-8.9. Bhuthanahalli village map with Majarevaradahalli habitation



a) Ulsoor village map prepared in the year 1903 and digitized recently



b) Ulsoor lake in old Bangalore City map prepared in the year 1900

Figure-8.10. Ulsoor lake in village map (1903) and Bangalore City map (19010)

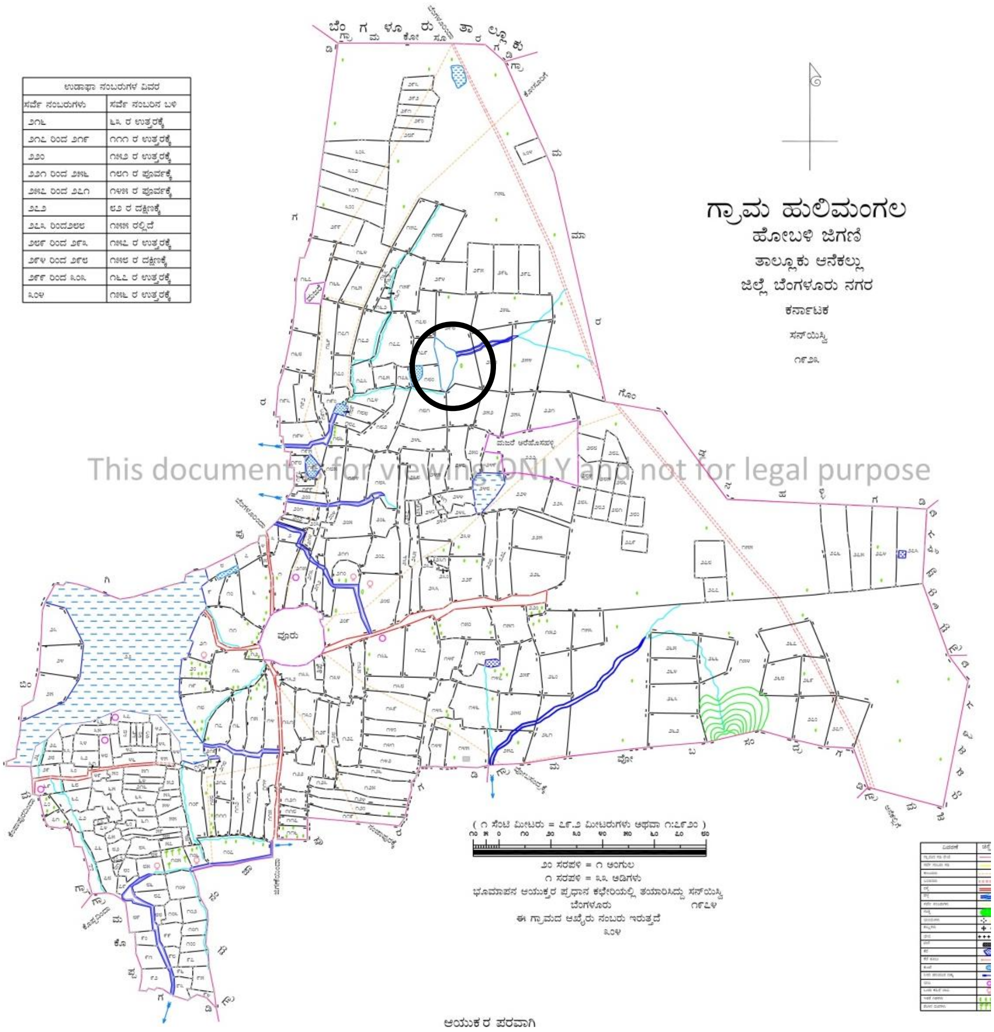


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Figure-8.11. Hulimangala Katte in Hulimangala village map

8.5.10. Challenge-10: Lakes located in-between the two Planning Authorities:

All the villages located in the BDA jurisdiction are considered in the study area. But few lakes (*Kere*) located in the boundary of the BDA jurisdiction has extended to the other villages of various Planning Authority jurisdictions. The details of the 10 lakes, which are located in between the two planning Authorities, are tabulated in the Table-8.1. Dibburu (Figure-8.12a) and Mathkuru (Figure-8.12b) lakes in the Hesaraghatta hobli of the Bengaluru North taluk are located in between the BDA and BIAAPA jurisdiction. Small part of the Mahadevana Kodaganahalli lake (BIAAPA) is located in the Marenahalli village (Figure-8.12c) of BDA in the Jala hobi of the Bengaluru North taluk. Disused Huskuru lake (Vacant land) in the Biderahalli hobli (Figure-8.12d) of the Bengaluru East taluk is located in between the HPA (Hoskote Planning Authority) and BDA (BBMP) area. Whereas the

Kurubarahalli lake (Figure-8.12e) in the Taverekere hobli and Maligondanahalli lake (Figure-8.12f) in the Kengeri hobli of the Bengaluru South taluk are located in between the MPA (Magadi Planning Authority) and BDA jurisdiction area.

In Anekal taluk, Kyalasanahalli Government lake (Figure-8.12g) in the Jigani hobli; Chembenahalli (Figure-8.12h) and Thimmasandra Government lakes (Figure-8.12i) in the Sarjapura hobli are located in between the APA (Anekal Planning Authority) and BDA jurisdiction area. Whereas, the Mutasandra Government lake (Figure-8.12j) located in Anugondanahalli hobli of Hoskote taluk is located in between the HPA and BDA jurisdiction area.

It is solved by the operational location of the lake in the village i.e. the lake has been included in the BDA area, when the bund of the lake is in the BDA village. If the lake bund is also shared in the two villages of the different planning Authorities, then the lake has been included in the BDA area.

Except Maligondanahalli lake in Kengeri hobli of the Bengaluru South taluk, nine lakes are not included in the study area because the maximum lake areas are spread over in the villages under the jurisdiction of other planning Authorities. Further, the bunds of the lakes are also identified in the villages of the other planning Authorities area. Only the Kuruberahalli Government lake bund is located in both the villages such as Kuruberahalli village of MPA and Yelecheguppe village of BDA. As the maximum area has been spread over in the Kuruberahalli village, the lake was not counted in the BDA jurisdiction area.

8.5.11. Challenge-11: Lakes located in between the villages:

Most of the lakes in the BDA area have been spread over in more than one village with the different name. Lake has been called in the name of location of villages; for example, Nagadasanahalli *Kere* (49.38 A-G) in the Yelahanka hobli, Bengaluru North taluk has been counted as three lakes such as Honnenahalli, Nagadasanahalli and Singanayakanahalli Amanikere lakes (Figure-8.13). During the count of lakes, there are possibilities to count same lake twice in different names.

Parts of the lakes have been verified in the Google imagery satellite imagery to confirm that the lake is one. The name of the lakes is finalized based on the location of the lake bund in the village, i.e. the lake bund is located in the Nagadasanahalli village, so the lake has been documented in the name of the Nagadasanahalli *Kere* and considered as the one lake. The lake has been counted once, which was also verified with the specific survey no. of the existing database i.e. SSLR lake database and draft Koliwad legislative Committee report.

Table-8.1. Details of the Lakes located in-between the two planning Authorities

S.No.	Lake Name	Village Name	Sy. No.	Extent (A-G)	Planning Authority	Hobli Name	Reason
Bengaluru North							
1.	Dibburu Kere	Dibburu	22	18.24	BIAAPA	Hesaraghatta	Bund and also most of the lake area is located in Dibburu village
		Madappanahalli	12	6.04	BDA		
		Total Extent		**24.28**			
2.	Mathkuru Kere	Mathkuru	54	67.26	BIAAPA		Bund and also most of the lake area is located in Mathkuru village
		Linganahalli village	61	14.15	BDA		
		Total Extent		**82.01**			
3.	Mahadevanakodag. Lake	Mahadevanakodaganahalli	194	118.38	BIAAPA	Jala	Bund and also most of the lake area is located in Mahadevana Kodaginahalli village and other BIAAPA jurisdiction villages
		Hoovinayakanahalli	53	12.33			
		Bagalur	193	37.25			
		Marenahalli	50	13.16	BDA		
		Total Extent		**182.32**			
Bengaluru East							
4.	Huskuru kere	Huskuru	52	20.16	HPA	Biderahalli	Bund and also most of the lake area is located in Huskuru village. Lake was vacant land
		Nimbekaipura	21	3.33	BBMP		
		Total Extent		**24.09**			
Bengaluru South							
5.	Kurubarahalli Govt. Lake	Kurubarahalli	123	3.39	MPA	Tavarekere	Bund of the lake is located in both the villages but most of the area is in Kurubarahalli village
		Yelecheguppe	219	1.30	BDA		
		Total Extent		**5.29**			

6.	Maligondanahalli Lake	Maligondanahalli	96	10.00	BDA	Kengeri	Bund and also most of the lake area is located in Maligondanahalli village. So the lake is counted in BDA jurisdiction
		Punagamaranahalli	31	7.10	MPA		
		Total Extent		**17.10**			
Anekal							
7.	Kyalasanahalli Govt lake	Kyalasanahalli	10	20.30	APA	Jigani	Bund and also most of the lake area is located in Kyalasanahalli village
		Vabasandra	33	15.12	BDA		
		Total Extent		**36.02**			
8.	Chembenahalli Govt lake	Chembenahalli	28	19.05	APA	Sarajapura	Bund and also most of the lake area is located in Chembenahalli village
		Tigala Choudenahalli	14	14.17	BDA		
		Total Extent		**33.22**			
9.	Thimmasandra Govt lake	Chikkathimmasandra	57	7.37	APA		Bund and also most of the lake area is located in Chikkathimmasandra village
		Hosahalli	79	3.32	BDA		
		Total Extent		**11.29**			
10.	Govt. Mutsandra Kere	Mutsandra (Anugondanahalli Hobli, Hoskote)	7	82.37	HPA		Bund and also most of the lake area is located in Mutsandra village
		Chikkanekundi	10	79.08	BDA		
		Total Extent		**162.05**			

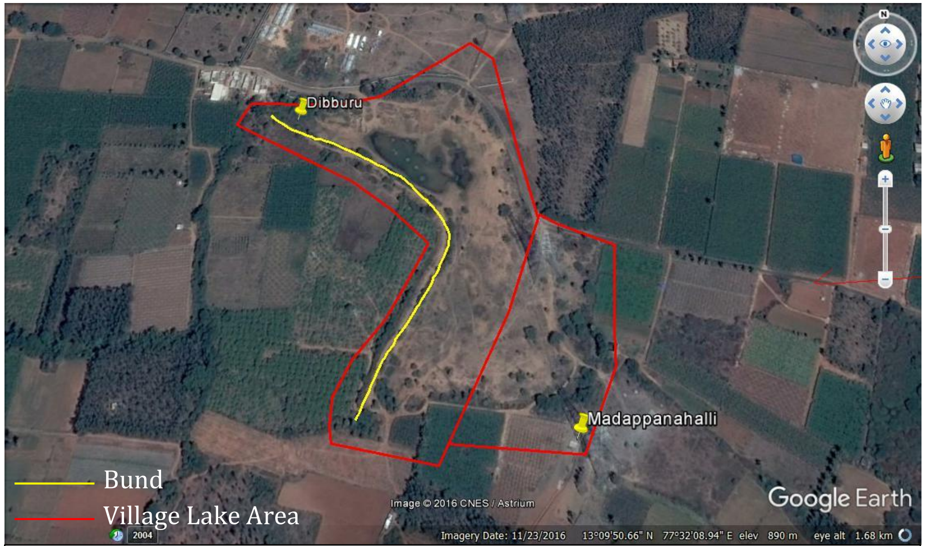

Figure-9.12a. Dibburu lake in Hesaraghatta hobli of Bengaluru North

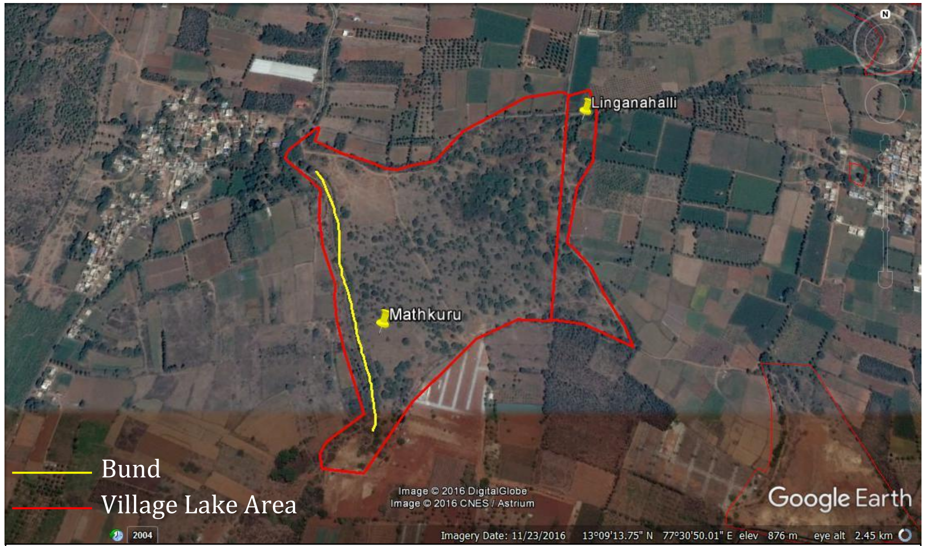

Figure-9.12b. Mathkuru lake in Hesaraghatta hobli of Bengaluru North taluk

Figure-9.12c. Mahadevanakodaginahalli lake in Jala hobli of Bengaluru North

Figure-9.12d. Huskuru lake in Biderahalli hobli of Bengaluru East taluk

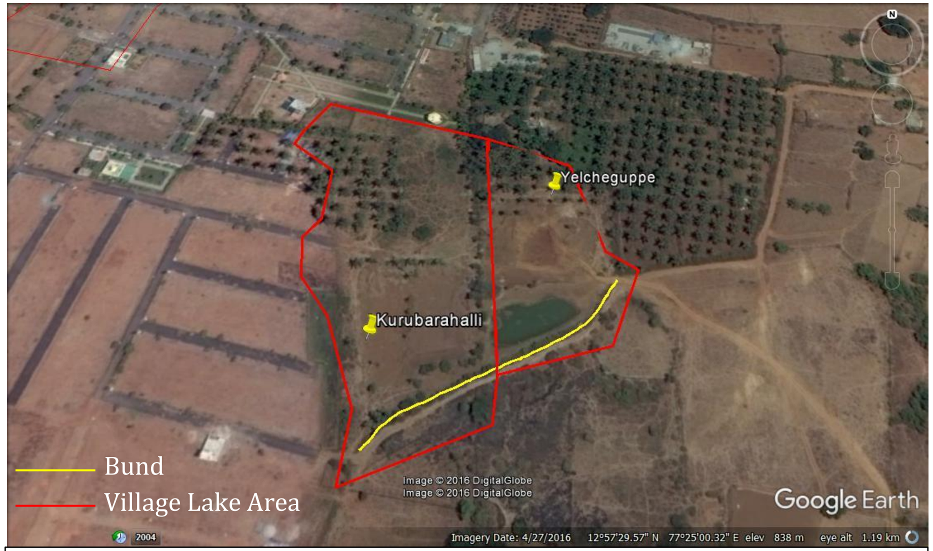

Figure-9.12e. Kurubarahalli lake in Tavarekere hobli of Bengaluru South

Figure-9.12f. Maligondanahalli lake in Kengeri hobli of Bangalore South

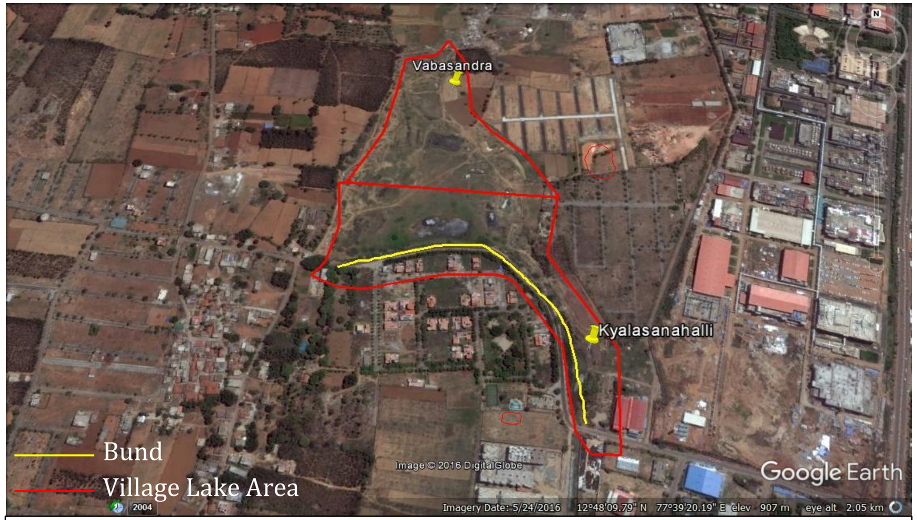

Figure-9.12g. Kyalasanahalli lake in Jigani hobli of Anekal taluk taluk

Figure-9.12h. Chembenahalli lake in Sarjapura hobli of Anekal taluk

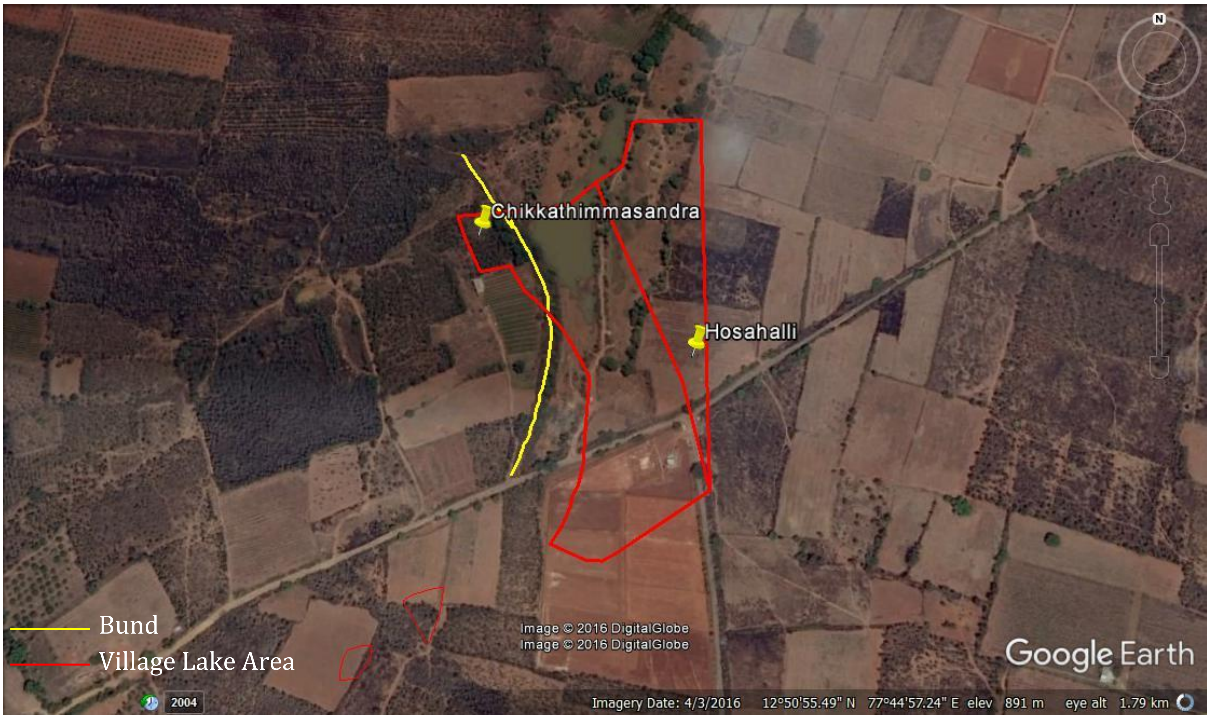

Figure-8.12i. Thimmasandra lake in Sarjapura hobli of Anekal taluk

Figure-8.12j. Mutsandra lake in Sarjapura hobli of Anekal taluk

8.5.12. Challenge-12: Confusion between the *Kunte* and the *Gokatte* by size mentioned in the Village Maps:

In few of the village maps, the sizes of the *Gokatte* and *Kunte* have been shown as bigger water bodies. So when counting the water bodies in the village maps, possibility of counting the *Gokatte* or *Kunte* as the *Kere* based on the size shown in the village maps. But it's not happening in the BMA lakes. There is also confusion between the *Gokatte* and *Kunte* such as in the Kannamangala village of Bidarahalli hobli of Bengaluru East taluk. There are eight water bodies in the Kannamangala village (Figure-8.14a) of Bidarahalli hobli, Bengaluru East taluk; within that, seven water bodies are counted as *Kunte*. The interesting fact is that the Government *Kunte* located in the Sy. no. 42 has been shown as larger than the Kannamangala *Gokatte*-2 located in the Sy. no. 138 of the village map.

There are three lakes and one *Kunte* in the Uttarahalli village (Figure-8.15a) of Uttarahalli hobli, Bengaluru South taluk; within that, the lake named as Moge Kere is located in the Sy. no. 111 has been shown as larger than the lake named as Subramhanyapura *Kere* is located in Sy. no. 64 in the village map. But the RTC showing that the Subramhanyapura *Kere* is larger than the Moge *Kere* has lead to confusion.

Extents of these water bodies have been twice verified with the RTC and corrected after the verification with SSLR data and the ground truth. As per the RTC, the size of the Kannamangala Government *Kunte* located in the Sy. no. 42 with the extent of 24 guntas is smaller than the Kannamangala *Gokatte*-2 (Figure-8.14b & c) located in the Sy. no. 138 with the extent of 1.06 A-G. Similarly, Moggie *Kere* located in the Sy. no. 111 with the extent of 15.16 A-G is smaller than the Subramhanyapura *Kere* (Figure-8.15b & c) located in the Sy. no. 64 with the extent of 18.06 A-G in the Uttarahalli village.

8.5.13. Challenge-13: Confusion between the Hills and Kunte:

In some of the older village maps, the small size hills have been marked as *Kunte* (by topographic map symbol) such as the Kachohalli village in the Dasanapur hobli of the Bengaluru North taluk; Sonnenahalli and Thannasandra villages in the KR Puram hobli of the Bengaluru East taluk. As per the old Kachohalli village map, a *Kunte* is located in the Survey no. 66 but the digitized village map showed that is a hill (Figure-8.16a). The confusion is also extended in the village maps of Sonnenahalli and Thannasandra villages in the Survey no. of 1, 39 and 40 (Figure-8.16b), and in the Survey no. 77 and 85 respectively (Figure-8.16c).

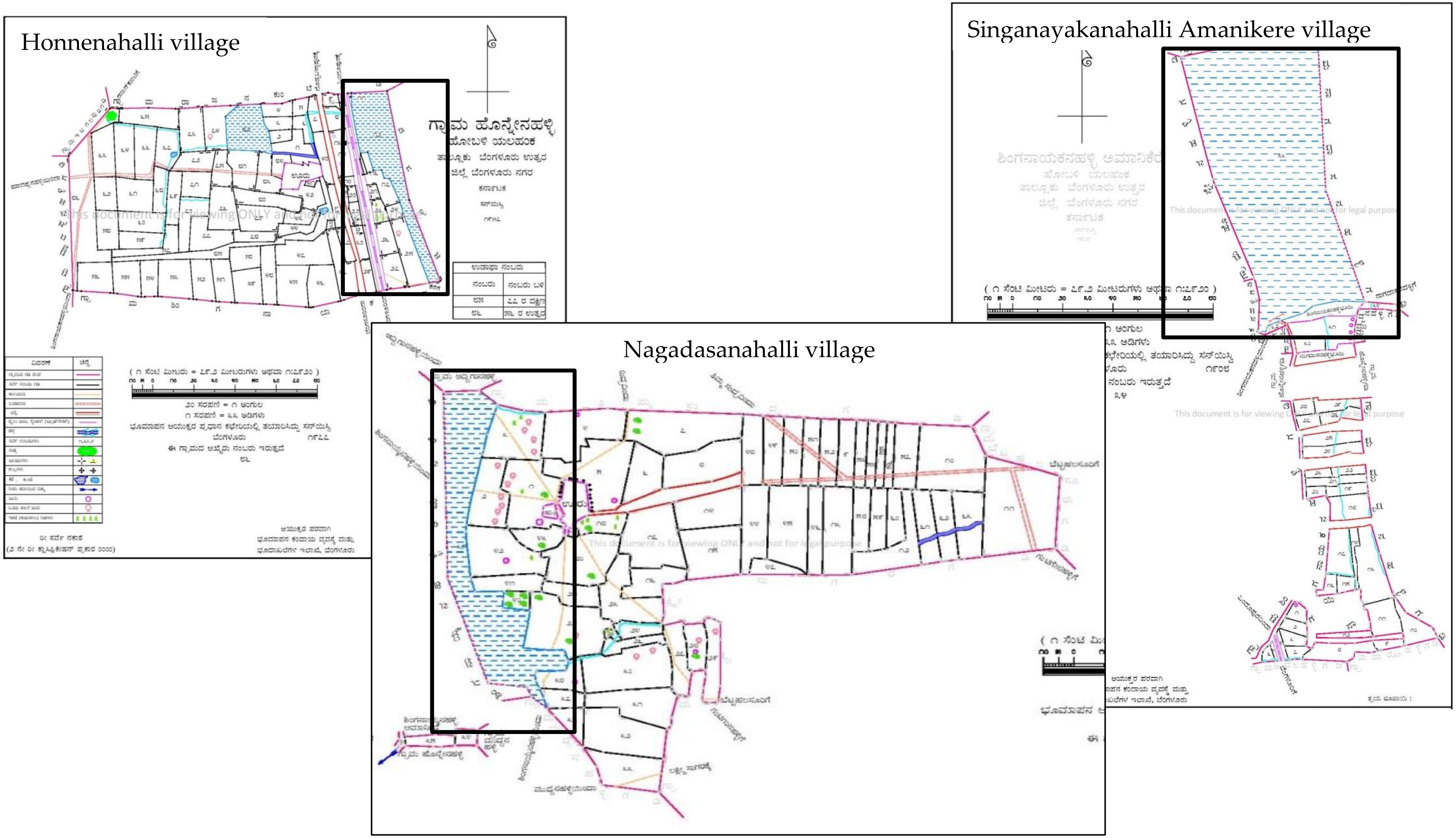

Figure-8.13. Location of Nagadasanahalli lake in three villages of Yelahanka hobli, Bengaluru North taluk

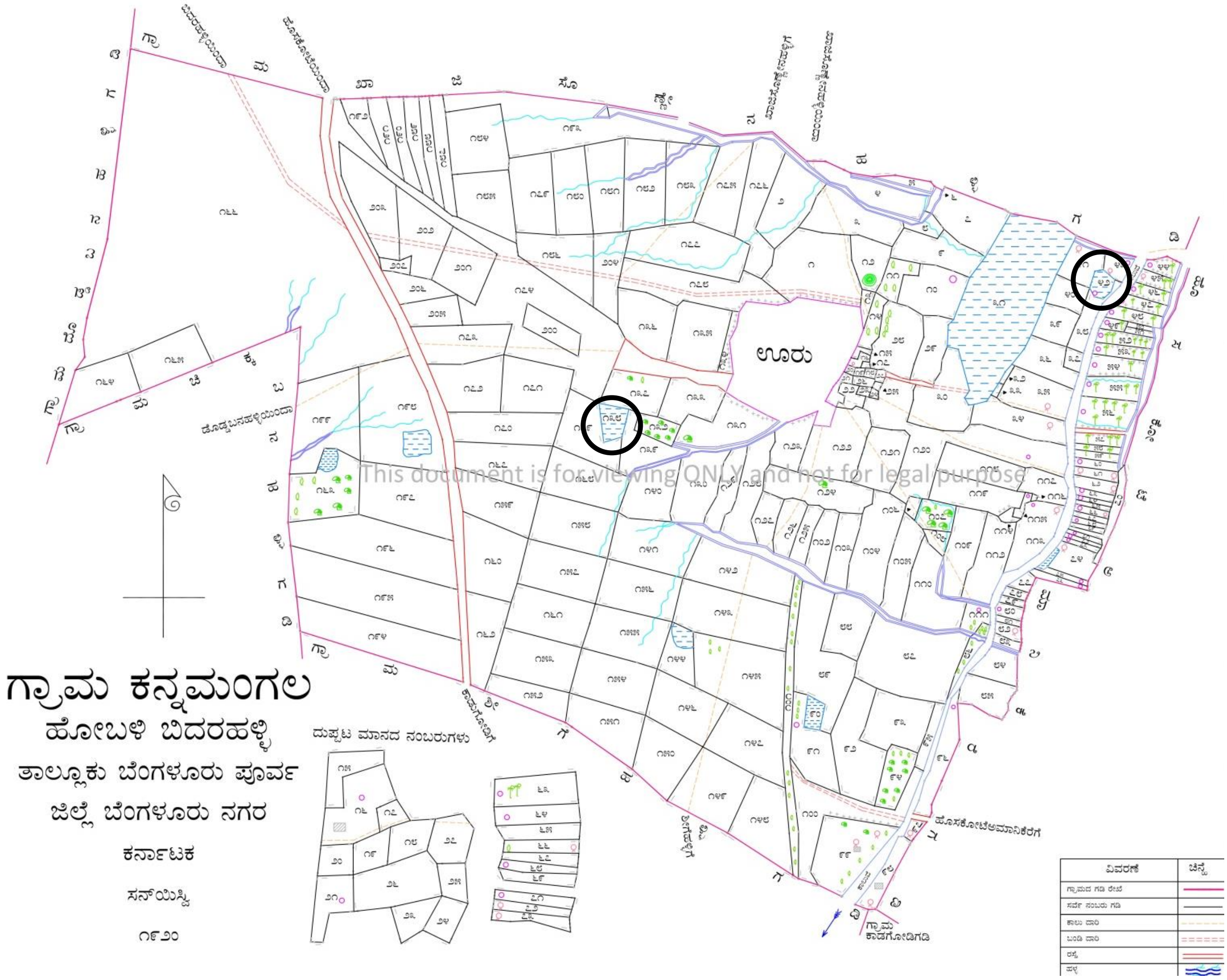

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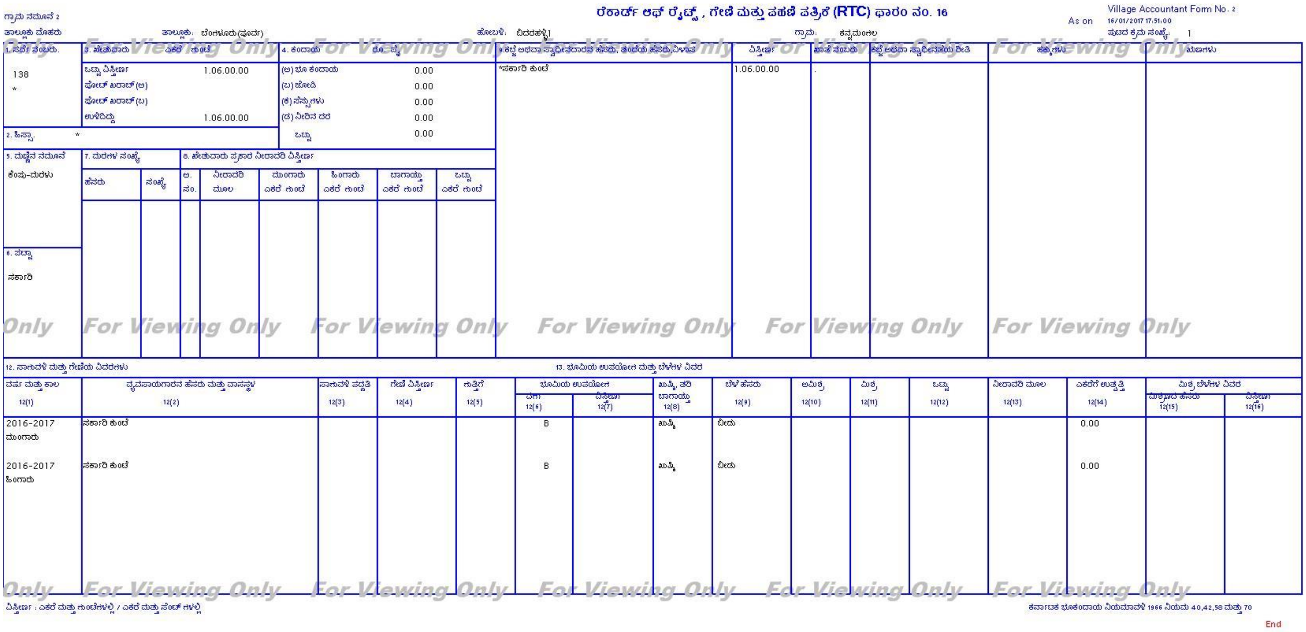
Figure-8.14a. Village map of Kannamangala in Bidarahalli hobli of Bengaluru East taluk



ಗ್ರಾಮ ನಮೂನೆ 2

ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್, ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 16/01/2017 17:51:00

ತಾಲ್ಲೂಕು ಮೊಹರು | ತಾಲ್ಲೂಕು: ಬೆಂಗಳೂರು(ಪೂರ್ವ) | ಹೋಬಳಿ: ಬಿದರಹಳ್ಳಿ1 | ಗ್ರಾಮ: ಕನ್ನಮಂಗಲ | ಪುಟದ ಕ್ರಮ ಸಂಖ್ಯೆ: 1

1. ಸರ್ವೆ ನಂಬರು	3. ಹಿಡುವಳಿ	ಎಕರೆ ಗುಂಟೆ	4. ಕಂದಾಯ	ರೂ. ಪೈ	9. ಕಬ್ಜೆ ಅಥವಾ ಸ್ವಾಧೀನದಾರರ ಹೆಸರು, ತಂದೆಯ ಹೆಸರು, ವಿಳಾಸ	ವಿಸ್ತೀರ್ಣ	ಖಾತೆ ನಂಬರು	ಕಬ್ಜೆ ಅಥವಾ ಸ್ವಾಧೀನತೆಯ ರೀತಿ	ಹಕ್ಕುಗಳು	ಋಣಗಳು
138 *	ಒಟ್ಟು ವಿಸ್ತೀರ್ಣ	1.06.00.00	(ಅ) ಭೂ ಕಂದಾಯ	0.00	*ಸರ್ಕಾರಿ ಕುಂಟೆ	1.06.00.00	.			
	ಪೋಟ್ ಖರಾಬ್ (ಅ)		(ಬ) ಜೋಡಿ	0.00						
	ಪೋಟ್ ಖರಾಬ್ (ಬ)		(ಕ) ಸೆಸ್ಸುಗಳು	0.00						
	ಉಳಿದಿದ್ದು	1.06.00.00	(ಡ) ನೀರಿನ ದರ	0.00						
2. ಹಿಸ್ಸಾ *			ಒಟ್ಟು	0.00						

5. ಮಣ್ಣಿನ ನಮೂನೆ: ಕೆಂಪು-ಮರಳು

6. ಪಟ್ಟಾ: ಸರ್ಕಾರಿ

7. ಮರಗಳ ಸಂಖ್ಯೆ		8. ಹಿಡುವಳಿದಾರ ಪ್ರಕಾರ ನೀರಾವರಿ ವಿಸ್ತೀರ್ಣ					
ಹೆಸರು	ಸಂಖ್ಯೆ	ಅ. ಸಂ.	ನೀರಾವರಿ ಮೂಲ	ಮುಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಹಿಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಬಾಗಾಯ್ತು ಎಕರೆ ಗುಂಟೆ	ಒಟ್ಟು ಎಕರೆ ಗುಂಟೆ

12. ಸಾಗುವಳಿ ಮತ್ತು ಗೇಣಿಯ ವಿವರಗಳು | 13. ಭೂಮಿಯ ಉಪಯೋಗ ಮತ್ತು ಬೆಳೆಗಳ ವಿವರ

ವರ್ಷ ಮತ್ತು ಕಾಲ 12(1)	ವ್ಯವಸಾಯಗಾರರ ಹೆಸರು ಮತ್ತು ವಾಸಸ್ಥಳ 12(2)	ಸಾಗುವಳಿ ಪದ್ಧತಿ 12(3)	ಗೇಣಿ ವಿಸ್ತೀರ್ಣ 12(4)	ಗುತ್ತಿಗೆ 12(5)	ಭೂಮಿಯ ಉಪಯೋಗ: ವರ್ಗ 12(6)	ವಿಸ್ತೀರ್ಣ 12(7)	ಖುಷ್ಕಿ, ತರಿ ಬಾಗಾಯ್ತು 12(8)	ಬೆಳೆ ಹೆಸರು 12(9)	ಅಮಿಶ್ರ 12(10)	ಮಿಶ್ರ 12(11)	ಒಟ್ಟು 12(12)	ನೀರಾವರಿ ಮೂಲ 12(13)	ಎಕರೆಗೆ ಉತ್ಪತ್ತಿ 12(14)	ಮಿಶ್ರ ಬೆಳೆಗಳ ವಿವರ: ಮಿಶ್ರಣದ ಹೆಸರು 12(15)	ವಿಸ್ತೀರ್ಣ 12(16)
2016-2017 ಮುಂಗಾರು	ಸರ್ಕಾರಿ ಕುಂಟೆ				B		ಖುಷ್ಕಿ	ಬೀಳು					0.00		
2016-2017 ಹಿಂಗಾರು	ಸರ್ಕಾರಿ ಕುಂಟೆ				B		ಖುಷ್ಕಿ	ಬೀಳು					0.00		

ವಿಸ್ತೀರ್ಣ : ಎಕರೆ ಮತ್ತು ಗುಂಟೆಗಳಲ್ಲಿ / ಎಕರೆ ಮತ್ತು ಸೆಂಟ್ ಗಳಲ್ಲಿ

ಕರ್ನಾಟಕ ಭೂಕಂದಾಯ ನಿಯಮಾವಳಿ 1966 ನಿಯಮ 40,42,58 ಮತ್ತು 70

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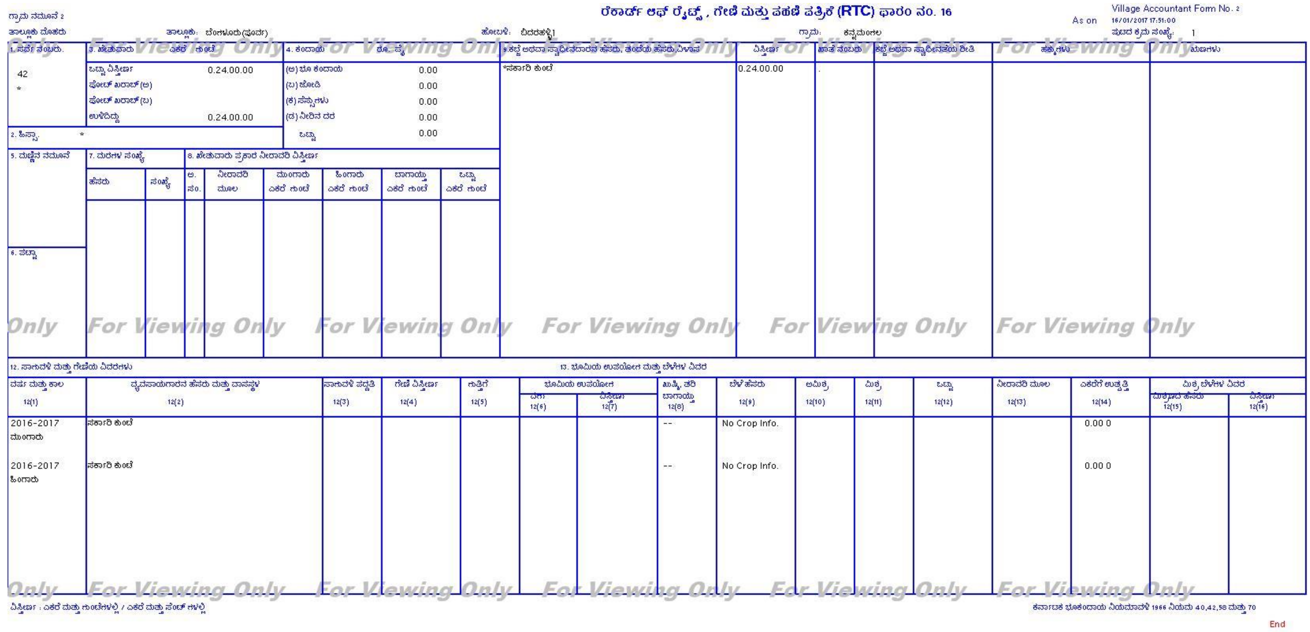
Figure-8.14b. RTC for Kannamangala *Gokatte*-2 located in the Survey No. 138



ಗ್ರಾಮ ನಮೂನೆ 2

ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್ , ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 16/01/2017 17:51:00

ತಾಲ್ಲೂಕು ಮೊಹರು | ತಾಲ್ಲೂಕು: ಬೆಂಗಳೂರು(ಪೂರ್ವ) | ಹೋಬಳಿ: ಬಿದರಹಳ್ಳಿ1 | ಗ್ರಾಮ: ಕನ್ನಮಂಗಲ | ಪುಟದ ಕ್ರಮ ಸಂಖ್ಯೆ: 1

1. ಸರ್ವೆ ನಂಬರು.	3. ಹಿಸ್ಸಾವಾರು ಎಕರೆ ಗುಂಟೆ		4. ಕಂದಾಯ ರೂ. ಪೈ		9. ಕಬ್ಜೆ ಅಥವಾ ಸ್ವಾಧೀನದಾರನ ಹೆಸರು, ತಂದೆಯ ಹೆಸರು, ವಿಳಾಸ	ವಿಸ್ತೀರ್ಣ
42 *	ಒಟ್ಟು ವಿಸ್ತೀರ್ಣ	0.24.00.00	(ಅ) ಭೂ ಕಂದಾಯ	0.00	*ಸರ್ಕಾರಿ ಕುಂಟೆ	0.24.00.00
	ಫೋಟ್ ಖರಾಬ್ (ಅ)		(ಬ) ಜೋಡಿ	0.00		
	ಫೋಟ್ ಖರಾಬ್ (ಬ)		(ಕ) ಸೆಸ್ಸುಗಳು	0.00		
	ಉಳಿದಿದ್ದು	0.24.00.00	(ಡ) ನೀರಿನ ದರ	0.00		
2. ಹಿಸ್ಸಾ. *			ಒಟ್ಟು	0.00		

5. ಮಣ್ಣಿನ ನಮೂನೆ

6. ಪಟ್ಟಾ

7. ಮರಗಳ ಸಂಖ್ಯೆ		8. ಹಿಸ್ಸಾವಾರು ಪ್ರಕಾರ ನೀರಾವರಿ ವಿಸ್ತೀರ್ಣ					
ಹೆಸರು	ಸಂಖ್ಯೆ	ಅ. ಸಂ.	ನೀರಾವರಿ ಮೂಲ	ಮುಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಹಿಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಬಾಗಾಯ್ತು ಎಕರೆ ಗುಂಟೆ	ಒಟ್ಟು ಎಕರೆ ಗುಂಟೆ

12. ಸಾಗುವಳಿ ಮತ್ತು ಗೇಣಿಯ ವಿವರಗಳು | 13. ಭೂಮಿಯ ಉಪಯೋಗ ಮತ್ತು ಬೆಳೆಗಳ ವಿವರ

ವರ್ಷ ಮತ್ತು ಕಾಲ 12(1)	ವ್ಯವಸಾಯಗಾರನ ಹೆಸರು ಮತ್ತು ವಾಸಸ್ಥಳ 12(2)	ಸಾಗುವಳಿ ಪದ್ಧತಿ 12(3)	ಗೇಣಿ ವಿಸ್ತೀರ್ಣ 12(4)	ಗುತ್ತಿಗೆ 12(5)	ಭೂಮಿಯ ಉಪಯೋಗ ವರ್ಗ 12(6)	ವಿಸ್ತೀರ್ಣ 12(7)	ಖುಷ್ಕಿ, ತರಿ ಬಾಗಾಯ್ತು 12(8)	ಬೆಳೆ ಹೆಸರು 12(9)	ಅಮಿಶ್ರ 12(10)	ಮಿಶ್ರ 12(11)	ಒಟ್ಟು 12(12)	ನೀರಾವರಿ ಮೂಲ 12(13)	ಎಕರೆಗೆ ಉತ್ಪತ್ತಿ 12(14)	ಮಿಶ್ರ ಬೆಳೆಗಳ ವಿವರ: ಮಿಶ್ರಣದ ಹೆಸರು 12(15)	ವಿಸ್ತೀರ್ಣ 12(16)
2016-2017 ಮುಂಗಾರು	ಸರ್ಕಾರಿ ಕುಂಟೆ						--	No Crop Info.					0.00 0		
2016-2017 ಹಿಂಗಾರು	ಸರ್ಕಾರಿ ಕುಂಟೆ						--	No Crop Info.					0.00 0		

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End

Figure-8.14c. RTC for Kannamangala Government *Kunte* located in the Survey No. 42

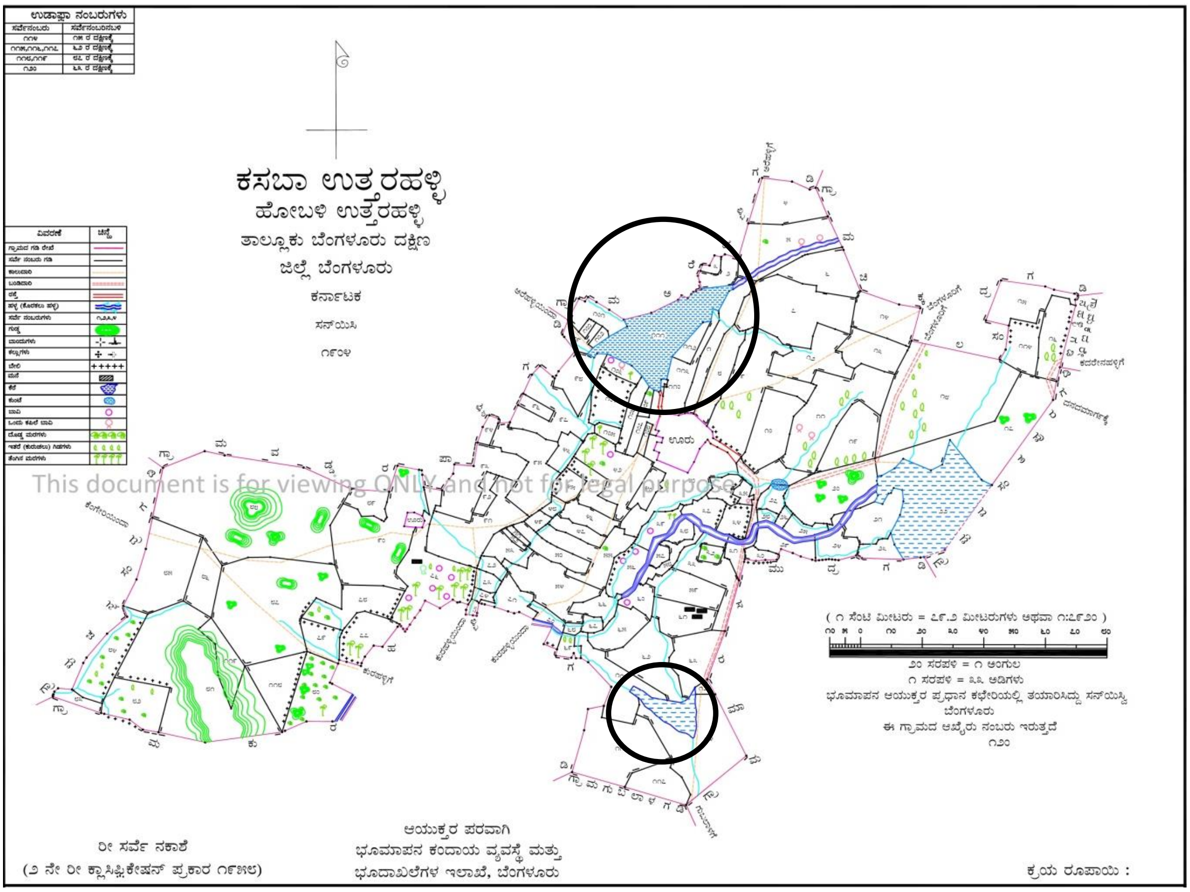
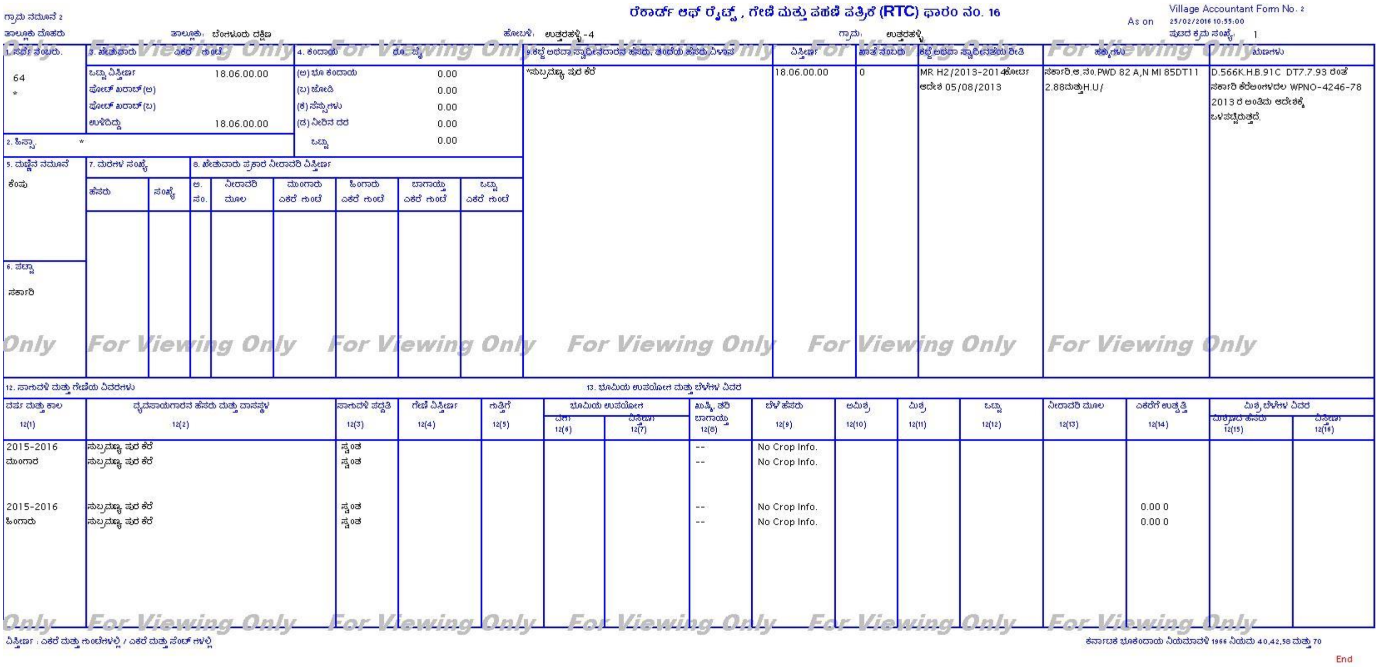


Figure-8.15a. Uttarahalli village in Bengaluru South taluk


ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್, ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 25/02/2016 10:55:00

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MR H2/2013-2014 05/08/2013

PWD 82 A,N MI 85DT11 2.88

D.566K.H.B.91C DT7.7.93 WPNO-4246-78 2013

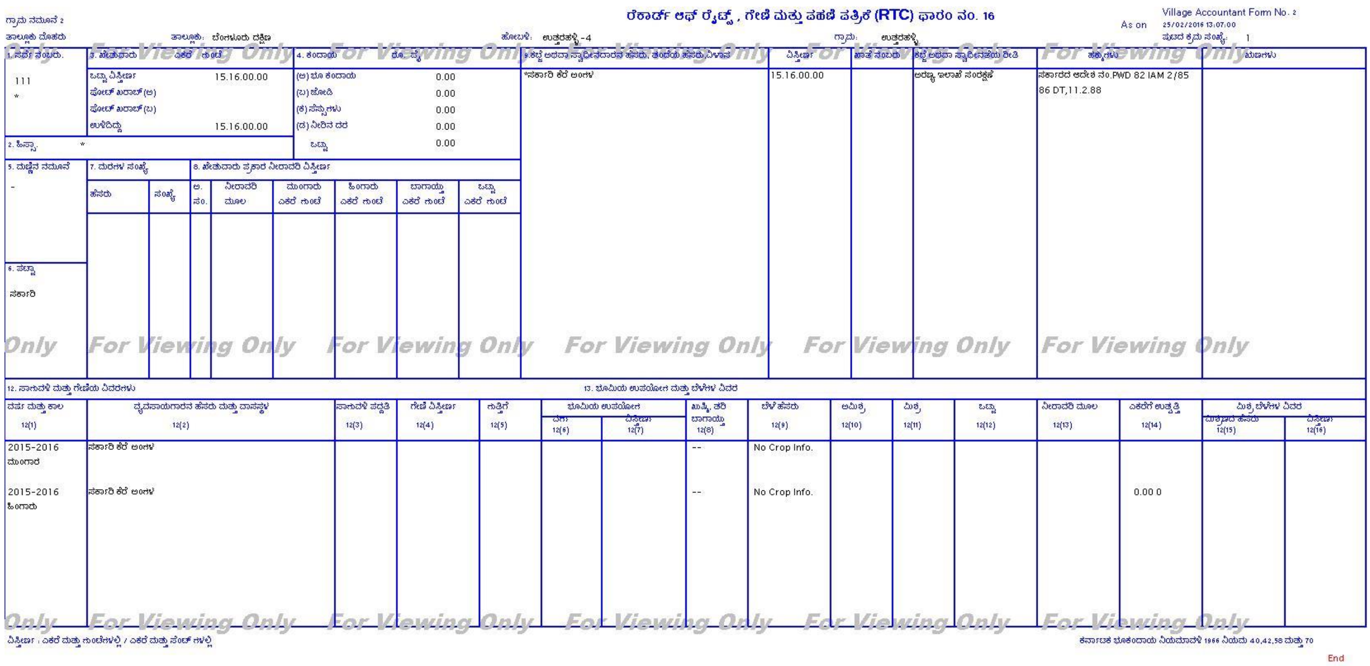
2015-2016

No Crop Info.

0.00 0

End

Figure-8.15b. RTC for Moggie *Kere* in Uttarahalli village of Bengaluru South taluk


ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್, ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 25/02/2016 13:07:00

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15.16.00.00

PWD 82 IAM 2/85 86 DT,11.2.88

2015-2016

No Crop Info.

0.00 0

End

Figure-8.15c. RTC for Subramhanyapura *Kere* in Uttarahalli village, Bengaluru South taluk

It was solved by verifying the survey number in RTC and also verification of slope near water body or hills during the physical verification of the *Kunte*. If it was confirmed as hills, then they were excluded from the water body database.

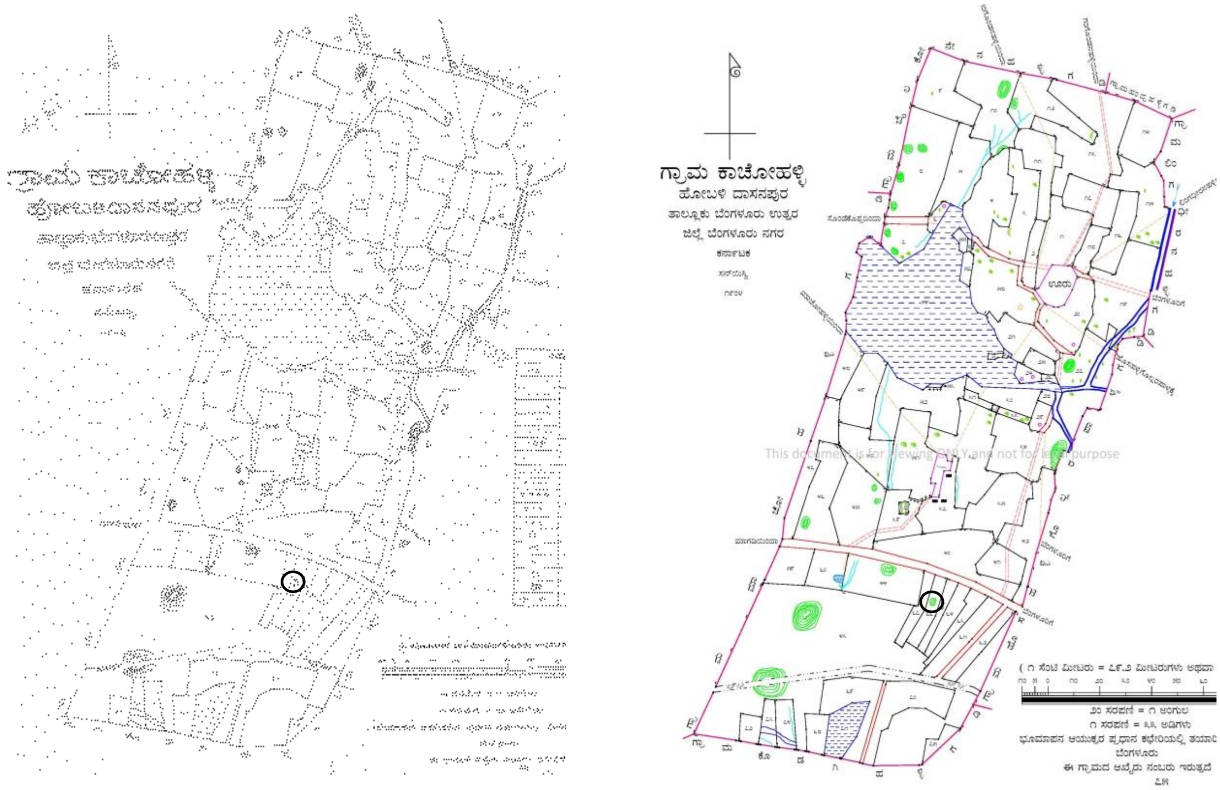


Figure-8.16a. Kachohalli village map

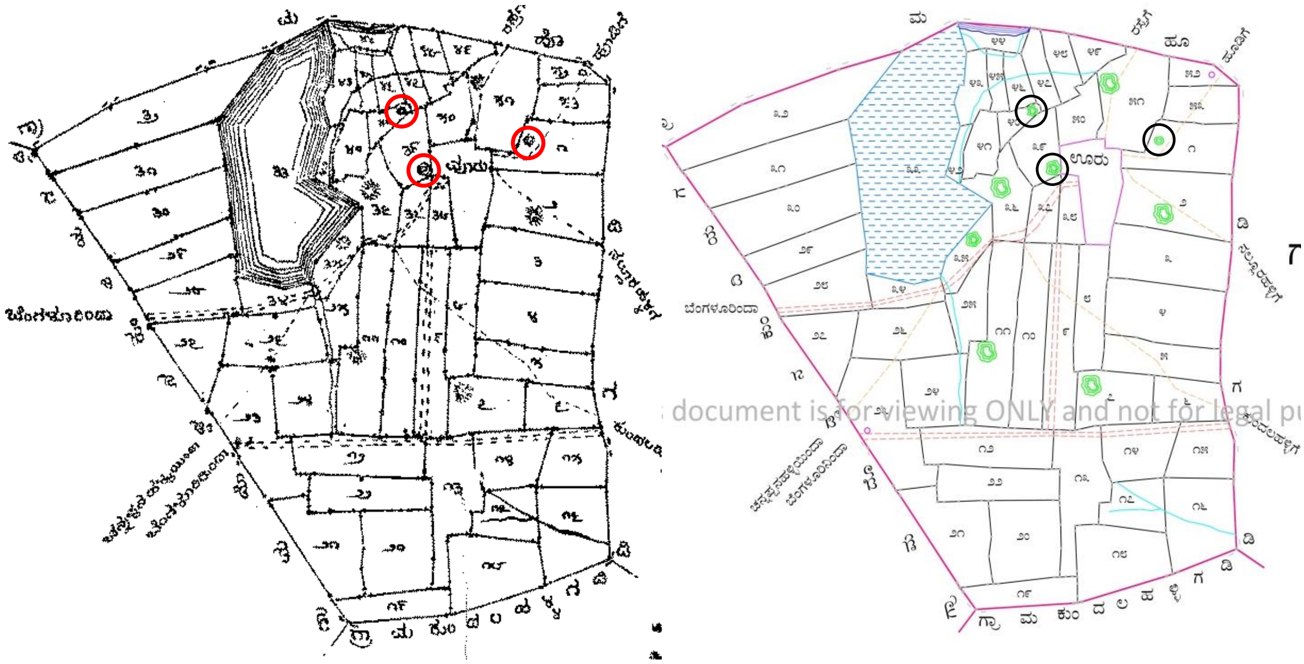


Figure-8.16b. Sonnenahalli village map

Figure-8.16c. Thannasandra village map

8.5.14. Challenge-14: *Kunte* located in the Forest area:

There are five tanks in the Bannerghatta village; four tanks in the Bannerughatta Kavalu village; two tanks in the Bhuthanahalli village; five tanks in the Bilwardahalli village; two tanks in the Byrappanahalli village; and three tanks in the Mantapa village. All these 21 tanks are located in the Bannerghatta Reserved Forest area. All these water bodies are located inside the reserve forest, whether these water bodies should be considered for the database because these pits or small artificial tanks have been constructed within the forest area for quenching the wildlife thirst to mitigate the man-wildlife conflicts.

The 21 pits (Figure-4.17) or the artificial tanks created to quench the wildlife's thirsty by the Karnataka Forest Department, which are listed in the six villages of the Bannerghatta forest area are not considered in the water body database.

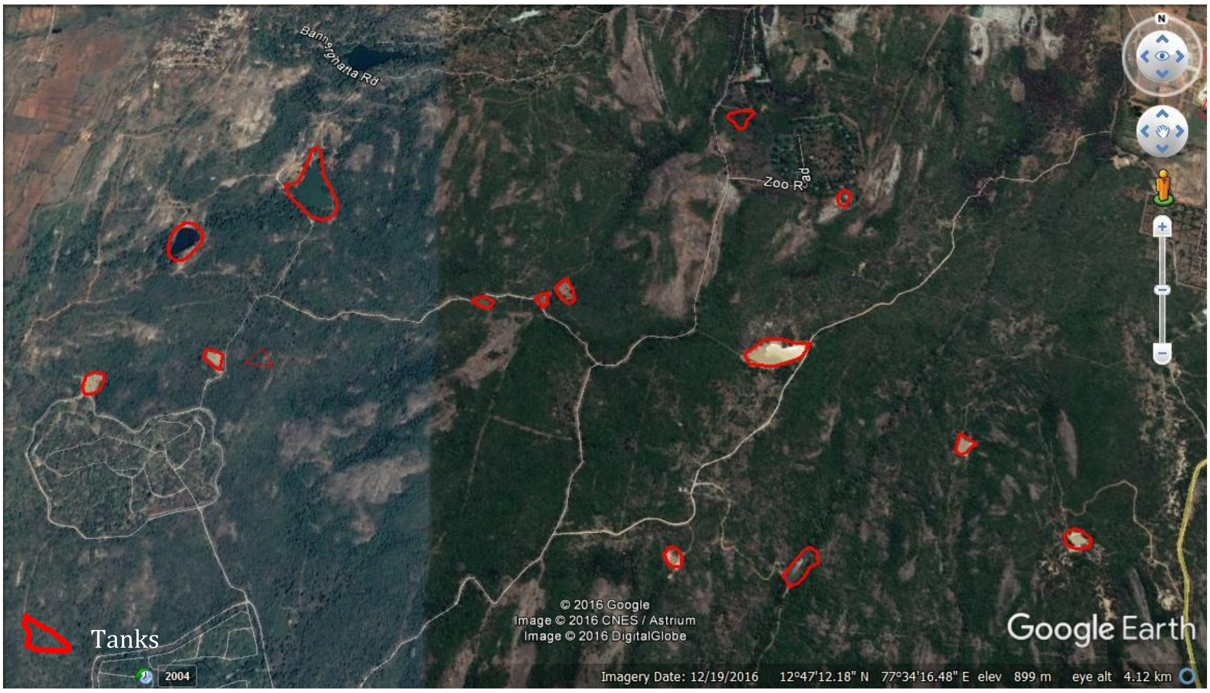


Figure-8.17. Wildlife thirst quench tank in Bannerghatta Reserve Forest

8.5.15. Challenge-15: No Survey Numbers for attached lakes:

There were no Survey numbers for the lakes located in the old Bangalore City of the Bengaluru Kasaba hobli, Bengaluru North taluk such as the Dharmambudy and Karanaji tanks. For the Karanji tank, only part of the lake survey number was available for the extent located in the Dodda Bailakhana village.

Jaraganahalli *Kere* located in the Yelachenahalli village of Uttarahalli hobli, Bengaluru South taluk has spread over in the villages of Yelachenahalli and Jaraganahalli. The Lake is located in the survey no. 23 of Yelachenahalli village, but there is no survey number for the Jaraganahalli village (Figure-4.18a). Due to the absence of the survey no. in the Jaraganahalli village, only the Yelachenahalli village extent only considered (2.09 a-g as per RTC) by the SSLR (Figure-4.18b). The remaining area in the Jaraganahalli village is not in the data of SSLR, which has led to misperception in total extent of the Jaraganahalli lake.

As the Dharmambudy and Karanaji tanks (Figure-8.19) have contributed to urban developments. So without the survey no., the total extents of the Dharmambudy and Karanaji tanks were found based on the secondary and historical data. Extent of Jaraganahalli lake in the Jaraganahalli village was estimated by using the GIS, which added to the available extent and found that the 5.26 a-g as the total extent area.

8.5.16. Challenge-16: Confusion between the Encroachment and the Custodian:

Lalbagh tank is located in the Upparahalli village, Bengaluru Kasaba of Bengaluru North taluk is maintained by the Horticulture Department; as the tank is located near Lalbagh park. Lalbagh tank is optical for public. But the SSLR surveyed sketch (Figure-8.20) has shown that the Horticulture Department has encroached the lake and there is no RTC for the lake for verification also.

Nagawara lake, which is spread over the extent of 103.23 a-g in the villages of Nagawara, Vishwanathnagahalli and Hebbal Amanikere in Bengaluru Kasaba hobli, Bengaluru North has been leased to the M/s Lumbini gardens for 15 years under the PPP (Public-Private-Partnership) model by KLCDA (LDA). The details in the RTC have shown that the part of the water body land as 3.11a-g has been with the BWSSB (Figure-8.21).

Lalbagh lake has been verified on ground and found that the Horticulture Department is maintaining the lake. The reasons that the lake has been encroached are probably due to lack of communication between the Agency/ Authority and the SSLR. Nagawara lake has been developed and maintained by the M/s Lumbini gardens but the custodian is still under the KLCDA. Extent of 3.11a-g lake land has been provided to the BWSSB for construction of STP (Sewage Treatment Plant) to treat the inflow of sewage water into lake.

8.5.17. Challenge-17: Mislead during inventorisation of newly created *Kunte*:

There are 10 newly created *Kunte*, which were created after the year 1995. As there are no records available with the Administrative/ Planning Authorities about the newly created *Kunte*, it's tough to inventorize the village-wise newly created *Kunte*. Even the people in the village were not aware about the newly created *Kunte's* due to the urbanization and floating population of that specific village.

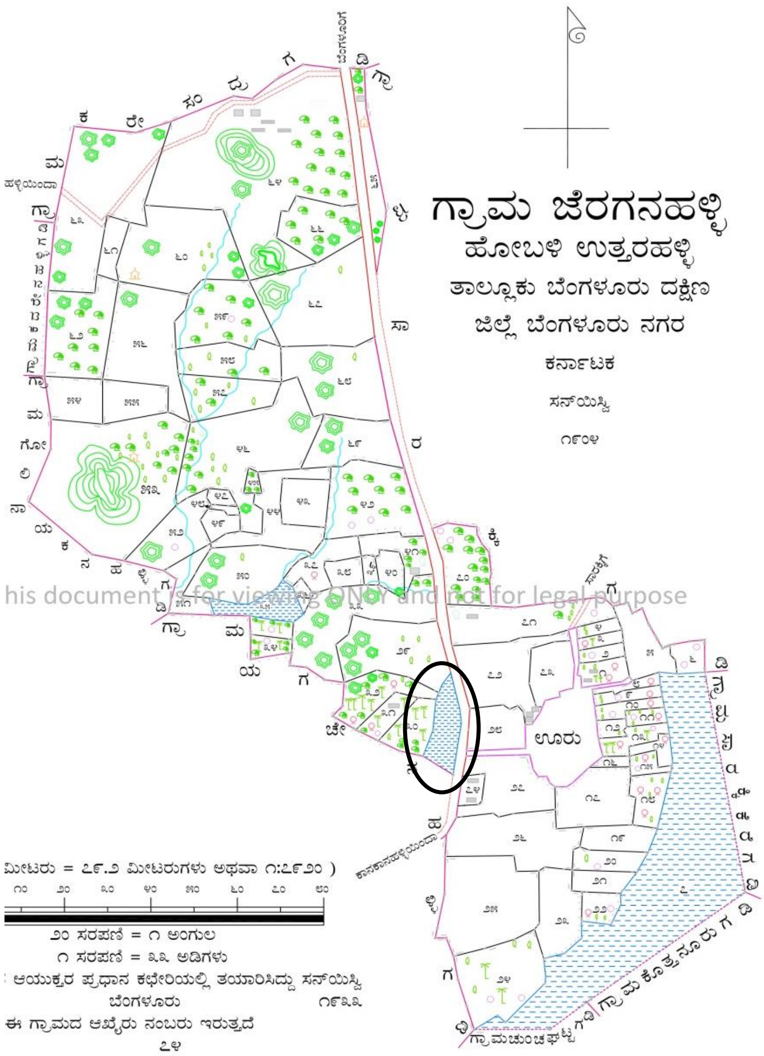
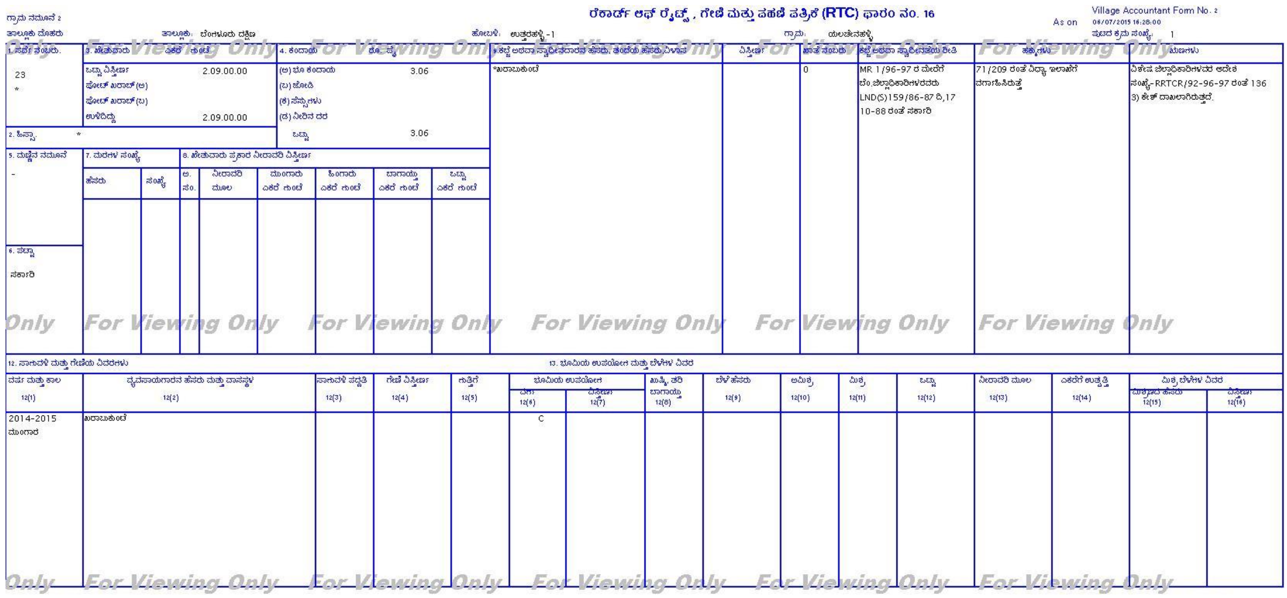


Figure-8.18a. Jaraganahalli village map without the survey no. for part of Jaraganahalli *Kere*



ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್, ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 06/07/2015 16:28:00

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Figure-8.18b. RTC of Jaraganahalli *Kere* in Yelachenahalli village, Uttarahalli hobli

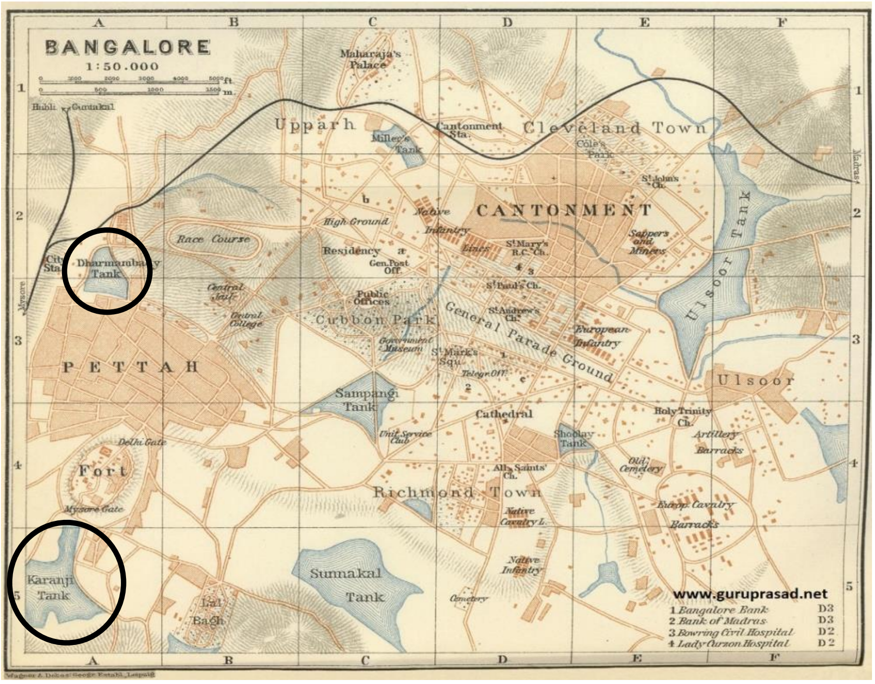


Figure-8.19. Dharmambudy and Karanaji lakes in Bangalore map of the year 1900's

The newly created *Kunte* is listed by taking location from the Google Imageries (Figure-8.22a & b) and the same has been confirmed through the RTC information and ground verification. Additionally, the details about the new *Kunte* are collected from the senior citizens residing in the area.

8.5.18. Challenge-18: Mislead during verification of disused *Kunte*:

In Bengaluru Metropolitan Area (BMA), *Kunte* landuse was changed to erect superstructures. As most of the population in the City are migrants and constitutes a vast floating population, the details of the disused *Kunte* (Figure-8.23) could not be collected from local area people. As there are no localities to guide the CLC team for inventorisation of disused water bodies, it was highly time-consuming.

Kunte which are no longer existing were found in village maps are located based on the landmarks such as the road, hill, tree, settlement or nala. The same has been first located in the Google Imageries and noted the approximate GPS location. The approximate GPS location will be uploaded in the GPS instrument to identify the location. Survey no. of Kunte has been verified with the surrounding area survey no. by interaction.

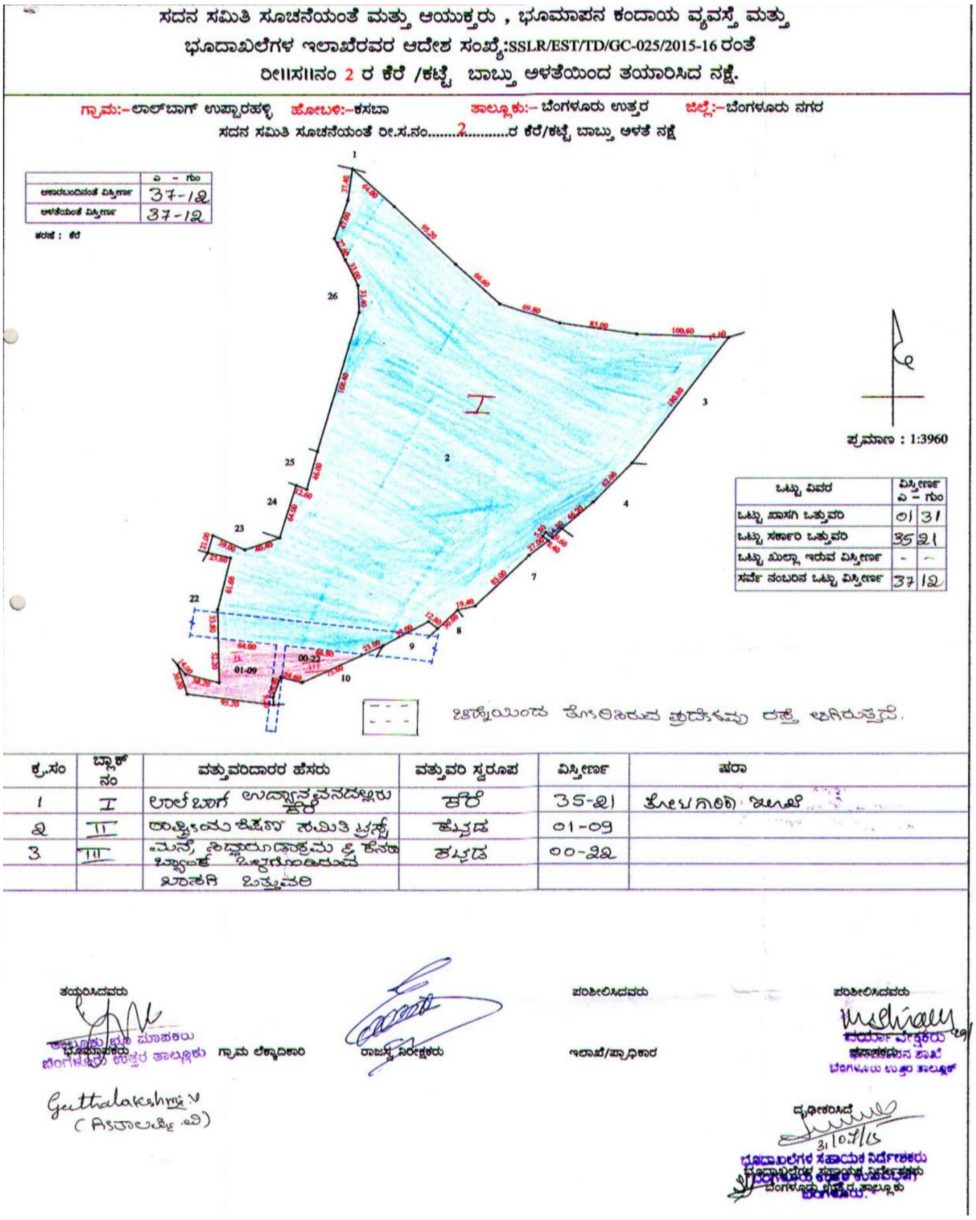
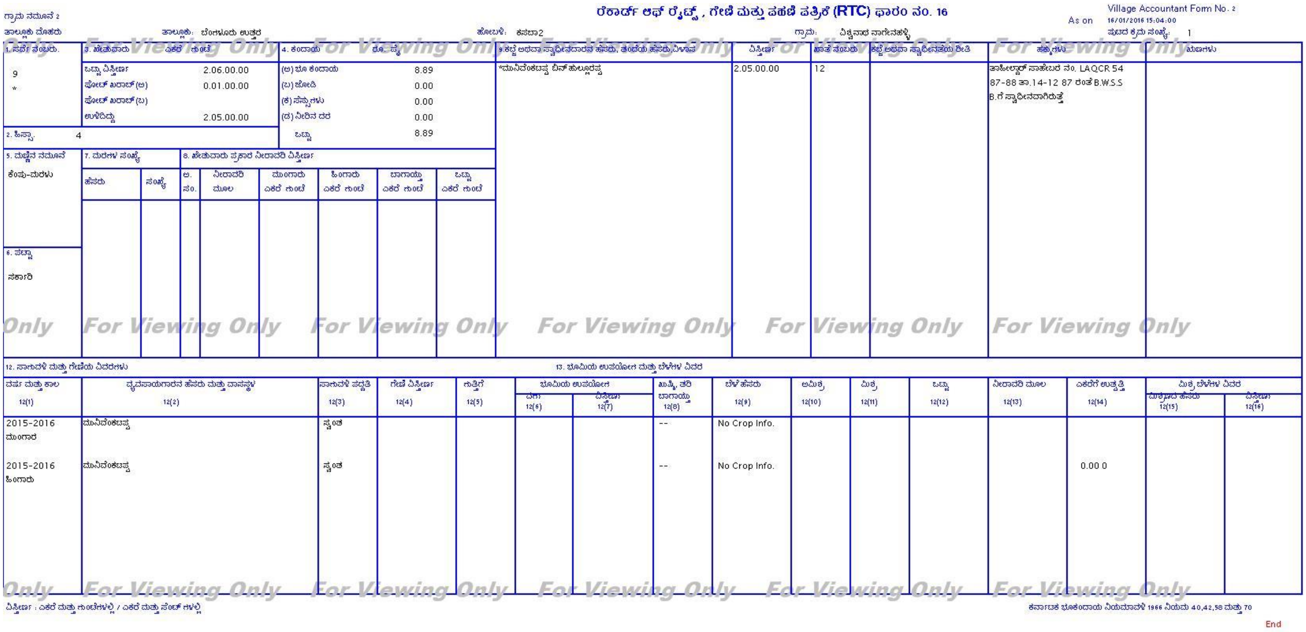


Figure-8.20. Existing Lalbagh lake has shown as encroached by Horticulture Department


ಗ್ರಾಮ ನಮೂನೆ 2

ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್ , ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Village Accountant Form No. 2

As on 16/01/2016 15:04:00

ತಾಲ್ಲೂಕು ಮೊಹರು — ತಾಲ್ಲೂಕು: ಬೆಂಗಳೂರು ಉತ್ತರ — ಹೋಬಳಿ: ಕಸಬಾ2 — ಗ್ರಾಮ: ವಿಶ್ವನಾಥ ನಾಗೇನಹಳ್ಳಿ — ಪುಟದ ಕ್ರಮ ಸಂಖ್ಯೆ: 1

1. ಸರ್ವೆ ನಂಬರು.	3. ಹಿಸ್ಸಾವಾರು ಎಕರೆ ಗುಂಟೆ	4. ಕಂದಾಯ ರೂ. ಪೈ	9. ಕಬ್ಜೆ ಅಥವಾ ಸ್ವಾಧೀನದಾರನ ಹೆಸರು, ತಂದೆಯ ಹೆಸರು, ವಿಳಾಸ	ವಿಸ್ತೀರ್ಣ	ಖಾತೆ ನಂಬರು	ಕಬ್ಜೆ ಅಥವಾ ಸ್ವಾಧೀನತೆಯ ರೀತಿ	ಹಕ್ಕುಗಳು	ಋಣಗಳು
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2. ಹಿಸ್ಸಾ. 4

5. ಮಣ್ಣಿನ ನಮೂನೆ: ಕೆಂಪು-ಮರಳು

6. ಪಟ್ಟಾ: ಸರ್ಕಾರಿ

7. ಮರಗಳ ಸಂಖ್ಯೆ: ಹೆಸರು	ಸಂಖ್ಯೆ	8. ಹಿಸ್ಸಾವಾರು ಪ್ರಕಾರ ನೀರಾವರಿ ವಿಸ್ತೀರ್ಣ: ಅ. ಸಂ.	ನೀರಾವರಿ ಮೂಲ	ಮುಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಹಿಂಗಾರು ಎಕರೆ ಗುಂಟೆ	ಬಾಗಾಯ್ತು ಎಕರೆ ಗುಂಟೆ	ಒಟ್ಟು ಎಕರೆ ಗುಂಟೆ

12. ಸಾಗುವಳಿ ಮತ್ತು ಗೇಣಿಯ ವಿವರಗಳು — 13. ಭೂಮಿಯ ಉಪಯೋಗ ಮತ್ತು ಬೆಳೆಗಳ ವಿವರ

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ಕರ್ನಾಟಕ ಭೂಕಂದಾಯ ನಿಯಮಾವಳಿ 1966 ನಿಯಮ 40,42,58 ಮತ್ತು 70

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Figure-8.21. Nagawara lake RTC for Survey No. in Vishwanatha Nagenahalli village for BWSSB

Figure-9.22a. Margondanahalli Hosakunte in imagery

Figure-9.22b. Rajanakunte in satellite imagery

Figure-9.23. Disused Dodkunte *Kunte*-3 for school in Bengaluru Kasaba of Bengaluru North taluk

8.5.19. Challenge-19: Confusion between the types of water bodies:

In few villages, the *Gokatte* referred as *Kere* or *Kere* referred as *Gokatte* or the *Gokatte* referred as *Kunte*. The local people have not classified the water bodies based on size or by multiple usages. E.g. water body has the extent of 6.29a-g in Laggere village, Yeshwanthapura hobli of Bengaluru North taluk has been called in the name of Bassappana *Katte* (Figure-8.24a). The doubt is that whether the water body is *Gokatte* or *Kere*.

In the water body database, name of the water body will remain the same as per the village people and the stakeholder documents, but the water body has been counted as *Kunte* or *Gokatte* or *Kere* based on the size of extent as per the EMPRI water body classification, which has been maintained throughout the study. E.g. Bassappana *Katte* has been counted as a *Kere* based on its extent (Figure-8.24b).

8.5.20. Challenge-20: Confusion between the names of the water bodies:

In most of the villages, the *Kere* are commonly called as the Hosakere (new lake), Halekere (old lake), Urumundina *Kere* (lake located before the entry of their habitat) as shown in Figure-8.25 (a&b) and most of the *Gokatte* has been called as Sarkari *Katte* (Figure-8.26a&b). In few villages, there are many *Kunte* (Figure-8.27) without name but local people identified through the land marks and surrounding area such as water tank and agriculture land owners respectively.

There are seven *Kunte* in villages of Doddakanalli, Pannathur, Sulikunte, Siddapura in Varthur hobli and Hulimangala in Jigani hobli; eight *Kunte* in villages of Srigandhakavalu of Yeshwanthapura hobli, Kommasandra in Sarjapura hobli, Banaswadi in KR Puram hobli, Agara, Kumbalagodu in Kengeri hobli and Begur in Begur hobli; Nine *Kunte* in villages of Rajanakunte in Hesarghatta hobli, Kanaminike in Kengeri hobli and Konappana Agrahara in Begur hobli; 10 *Kunte* in villages of Kempepura Agrahara in Bengaluru Kasaba hobli, Sathanoor in Jala hobli, Varthur in Varthur hobli, Khajisonnenahalli in Biderahalli hobli and Ramohalli in Kengeri hobli; 11 *Kunte* in villages of Doddabiderakallu and Peenya in Yeshwanthapura hobli, and Hoodi in KR Puram hobli; 12 *Kunte* in Kengeri village of Kengeri hobli; 13 *Kunte* in Pattandur Agrahara village of KR Puram hobli; 15 *Kunte* in Dommasandra; and a maximum of 17 *Kunte* in Kodathi villages of Varthur hobli were recorded. These common traditional names of *Kere* and *Gokatte*, and absence of names for many *Kunte* in a village has raised doubt during recording of water bodies.

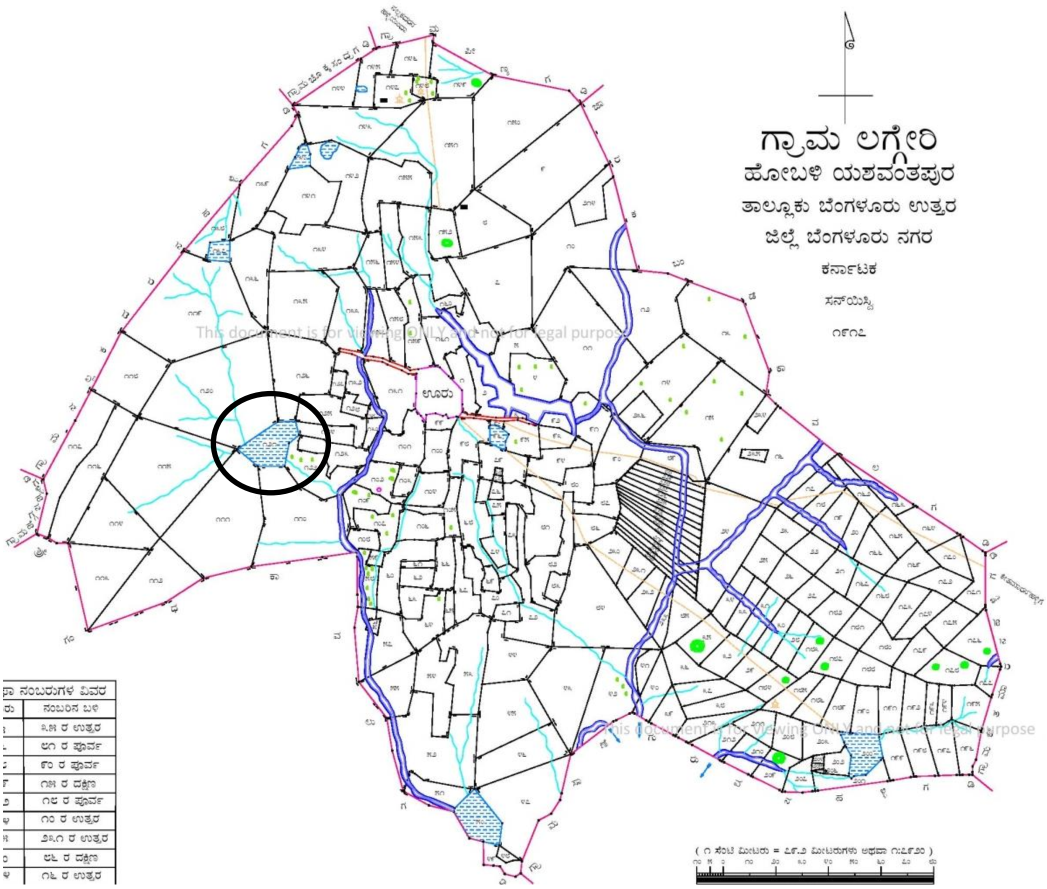


Figure-8.24a. Location of Basappana *Katte* in Laggere village of Yeshwanthapura hobli

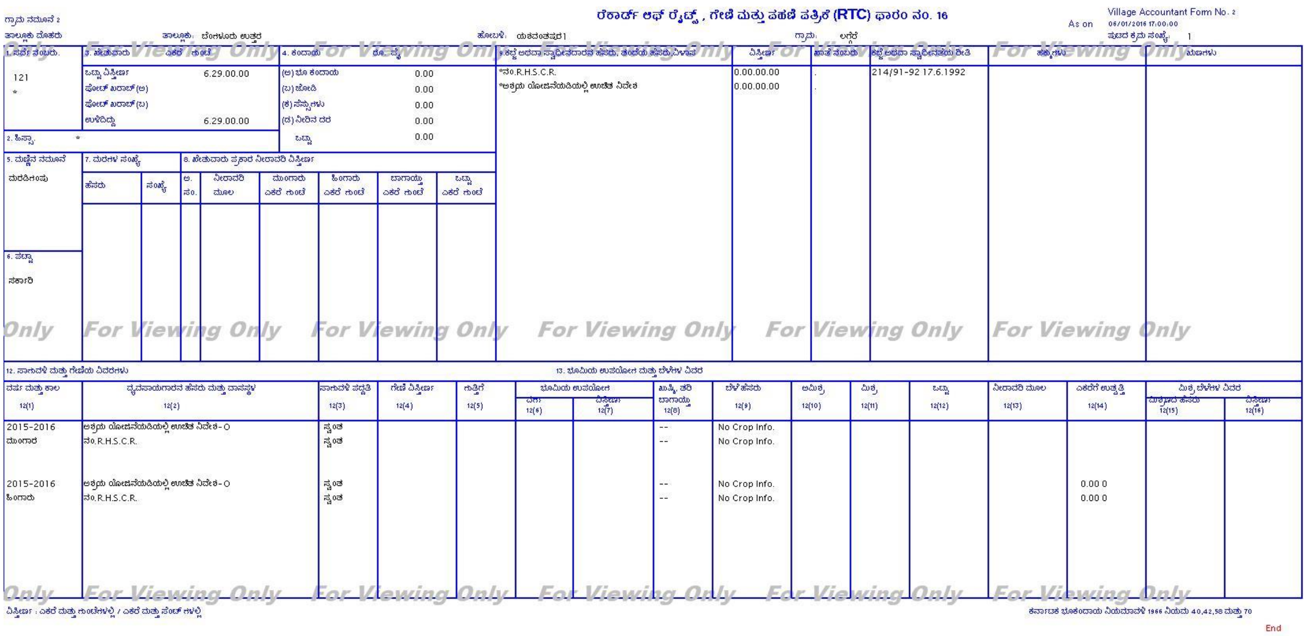
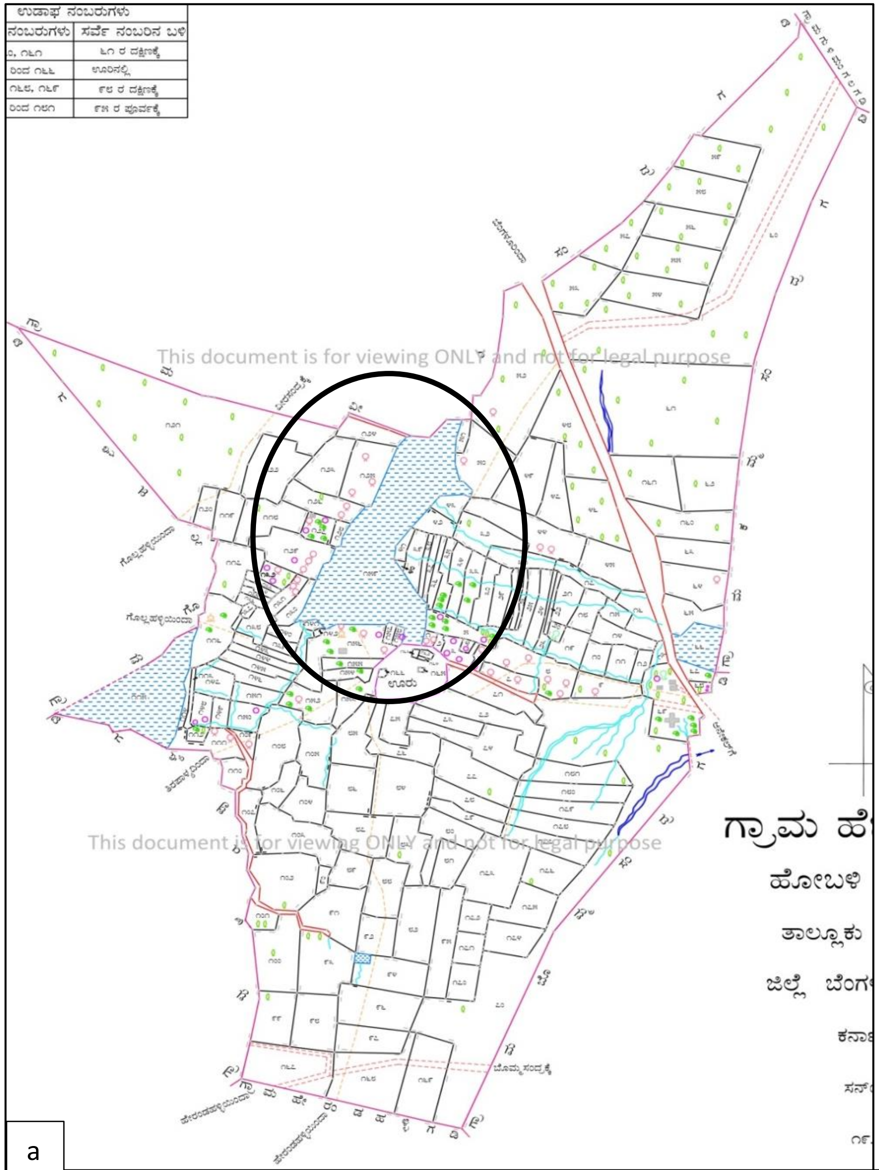


Figure-8.24b. RTC of Basappana *Katte* in Laggere village of Yeshwanthapura hobli



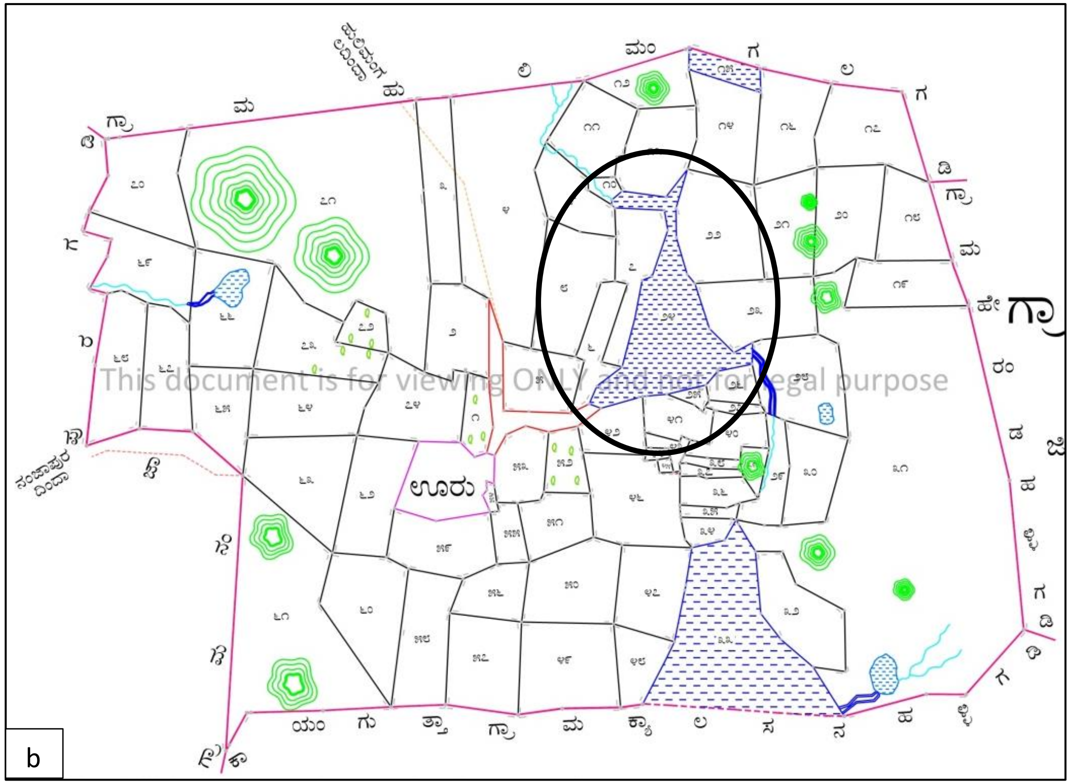


Figure-8.25. Location of Urumundina Kere in (a) Hebbagodi village of Athibele hobli and (b) Vabasandra village in Jigani hobli of Anekal taluk

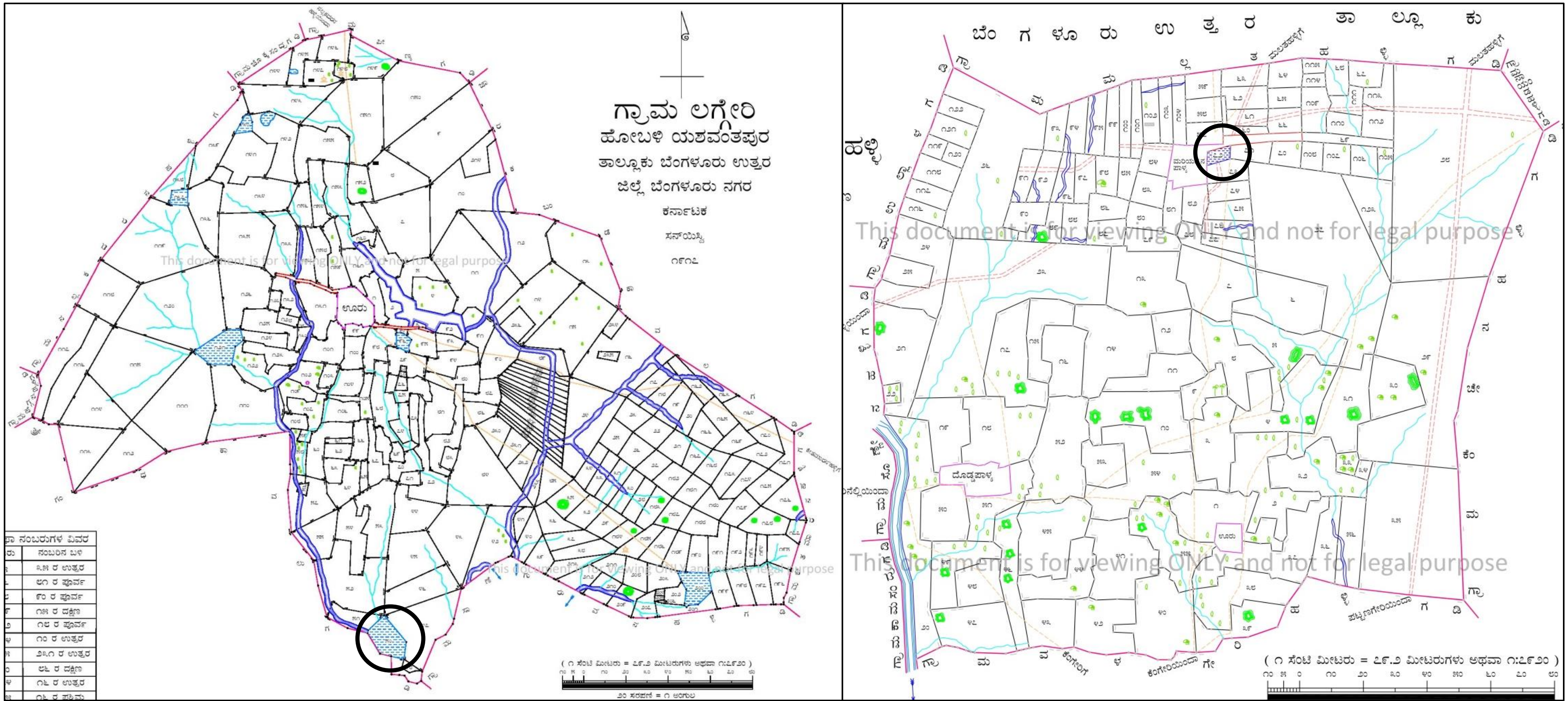


Figure-8.26. Location of Sarkari *Katte* in (a) Laggere village of Yeshwanthapura hobli, Bengaluru North taluk and (b) Nagadevanahalli village in Kengeri hobli of Bengaluru South taluk

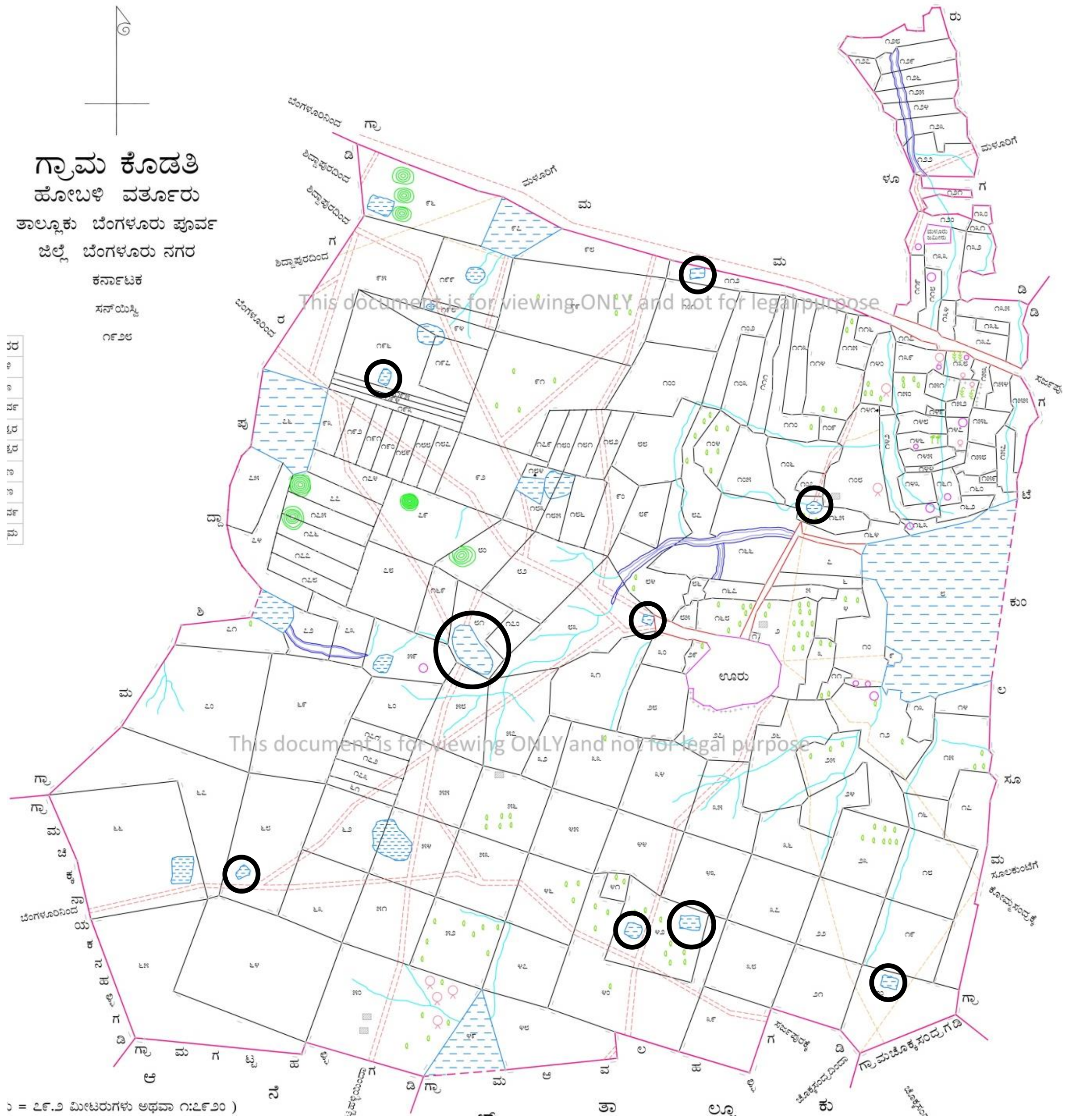


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Figure-8.27. Location of 15 *Kunte* in Doddabiderakallu village map of Yeshwanthapura hobli

Commonly called *Kere* such as Hosakere, Halekere, Urumundina *Kere* and Sarkari *Katte* has been differentiated by use of the location based unique code developed by EMPRI. For example, Sarkari *Katte* in Laggere and Nagadevenahalli villages were coded as BUBNYPlag_kr3-159 and BUBSKGngd_ku1-1273 respectively. As there are many *Kunte* in more than 25 villages in the BMA, the no. of *Kunte* has been counted and numbered numerically in clock-wise direction of the village map.

8.5.21. Challenge-21: Confusion for Declaring the *Kunte* as Disused:

Dried *Kunte* has been visually considered as the vacant land, but these *Kunte* will receive and store the rainwater during the rainy season lead to doubt that whether the *Kunte* is still existing or disused.

During encroachment of water bodies, the slope of the water bodies have been breached and converted as the flat surface. The water bodies are converted to flat surface by dumping the Construction and Demolition (C&D) wastes to encroach the land for the building construction or by use of soil for the agriculture purpose. These water bodies are converted as vacant land even after the eviction of the encroachment. These types of *Kunte's* are ground verified with the additional effort such as by considering the slope (ridge) of the surrounding area and any structure (Stone pitch as bund or sand bund) as evidence for the existing of *Kunte*. For example, Kammagondanahalli *Kunte* (Figure-8.28a) and Bagalakunte (Figure-8.28b) in Yeshwanthapura hobli are located above the ground level as compared to its surroundings.

Figure-8.28a. Disused Kammagondanahalli *Kunte* in Yeshwanthapura hobli, Bengaluru North taluk

Figure-8.28b. Disused Bagalakunte in Yeshwanthapura hobli of Bengaluru North taluk

8.5.22. Challenge-22: No Single Source data for Disused Specific Water body:

Disused Rampura *Kunte* was located in the Bidarahalli hobli of Bangalore East taluk with the extent of 36 guntas spread over in two villages (Figure-8.29a & b) viz… Huvinaane (Sy.no.56) and Rampura (in Sy.no.93). This is the only *Kunte*, which is spread-over in two villages and there was no single source like RTC or SSLR surveyed map to confirm the extent of *Kunte*. Similarly, disused Sunnakall *Kere* with the extent of 116.18a-g was spread over in Sy.no.33 of Audugodi village in Begur hobli of Bangalore South taluk; Sy.no.1 of Arekempanahalli and in Sy.no.10 of Annipura villages in Bengaluru Kasaba hobli of Bengaluru North taluk. There was no RTC as well as SSLR data for the disused lake located in the part of Arekempanahalli village. Further, there was no RTC for the part of lake land in Annipura village and no SSLR data for the part of lake land in Audugodi village has lead to question on total extent of disused lake.

The total extent of the disused Rampura *Kunte* for the coconut plantation has been estimated by adding the extent of two villages data i.e. RTC extent of 21 guntas for the Sy.no.56 of Huvinaane village (Figure-8.29c) and SSLR surveyed map data of 15 guntas for the Sy.no.93 of Rampura village (Figure-8.29d).

Similarly, the total extent for the disused Sunnakall lake as Shanthi Nagar bus stand has been estimated by using the GIS method to include the extent of lake in Arekempanahalli village (Figure-8.30a) and the extent of other part of lakes located in the Audugodi and Annipura villages are used for the verification of the total extent of disused lake. i.e. RTC extent of 79.32a-g for the Sy.no.33 of Audugodi village (Figure-8.30b & c) and SSLR surveyed map data of 9 acres for the Sy.no.10 of Annipura village (Figure-8.29d & e).

8.5.23. Challenge-23: Unable to Verify the water bodies located in the Central Government Agency Custodian:

Water bodies located in the Central Government Agencies such as located within the Defence area, HAL (Hindustan Aeronautical Limited), HMT (Hindustan Machine Tools Limited). All these water bodies are disused and not visited by the EMPRI team due to the permission denied by the Central Government Agencies. Disused Banaswadi *Kunte*-4 & 5 (Figure-8.31a) with the extent of two and three guntas respectively in Banaswadi hobli of the Bengaluru East taluk was located inside the Defence Area; disused Kempapura *Kere* (Figure-8.31b) with the extent of 13.32 a-g in Varthur hobli of the Bengaluru East was located inside the HAL; and disused Peenya plantation *Kunte* (Figure-8.31c) in Yeshwanthapura hobli of Bengaluru East taluk with the extent of seven gunta was located within the area of HMT.

Similarly, the disused Pattandur Agrahara *Kunte*-1 (Figure-8.31d) with the extent of 15 guntas in KR Puram hobli of the Bangalore East taluk was located inside the BSNL compound and the disused Kadugodi *Kunte*-3 (Figure-8.31d) with the extent of 15 guntas in Biderahalli hobli of the Bengaluru East taluk was located inside the private Safal Market.

As there is no permission to visit these six water bodies, the status of the water bodies has been documented from the google Imageries and noted in the water bodies database as disused water bodies.

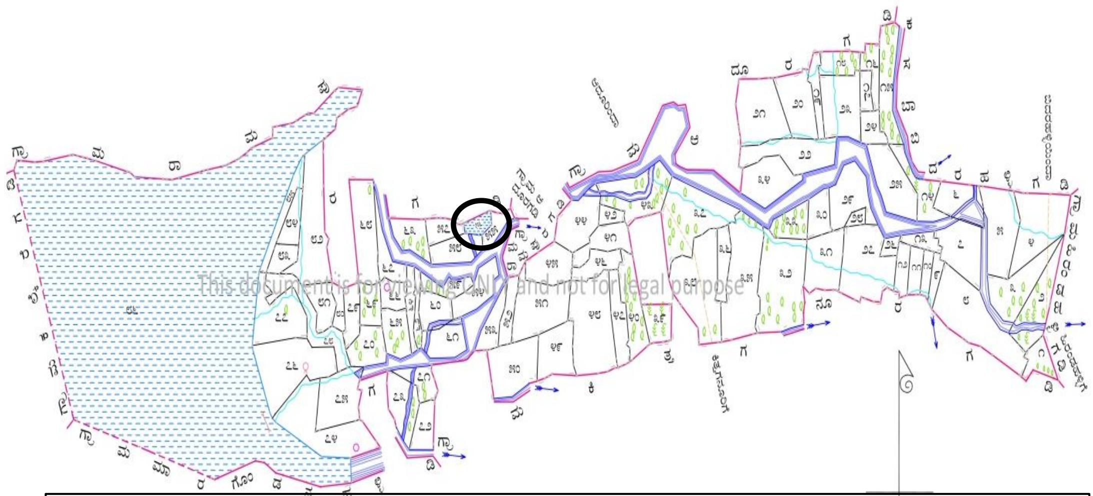

Figure-8.29a. Part of disused Rampura *Kunte* in Huvinaane village

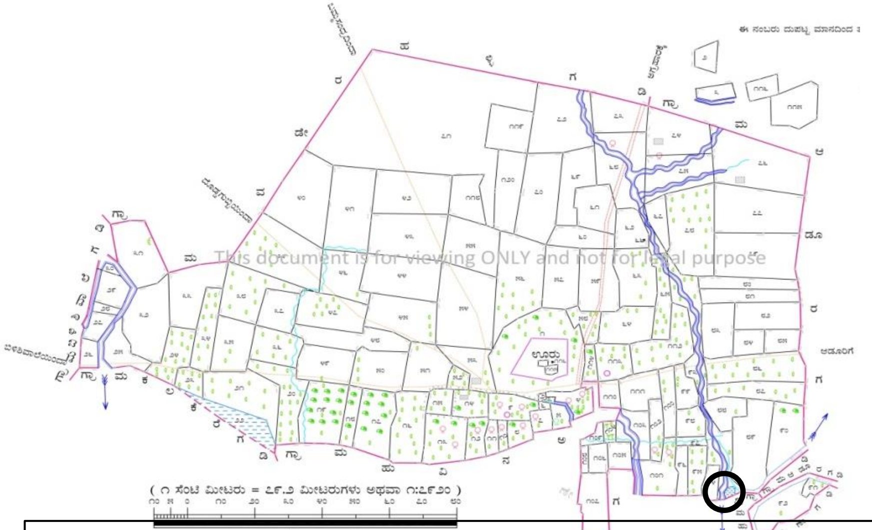

Figure-8.29b. **Part of disused** Rampura *Kunte* in Rampura village

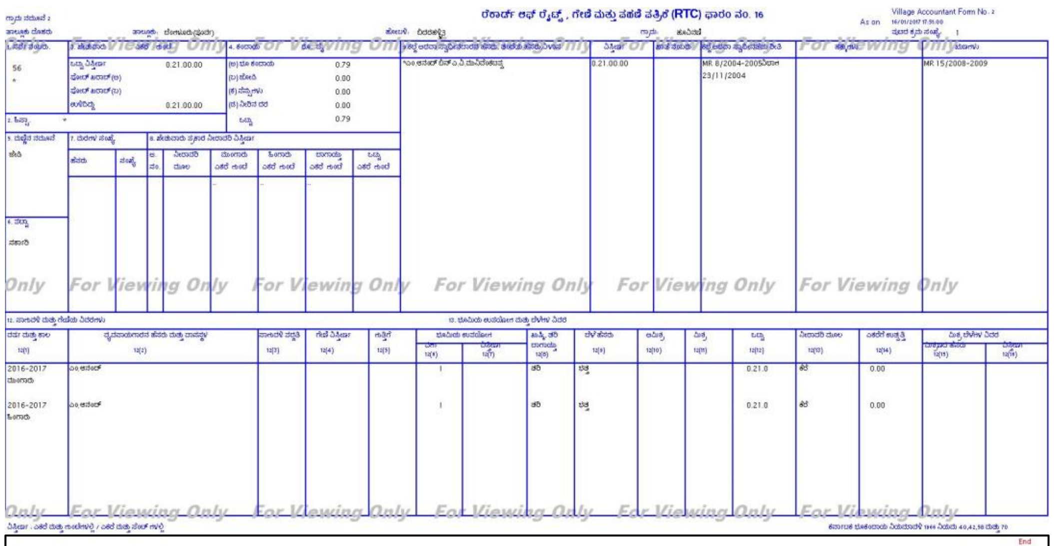

Figure-8.29c. RTC for part of disused Rampura *Kunte* in Huvinaane village, Biderahalli hobli of Bengaluru East taluk

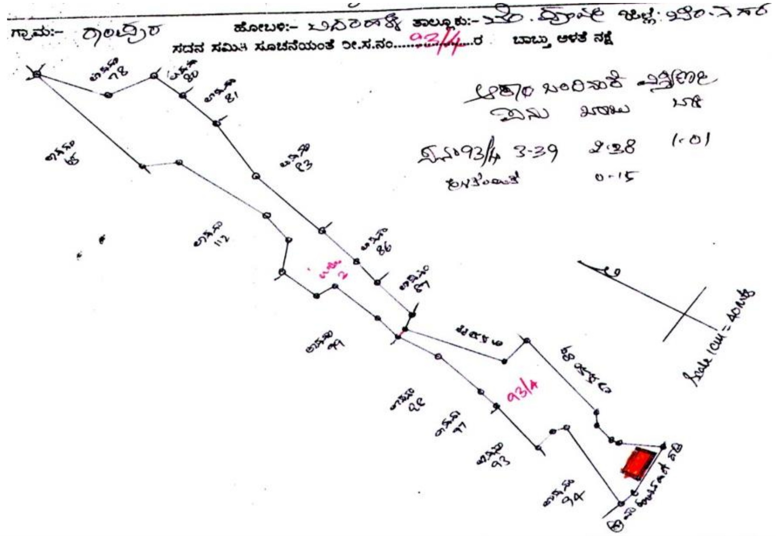

Figure-8.29d. SSLR surveyed map for part of disused Rampura *Kunte* in Rampura village, Biderahalli hobli of Bengaluru East taluk

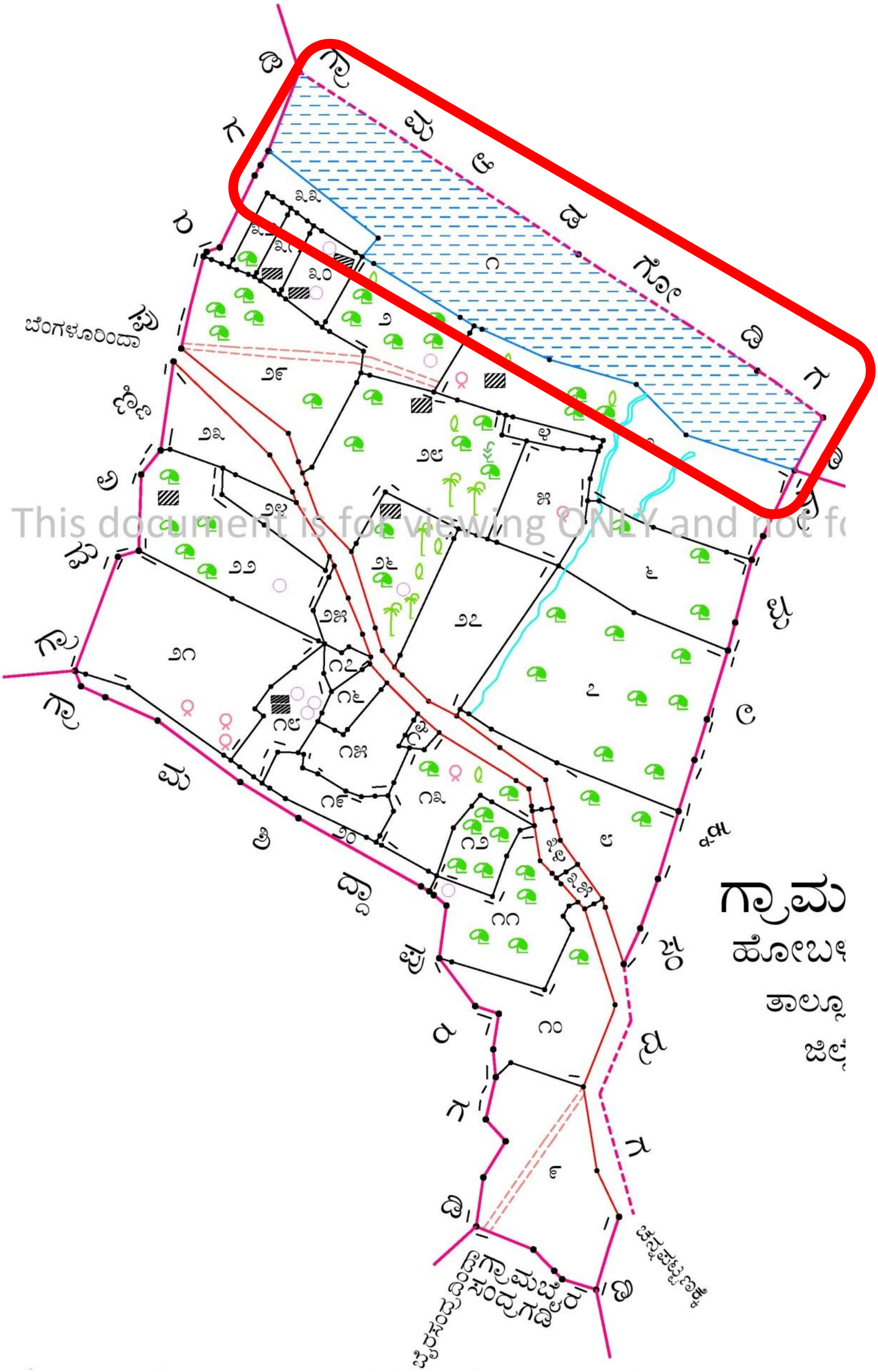

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Figure-8.30a. Location of disused Sunnakall lake in Arekempanahalli village

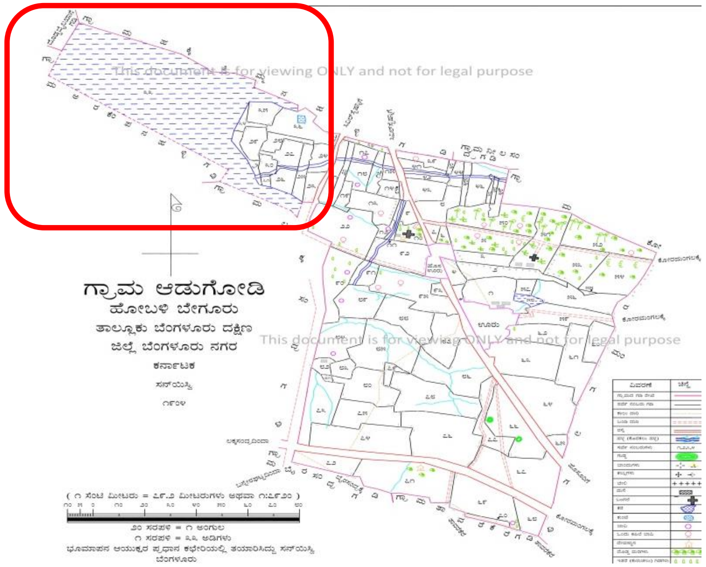

Figure-8.30b. Disused Sunnakall lake in Adugodi village

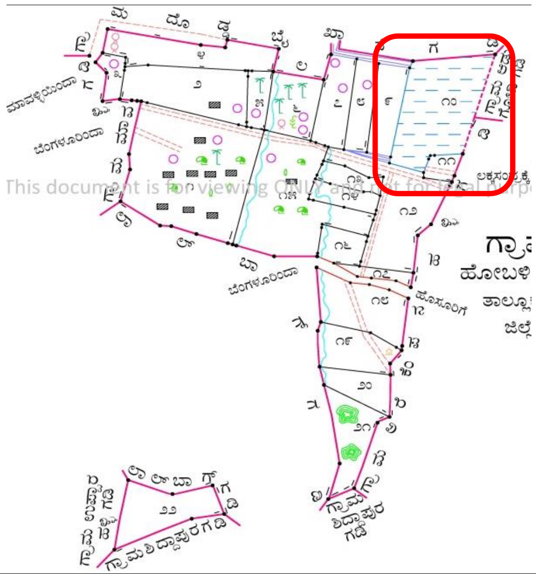

Figure-8.30d. Disused Sunnakall lake in Annipura village

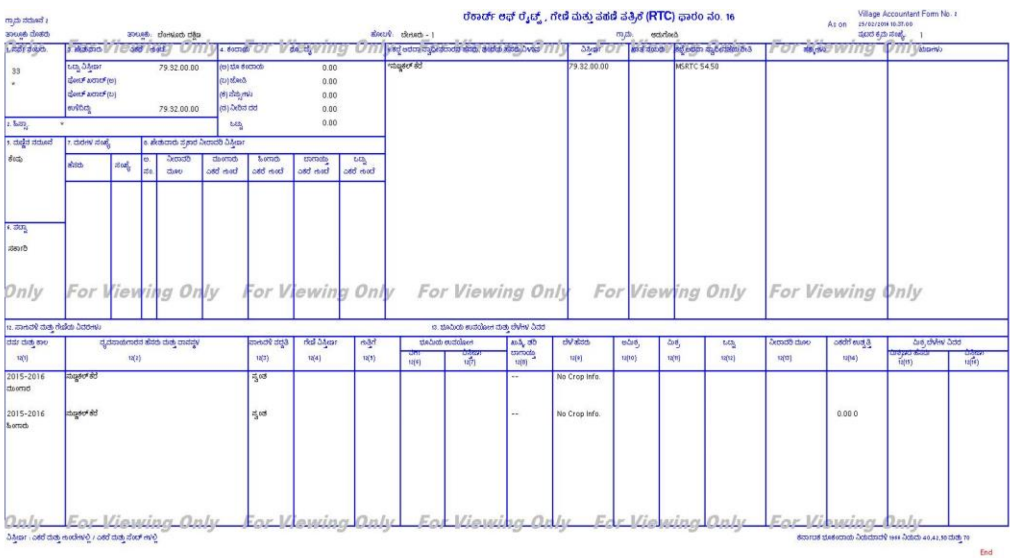
ರೆಕಾರ್ಡ್ ಆಫ್ ರೈಟ್ಸ್, ಗೇಣಿ ಮತ್ತು ಪಹಣಿ ಪತ್ರಿಕೆ (RTC) ಫಾರಂ ನಂ. 16

Figure-8.30c. RTC of disused Sunnakall lake in Adugodi village

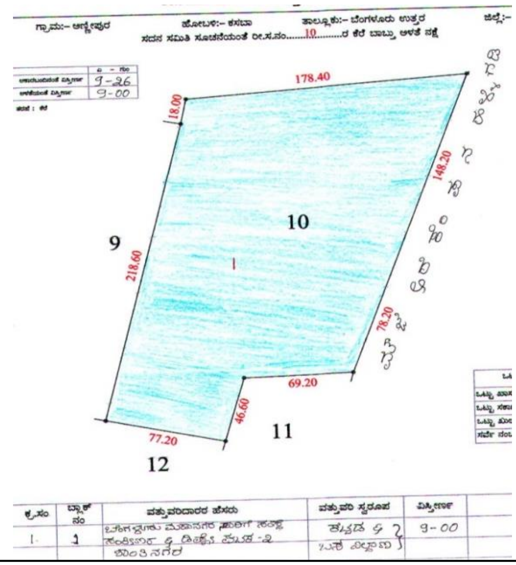

Figure-8.30e. SSLR surveyed map for disused Sunnakall lake in Adugodi village

Figure-8.31a. Disused Banaswadi Kunte-3 & 4 located within Defence

Figure-8.31b. Kempapura Kere located within the HAL

Figure-8.31c. Peenya plantation *Kunte* located within the HMT

Figure-8.31d. Disused Pattandur Agrahara Kunte-1 located inside BSNL compound and Kadugodi Kunte-3 located within the Safal Market (Pvt.)

8.5.24. Challenge-24: Streams extended as Water bodies:

Most of the water bodies lost their characteristics due to rapid urbanization, the three water bodies located near the stream (as per village map) namely Bandematta Hosakere, Cholana *Katte* and Yelachaguppe Rampura Sarkaari *Katte* extents are mismatched with the size mentioned in the village map as well as the SSLR data.

Bandematta Hosakere (Figure-8.32a & b) in Valagerahalli village, Kengeri hobli of the Bengaluru South taluk was shown as a stream in the village map generated during pre-independence, but the same has been mentioned as a lake in the toposheet (57H/05) generated in the year 1973 due to the expansion of the stream. Presently, the Bandematta Hosakere (Gandhi Nagar lake) has an extent of 54.14 a-g and is located in the Survey no.16. Similarly, the Cholana *Katte* (Figure-8.32c & d) in Yelachaguppe village, Tavarekere hobli of Bengaluru South taluk is shown as a stream in the village map generated in the year 1960 and the same has been extended as the *Kunte* in the survey no.93 with the extent of ≈1 acre.

Yelachaguppe Rampura Sarkaari *Katte* (Figure-8.32e & f) of Tavarekere hobli, Bangalore South taluk is a stream in the village map generated in the year 1913, which has been converted in to the water body in the survey no. 21 & 22 with an extent of ≈2 acres. The present status of these three water bodies have been considered as *Kere*, *Kunte* and *Gokatte* respectively for the database based on the present extent of the water bodies.

8.3.25. Challenge-25: *Gokatte* extended as *Kere*:

Two lakes namely Chinnakurchi Kere-1 and Ambalipura Kelaginakere extents details are mismatched with the size of the water bodies in the village maps, which lead to the confusion on the extents and types of water bodies.

The challenge was resolved by the re-verification of these two water bodies physically in the field and also by using the GIS. Chinnakurchi *Kere*-1 (Figure-8.33a & b) located in Kengeri hobli of Bengaluru South taluk was shown as *Gokatte* as per the village map generated on 1903, which was digitized on 2005. But the physical verification has shown that these *Gokatte* has extent of 69.31a-g as *Kere* in the Survey no. 66 of Chinnakurchi village. Similarly, Ambalipura Kelaginakere (Figure-8.33c & d) in Varthuru hobli of Bengaluru East taluk is located in the Survey no.40 as per the village map generated in the year 1958 as *Gokatte*, but the same has been extended to the survey no.41 for the construction of wetland as *Kere* with the extent of 7.09a-g. Both the water bodies have been considered as *Kere* based on its present extents and the same has been maintained in the database also.

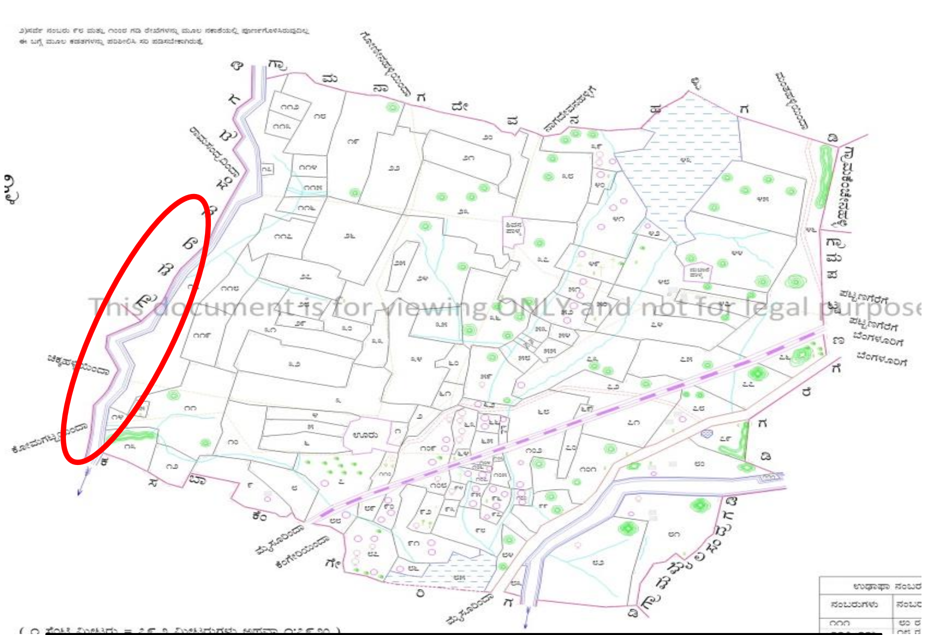

Figure-8.32a. Bandematta Hosakere in Valgerahalli village map

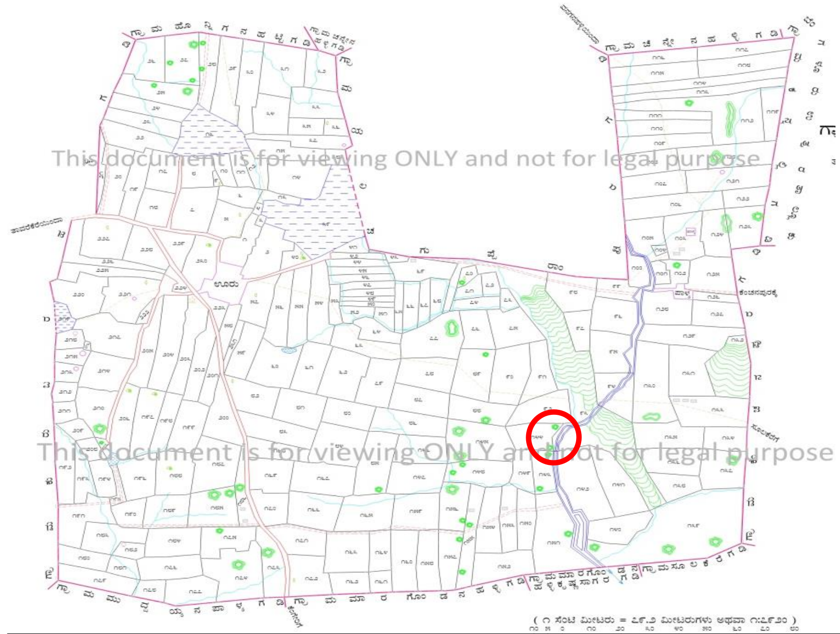

Figure-8.32c. Cholana Katte in Yelachaguppe village map

Figure-8.32b. Bandematta Hosakere located in toposheet

Figure-8.32d. Cholana Katte located in Google Imagery

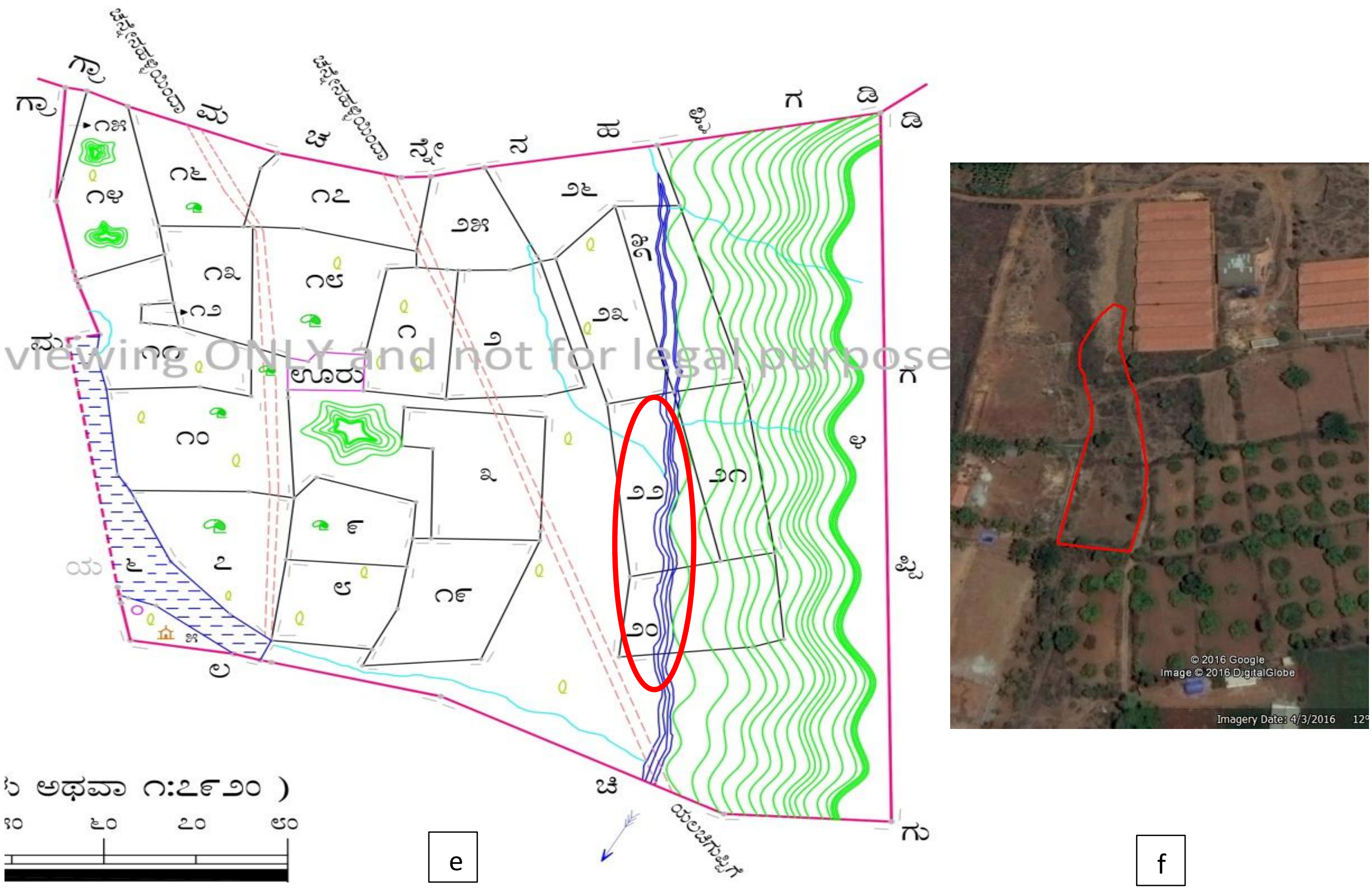

Figure-8.32. Yelacheguppe Rampura Sarkari Katte in (e) village map (f) Google Imagery

8.5.26. Challenge-26: *Kere* Shrunk as *Kunte*:

Sampangie *Kere* in Bengaluru Kasaba hobli of Bengaluru North taluk has been converted for the construction of Sri Kanteerava Stadium as per the Karnataka High Court Committee report (Patil, 2011). But there is small *Kunte* located in the Sri Kanteerava Stadium premises has lead to the confusion on the existence of the Sampangie *Kere*.

The existence of Sampangie *Kere* has been solved based on the literature published by the Fathima Samana and Rajesh Gopinath (2012) which revealed that the *Kere* has shrunk to *Kunte* (Figure-8.34a). The Sampangie *Kere* is still maintained as the *Kunte* due to its traditional cultural values (Figure-8.34b) for annual Karaga festivities (Hita Unnikrishnan *et al*., 2016). Therefore, the Sampangie *Kere* in the database has maintained as existence *Kunte* rather than the disused lake.

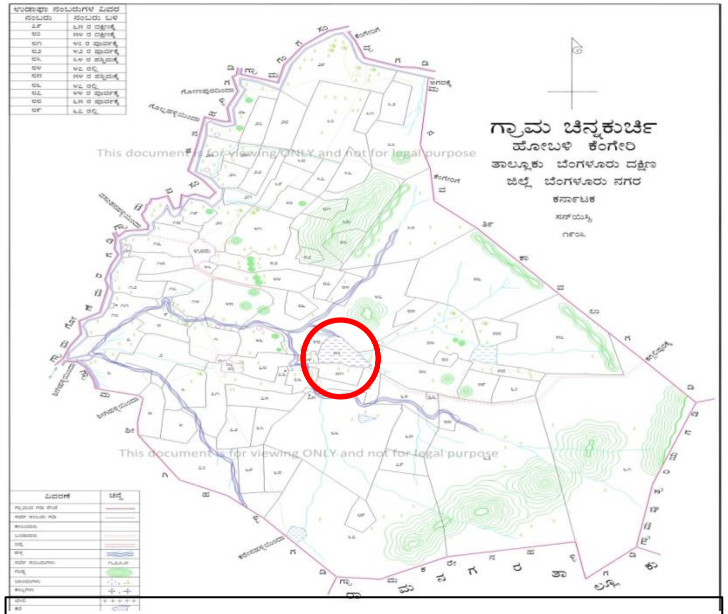

Figure-8.33a. *Gokatte* in Chinnakurichi village map

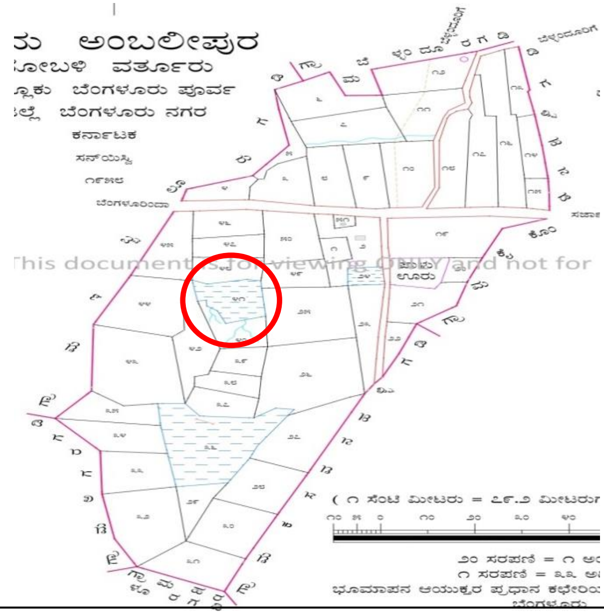

Figure-8.33c. Gokatte in Ambalipura village map

Figure-8.33b. *Gokatte* extented as Chinnakurichi Kere-1 is located in Google Imagery

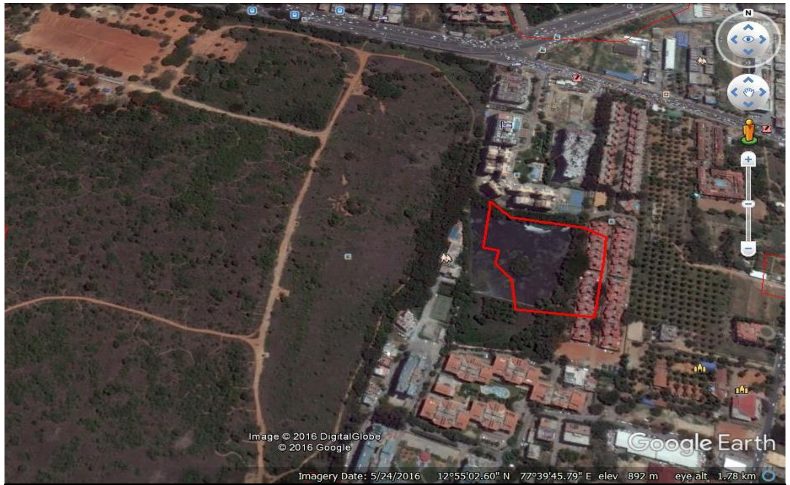

Figure-8.33d. Gokatte extented as Ambalipura Kelaginakere for construction of wetland is located in Google Imagery

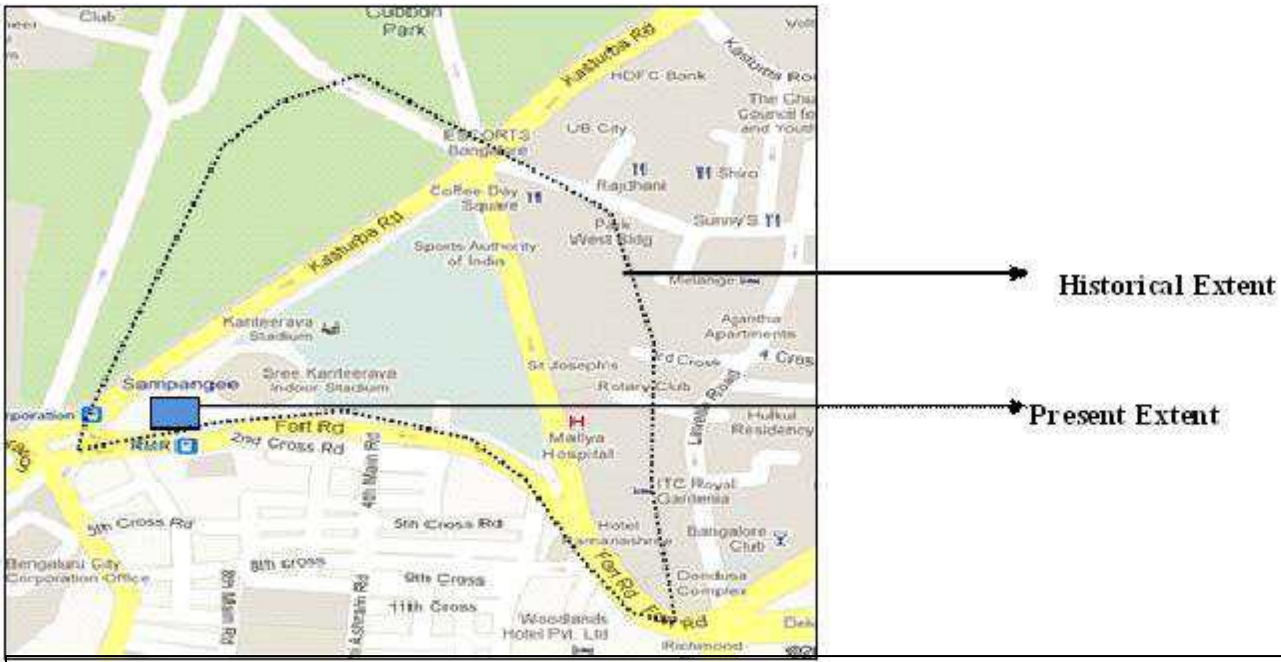

Figure-8.34a. Comparative map for the Sampangie *Kere* by Fathima and Rajesh, 2012

Figure-8.34b. Present Sampangie *Kere* located inside the Sri Kanteerava Stadium

8.5.27. Challenge-27: Water body RTC is in Individual name:

RTC has been collected to verify the water bodies extent, but few RTC for the water bodies have shown that the water body area is in the individual name and create the confusion on the custodian of the water body. Disused Doddanekundi *Kere*-1 (Figure-8.35a) located in the Sy.no.78 with the extent of 12.28a-g in KR Puram hobli of Bangalore East taluk is in the name of four individuals for the coconut plantation. RTC of disused *Kere* (Figure-8.35b) are in the name of Mr. Guruappa Reddy (2.29a-g), Mr. Anand (33 gunta), Mr. Radha Krishnan (4.30a-g) and Mr. Srinivas (4.05a-g). Similarly, the RTC for the disused Chudasandra *Kere* also known as Halanayakanahalli *Kere*-2 (Figure-8.35c) located in Sy.no.45 with extent of 4.06a-g in Halanayakanahalli village, Varthuru hobli of Bengaluru East taluk is in the name of Mr. Venkataswamy (Figure-8.35d) for the Eucalyptus plantation. Apart from these, about 40 *Kunte* RTC are in individual names has led to confusion on location of the water bodies land.

As per the village map and SSLR data, the area has been demarked as the water bodies. But due to some reasons, the RTC is in some of the individual names. History of the Karnataka water bodies has shown that the *Kunte* and *Gokatte* are created by the landlords in their land for their cattle and these water bodies are in the name of the landholders. So these water bodies have been converted for their own use such as plantation by their future generations, this may also replicate in the RTC. So the details about the RTC in the individual names are also considered an issue and it is elaborated in pollution and issues database sheet. This should be once again verified by the water body custodian (KLCDA/BBMP/BDA) with the SSLR and the details should be corrected in RTC, if not that should be filed for future references.

8.3.28. Challenge-28: RTC of Water bodies are mismatched with SSLR data:

In the present study, the RTC has been used as one of the document for evidencing the area of water bodies extent. But the secondary data collected from the Authorities has led to the confusion when compared with the RTC. Two lakes namely Yediyur *Kere* in Uttrahalli hobli and Koramanagala *Kere*-2 in Begur hobli of Bangalore South taluk have different extents between the data of MI and SSLR. There were no RTC as well as SSLR surveyed data for the Yediur *Kere*, but the MI data shown that the lake extent is 13.37 a-g which was reported as 18.02 a-g by the Koliwad Committee report. Similarly, the Koramangala *Kere*-2 has the extent of 99.02 a-g on Sy.no.36 of Koramanagala and on Sy.no.79 of Nilsandra (Bengaluru Kasaba hobli) villages.

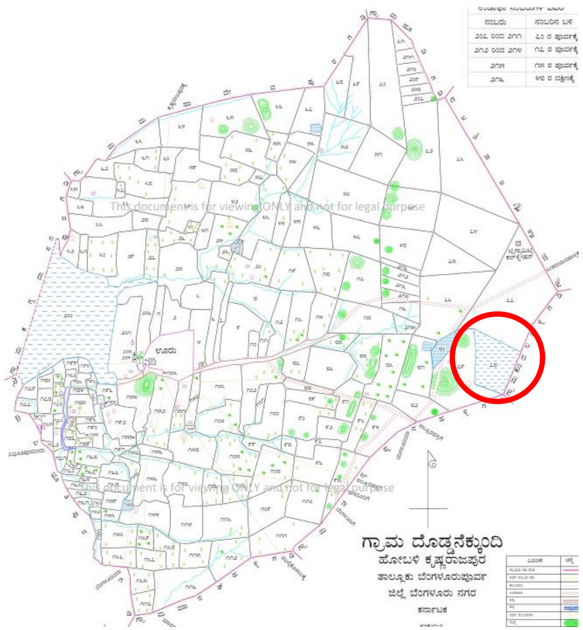

Figure-8.35a. Doddanekundi *Kere*-1 in the village map

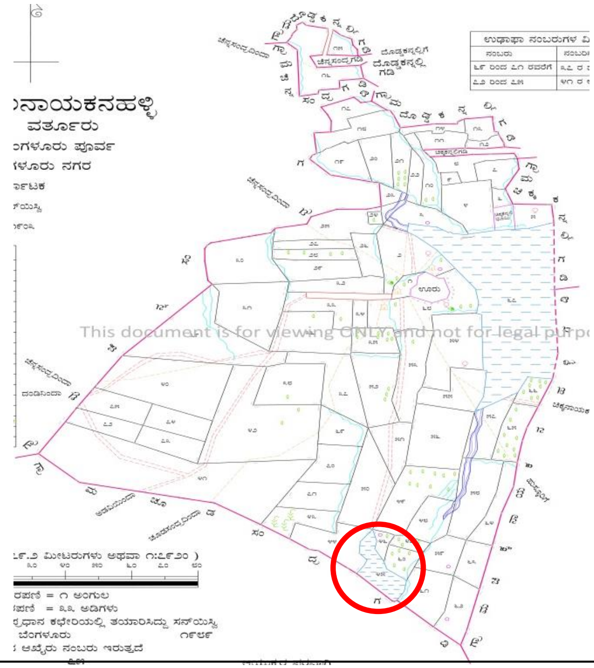

Figure-8.35c. Halanayakanahalli village map for the Sampangie *Kere*

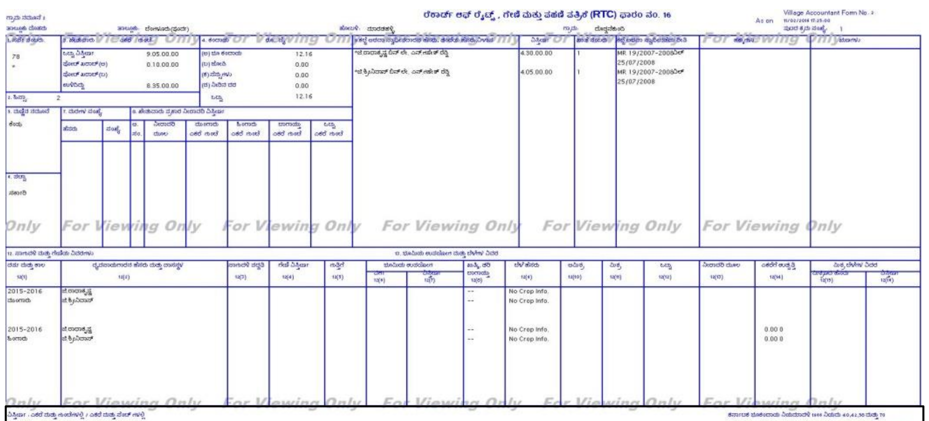

Figure-8.35b. RTC is in individual name for the Sampangie *Kere* in Doddanekundi village

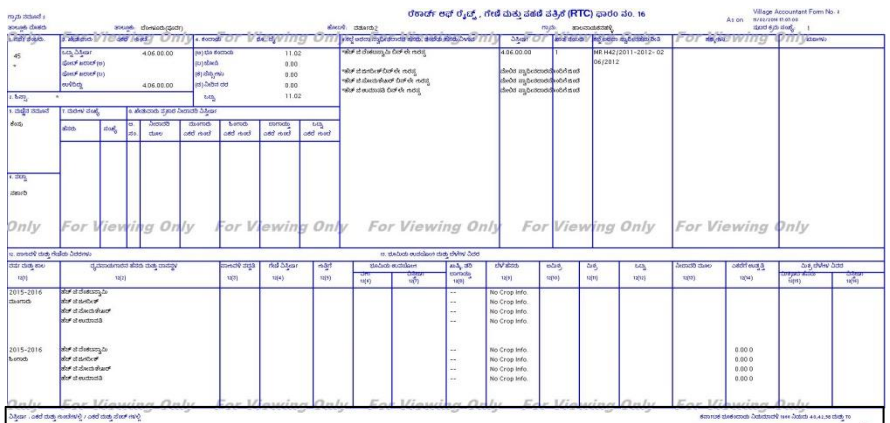

Figure-8.35d. RTC in individual name in Halanayakanahalli village

The RTC for the lake land in the Koramangala village is shown as 83.30a-g as mentioned by MI, but the extent located in the Sy.no.79 of Nilsandra village has been shown as 15.12 a-g as per SSLR. These two different extents from the Authorities have mismatched on the extent of these two lakes.

In few water bodies, the RTC has been given for the entire Survey no. rather than the water body area, which mislead the water body extent from *Kunte* or *Gokatte* to *Kere*. RTC for the Chikkanagamangala *Kunte*-2 & 3 (Figure-8.36a & b) located in the Sy.no.30 was shown as 5.09a-g with the inclusion of karab area and Hosahalli *Kunte*-3 (Figure-8.36c & d) located in the Sy.no.12 has shown as 3.30a-g with karab land are located in Sarjapura hobli of Anekal taluk. Further, the RTC of Bikasipura *Kunte* in Uttarahalli hobli of Bengaluru East taluk located in the Sy.no.1 has the extent of 75.30a-g with the inclusion of 3.07a-g of karab land.

The village map data has been compared with the secondary data collected from the Authorities such as SSLR, MI and Koliwad Committee Report. Then the approximate total lake extent has been estimated in the GIS platform to identify the exact lake extent data collected from the Authorities. Accordingly, the extent of Yediur *Kere* (Figure-8.37a) and Koramangala *Kere*-2 (Figure-8.37b) are based on the .KMZ format of SSLR data and Koliwad Legislative Committee report. RTC given for the entire survey numbers rather than the water bodies area have been verified with the .KMZ data and confirmed through the GIS platform. Chikkanagamangala *Kunte*-2 & 3 have the extent of 10 and 38 gunta respectively and Hosahalli *Kunte*-3 has the extent of 16 gunta. Further, the Bikasipura *Kunte* has 4 gunta of extent on the karab land.

8.5.29. Challenge-29: Mismatch of Surveyed and GIS data of SSLR published water bodies:

The SSLR has published the data on water bodies of Bengaluru Urban district in three different formats such as RTC, SSLR water bodies surveyed maps and .KMZ format file as GIS format can be used on the open Google earth Imageries. Within these three formats, the .KMZ file format was mismatched with the SSLR surveyed lake maps on the location of the water bodies. Kempapura Agrahara *Kunte*-2 in Sy.no. 265 with the extent of 1.02a-g was located in the Bengaluru Kasaba hobli of Bengaluru North taluk was disused for the Kalyan Housing Society building as per the SSLR surveyed water body map (Figure-8.38a) but the .KMZ file of SSLR data is showing apartment as Housing Society building (Figure-8.38b). Similarly, the Sunkanahalli *Kunte*-1 in Bengaluru Kasaba hobli of Bengaluru North taluk was located in the Sy.no. 5 with the extent of seven gunta.

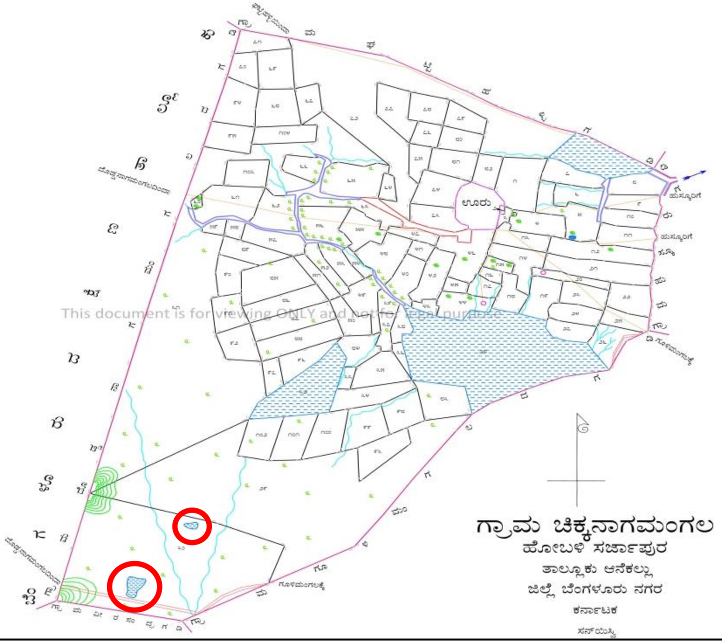

Figure-8.36a. Chikkanagamangala *Kunte*-2 & 3 in the village map

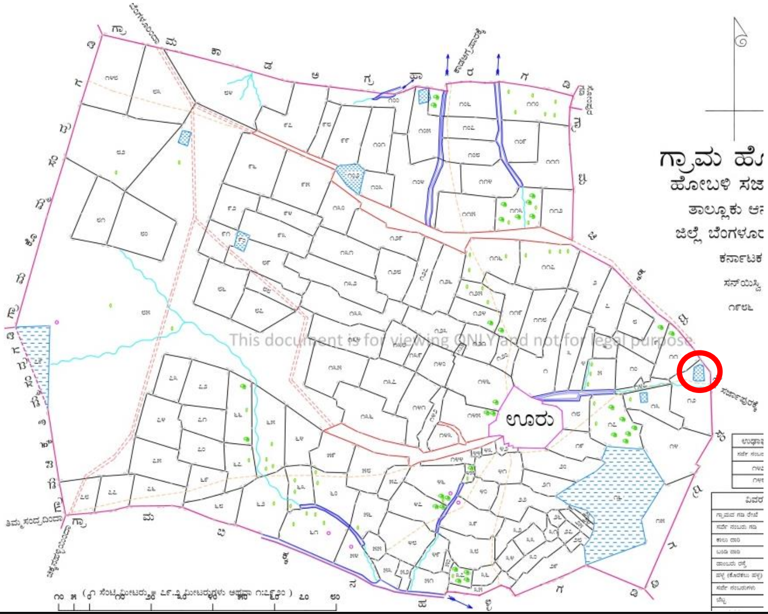

Figure-8.36c. Hosahalli *Kunte*-3 in the village map

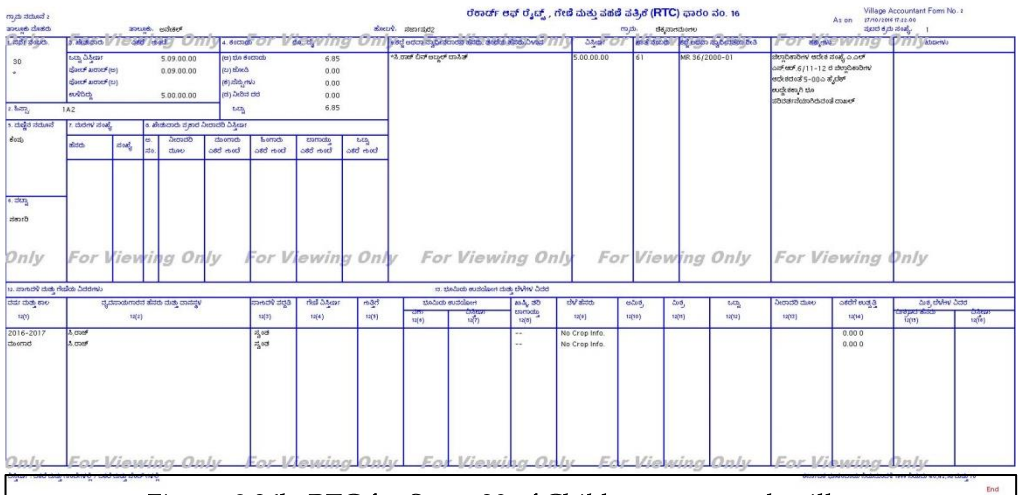

Figure-8.36b. RTC for Sy.no.30 of Chikkanagamangala village

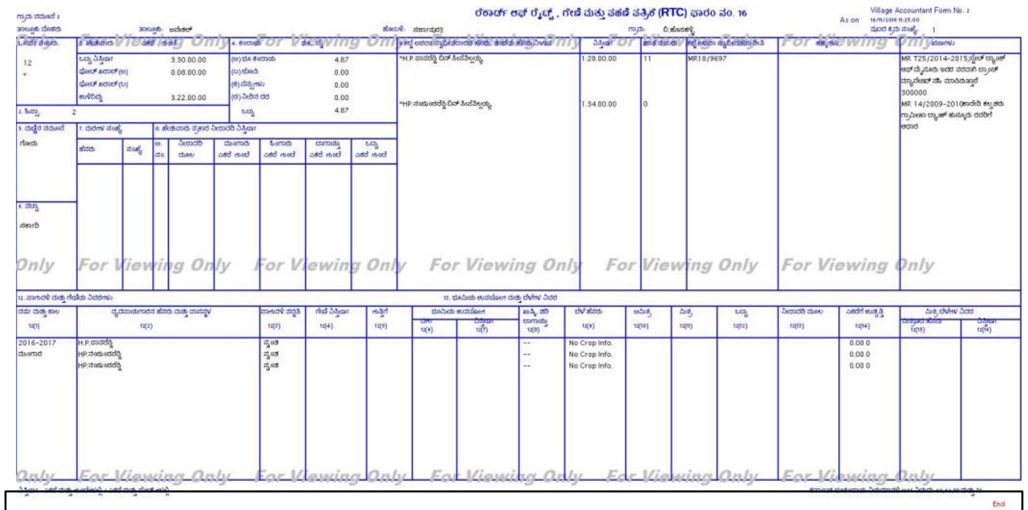

Figure-8.36d. RTC for Sy.no. 12 of Hosahalli village

Figure-8.37a. SSLR .KMZ file of Yediur lake on the Google Imagery

Figure-8.37b. SSLR .KMZ file of Koramangala *Kere*-2 on the Google Imagery

This *Kunte* was disused for the Kalyana Mantapa building as per the SSLR water bodies surveyed map (Figure-8.38c), but the .KMZ file of SSLR data is shown in the Sy.no.7 (Figure-8.38d). These mismatched data from the SSLR has led to confusion as well as reduced the reliability on data.

The reliable data of the SSLR has been selected based on the physical verification and the documented GPS location of the water bodies. The .KMZ file is not exactly located on the google earth imageries. The .KMZ file layer of the village map as well as the water bodies were overlaid on the Google imagery and the documented GPS location of the water bodies by EMPRI in the field also plotted in the Google imagery to verify the exact location of water bodies in the village map. After the verification, the authenticated data of SSLR has been used for the water bodies database.

8.5.30. Challenge-30: SSLR surveyed map for hills as water body:

Some of the small hills in the village maps have been mentioned as the water bodies, particularly as Kunte and surveyed maps of them are available with SSLR. But the survey no. of the water bodies are shown as hills even in the digitized village maps and there were no RTC for these specific land parcel. Kachohalli *Kunte*-1 (Figure-8.39a & b) located in the Sy.no.66 with extents of 7.5 gunta in Dasanapura hobli of Bengaluru North taluk and Chanenahalli *Kunte*-3 (Figure-8.39c & d) located in the Sy.no.8 with extents of 2.03a-g have been mentioned as hill in the digitized village maps. Hills of the village map mentioned as water body and surveyed have led to the confusion.

The hills in the specific village may be quarried and the water stagnant in that quarry may be considered as *Kunte*. The other reason may be that near the hills, most of the land is gomala land, so locals or by Grama panchayat may construct the small *Kunte* to harvest and store the rainfall runoff water from the hills. As the SSLR itself surveyed and

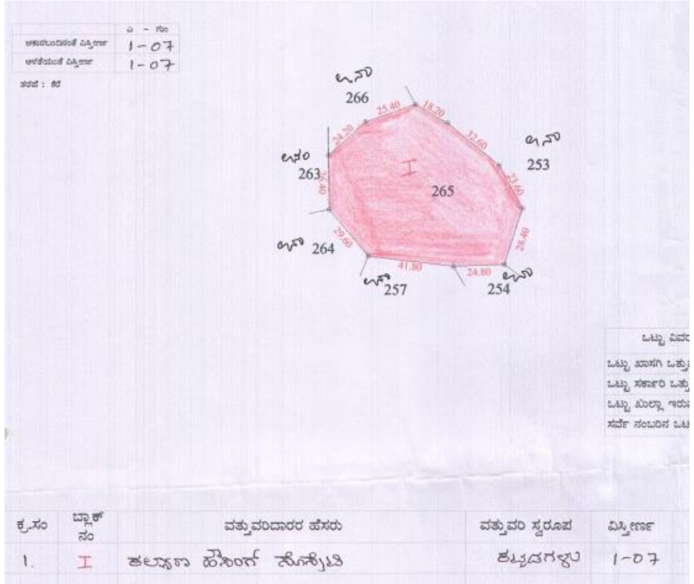

Figure-8.38a. SSLR surveyed map for Kempapura Agrahara *Kunte*-2

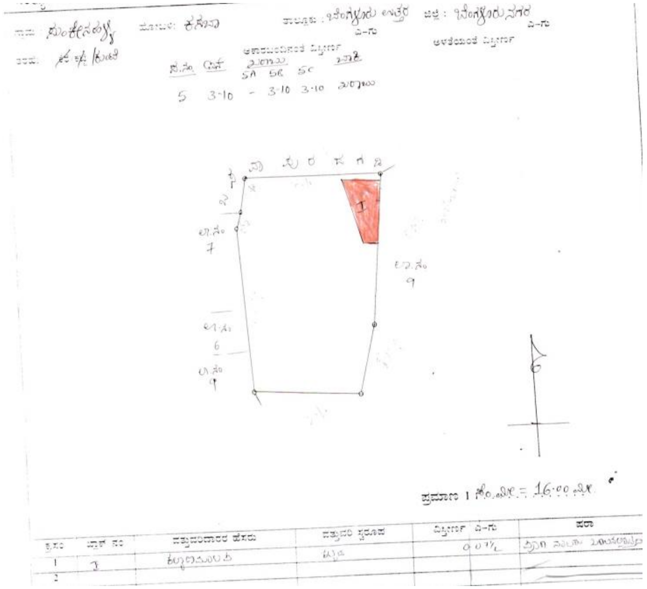

Figure-8.38c. SSLR surveyed map for Sunkanahalli *Kunte*-1

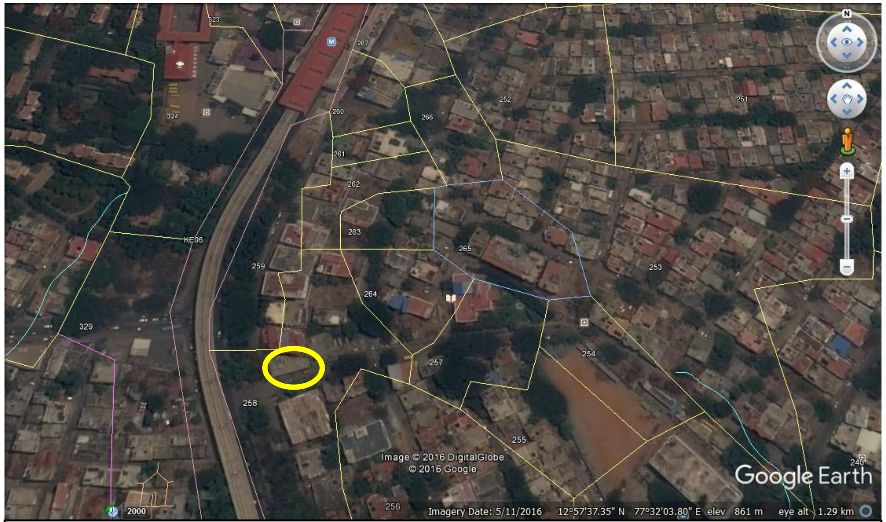

Figure-8.38b. SSLR .KMZ format for Kempapura Agrahara village

Figure-8.38d. SSLR .KMZ format for Sunkanahalli village


Figure-8.39a. Location of Kunte-1 in Digitised Kachohalli village map

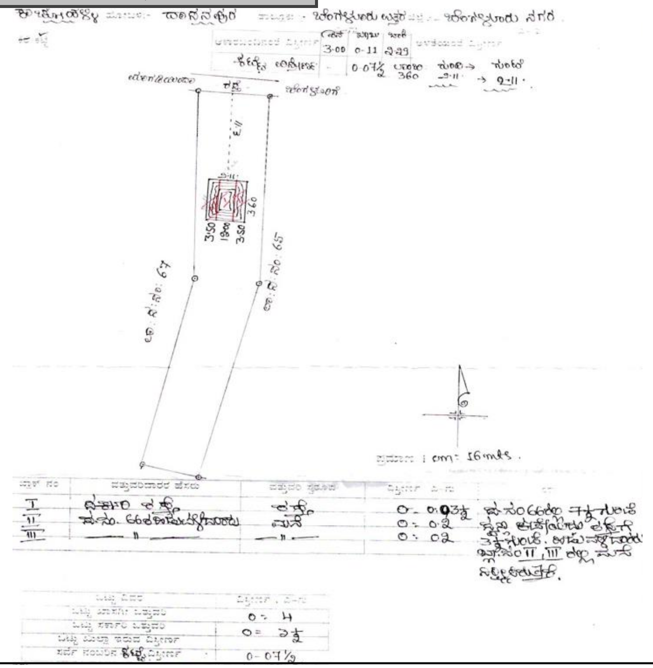
Figure-8.39b. SSLR surveyed map for Kachohalli Kunte-1 of Sy.no.66

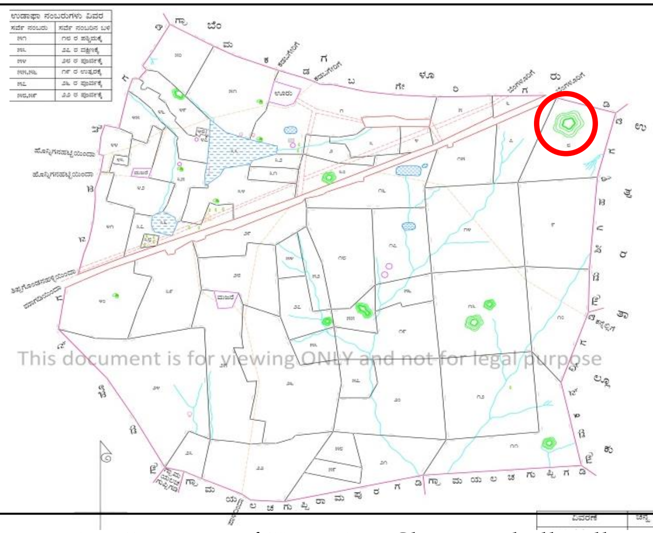
Figure-8.39c. Location of *Kunte*-3 in Channenahalli village map

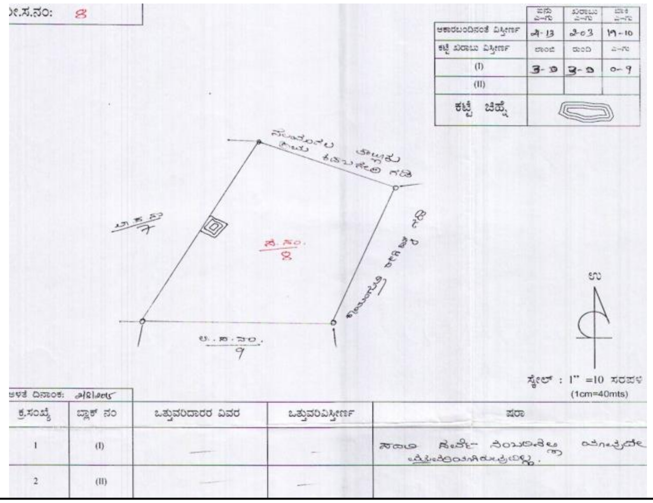
Figure-8.39d. SSLR surveyed map for Channenahalli *Kunte*-3 of Sy.no.8

documented as the water bodies, the same have been documented in the database for BMA water bodies.

8.5.31. Challenge-31: No Water bodies but SSLR surveyed:

There were no water bodies in the specific Sy.no. of the village maps, but the SSLR had surveyed the part of the land parcel and mentioned as the water bodies have led to the confusion on the created water bodies that were created newly or existing earlier or disused. There were no water bodies in the Sy.no.20 of the Doddabanahalli village (Figure-8.40a) in Bidarahalli hobli of Bengaluru East taluk and in Sy.no.29 of Koluru village (Figure-8.40b) in Tavarekere hobli of Bengaluru South taluk as per the village maps. But, the Doddabanahalli *Kunte*-2 (Figure-8.40c) also known as Government *Kunte* with extent of 27 gunta is existing in the Sy.no.20 and disused Koluru *Kunte*-4 (Figure-8.40d) with extent of 12 gunta was in Sy.no.29 as per the SSLR water body surveyed map.

There was no water body in the Sy.no.6 of Varthur hobli of Bengaluru East taluk as per the village map (Figure-8.41a). But the surveyed water body map of SSLR has mentioned that the Siddapura *Kunte*-2 is located in the Sy.no.6 (Figure-8.41b) of the village has led to the confusion on the water body location Sy.no.

Existing Doddabanahalli *Kunte*-2 has been confirmed by the physical verification in field but the disused Koluru *Kunte*-4 had lost its characters and there is no evidence of the *Kunte* in the specific Sy.no. Both the Kunte have been included in the water bodies database based on the SSLR data. In the case of disused Siddapura *Kunte*-2, the Sy.no.6 has been maintained as the location of the water body as per the SSLR data.

Apart from these 31 challenges, two small challenges such as no year of generation for the Banaswadi village in KR Puram hobli of Bangalore East taluk and the KR Puram hobli has been segregation in to six hobli's as KR Puram, KR Pura-1, KR Pura-2, KR Pura-3, Mahadevapura and Marathahalli by the SSLR in Bhoomi website for their ease of work also faced during the inventorisation of the BMA water bodies. Thus, the year of water bodies were created was mentioned as blank for the Banaswadi village water bodies and all the sub-hobli's of the KR Puram have been comprised and maintained as one hobli in the water bodies database according to the taluk map.

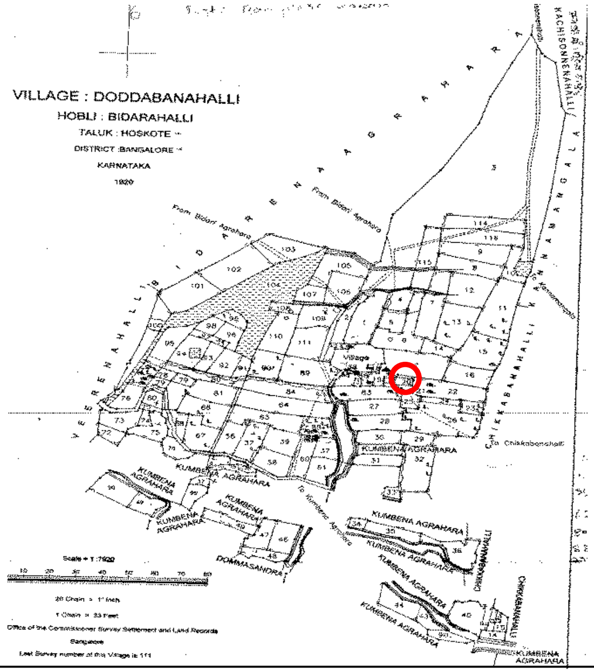

Figure-8.40a. Location of Sy.no.20 in Doddabanahalli village map

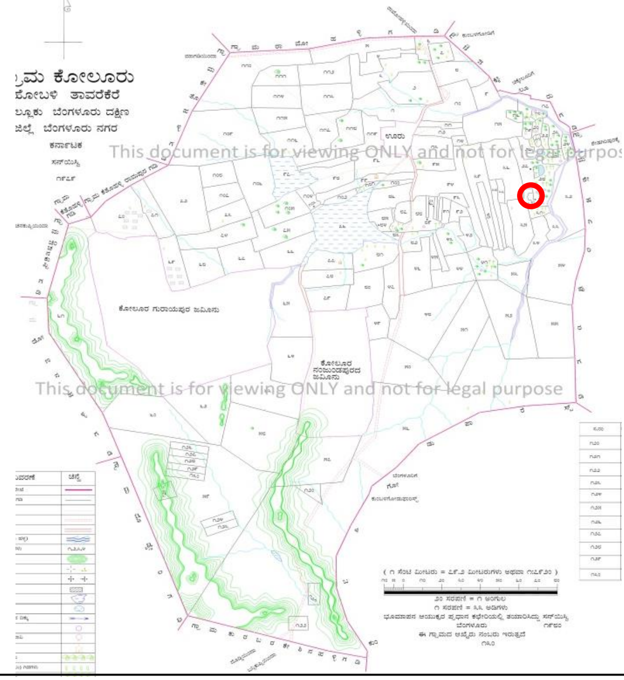

Figure-8.40b. Location of Sy.no.29 in Koluru village map

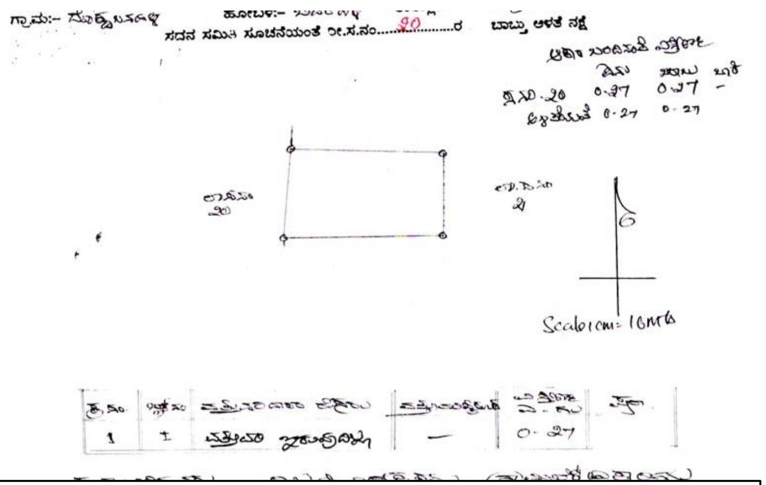

Figure-8.40c. SSLR surveyed map for Doddabanahalli *Kunte*-2

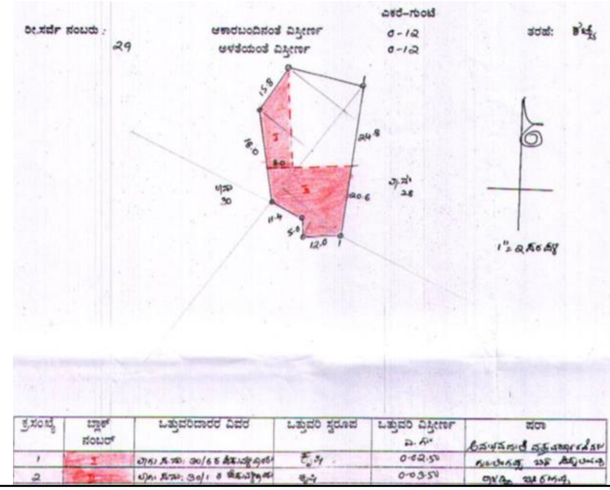

Figure-8.40d. SSLR surveyed map for Koluru *Kunte*-4

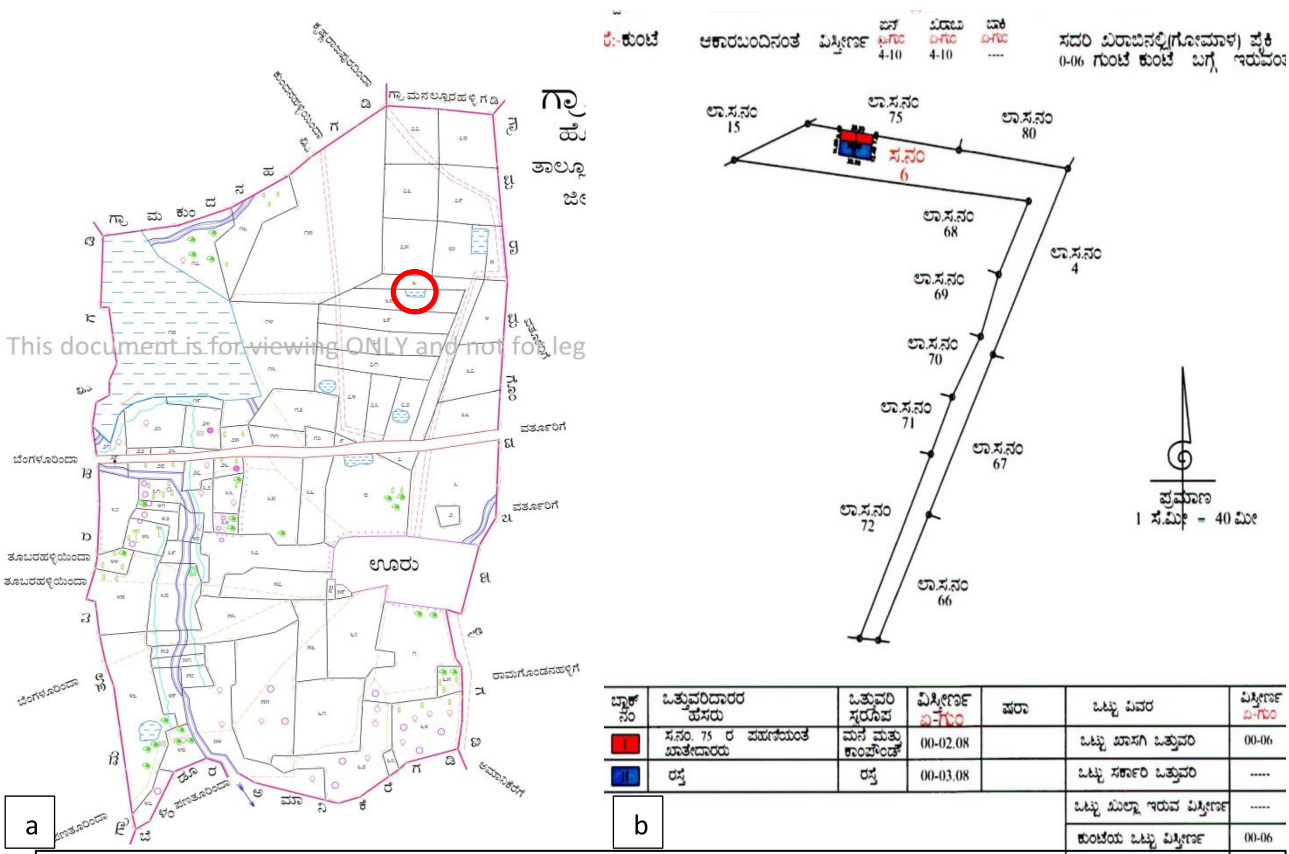

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Figure-8.41. Location of Siddapura *Kunte*-2 in (a) village map and (b) SSLR surveyed map

8.6. Manual for the Inventorisation of Water bodies:

About 33 challenges are confronted during the study period for the inventorisation of BMA water bodies, which have also been considered as the lessons learned during the inventorisation of water bodies. The cause and effect of the challenges in the inventorisation of the water bodies in the BMA have been plotted as the Ishikawa or Fish Bone diagram (Figure-8.42) for the visualization of potential causes and to identify the root causes of problems. These compiled challenges with solutions will be used as the manual for the inventorisation of the water bodies in other Cities of Karnataka.

8.7. Conclusion:

The elementary challenges that emerged in the study area are due to the gaps in the data management, updation and the absence of coordination between the Agencies and Authorities. About 33 challenges have been documented during the inventorisation of water bodies in BMA and these challenges were tackled technically to eliminate the error in the water bodies database. The challenges ranged from the major challenges such as the overlapping of planning Authorities jurisdiction, confirmation of water bodies extents, etc. to the minor challenges such as the confusion within the types and names of the water bodies.

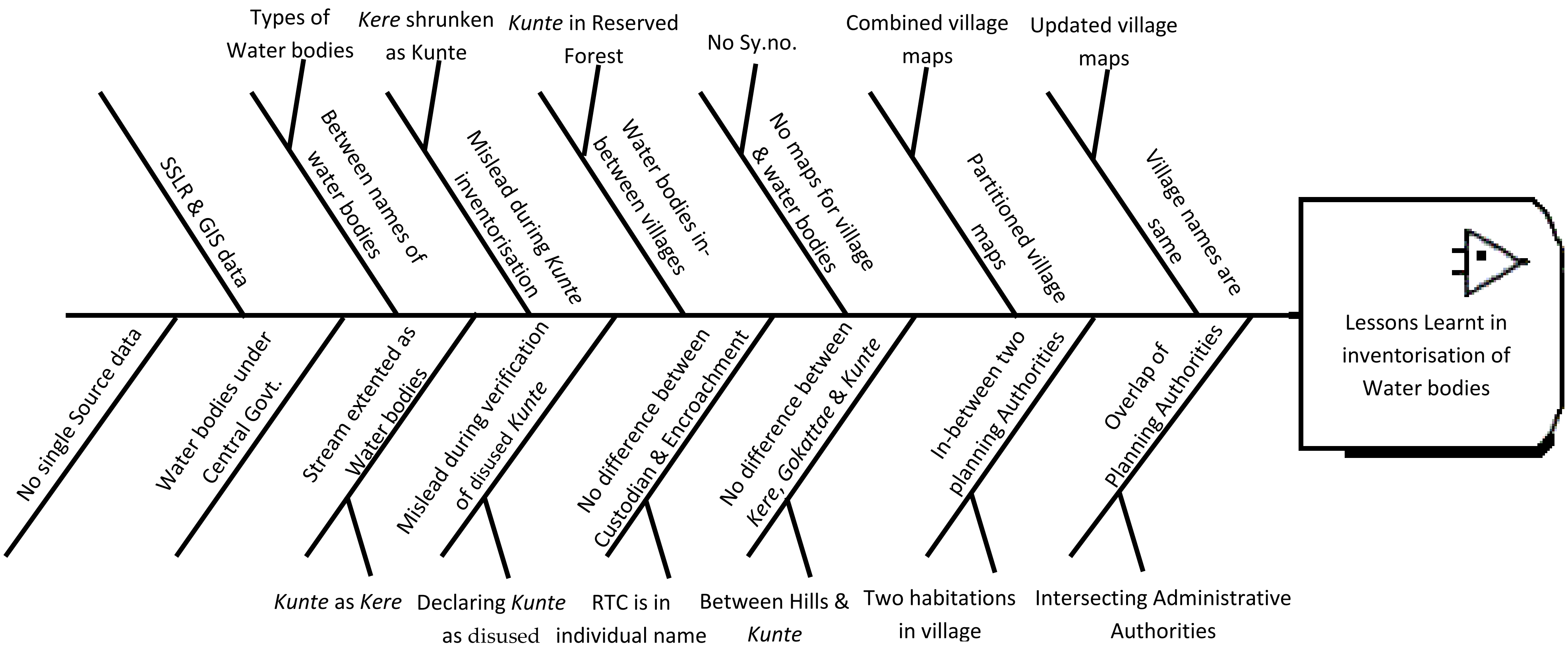

Figure-8.42. Challenges in BMA water bodies inventorisation

These challenges are the cause and effect for the mis-interpretation of the water bodies in the BMA and have been compiled to tackle similar problems in the inventorisation of water bodies in other parts of the State. These identified challenges can be eliminated from the systems of Planning and Administrative Authorities by communication only. As KLCDA is the nodal Agency for the Conservation and Preservation of the water bodies in BMA, they can also act as the 'Relation Manager' between the Administrative and Planning Authorities. Further, if the "Data Transparency Policy" has been maintained by Authorities as well as KLCDA, this will eliminate the data duplication, wrong data and also ease data updation after the rejuvenation of lakes or transfer of lake custodian.


Mahadevapura *Kere*

CHAPTER

9

CONSERVATION STRATEGIES

Chapter-9: Conservation Strategies

9.1. Introduction:

Water bodies are one of the landscape features that significantly contribute to increase the quality of life in urban areas by providing the recreational and educational activities by increasing the urban amenity and also contribute to mitigate the urban climate (Martinez and Jauregui, 2000). Faecal contamination and algal blooms have deteriorated the ecological value of water bodies environments and transformed them into potential risk for human health.

In this study, it was found that there are 1521 water bodies in the BMA, within that only 684 water bodies are exist, which include 395 lakes, 85 *Gokatte* and 204 *Kunte*. Conservation strategies for the water bodies in the BMA have been formulated on the basis of issues documented during field visits and considering the inputs from stakeholders. Views of local residents near water bodies of the locality, NGO's and residential welfare associations involved in the lake maintenance, which are helpful in the conservation of water bodies are being considered.

Biota and various issues affecting the water bodies are documented through physical verification. Additionally, the pollutants of the water bodies are documented and confirmed through the water quality analysis. Based on the study, the conservation strategies are formulated to mitigate the pollution and improve the ecology of the water bodies. Additionally, the inputs are also taken from the Project Advisory Committee and Research and Training Advisory Committee (RTAC) of EMPRI.

The draft of conservation strategies based on the study, opinion and suggestions from experts in the RTAC and Project Advisory Committee have been presented before the stakeholders at the taluk level and discussed. After discussion, the views that emerged during the meeting have also been considered in the formulation of strategies for water bodies conservation.

9.2. Summary of Findings:

During the study, 1521 water bodies are inventorised in the 1307 Km^2 of BMA. There are only 684 water bodies exist, out of which 395 are *Kere* (extent area are more than 3 Acres), 85 are *Gokatte* (extent area are between 1 and 3 Acres) and 204 are *Kunte* (extent area are less than 1 Acre). The 14 water quality parameters were analysed in the EMPRI water quality analysis laboratory from the water samples collected from the 303 *Kere*. Further, 310 species of biota are observed in the 681 BMA water bodies including the flora such as trees, shrubs and herbs, hydrophytes; fauna such as fish, insects, macro-benthos, avifauna and visiting mammals. Issues such as possibilities of encroachment (48.6%); pollutants like solid waste dumping (44.5%), sewage inflow, and soil excavation (19%) are observed in the existing BMA water bodies.

9.3. Rationale:

Conserving water bodies is the need of the hour as they are used for harvesting the precious rainwater and augment shortfall in drinking water supply demand, moderate the flood risk by interconnectivity of the lakes, utilize the wastewater by treatment during dry weather and maintain lake water balance, improve the groundwater recharge within the influence zone, improve the groundwater quality, improve the health conditions of the people living in the surroundings of the lakes, enhance the biodiversity in and around the lakes, induce recycling and reuse of waste water after treatment for non-potable uses and develop local economy through eco-tourism activities at lakes, etc. Conservation of lakes also gives additional benefits from socio-economic angles such as the employment generation through the eco-tourism, improved aesthetics and enhancement of property values in the lake surroundings.

9.4. Conservation Strategies:

The prioritization of the conservation of water bodies are based on the numbers and size of the threats for the BMA water bodies. According to the size of the threats, the following conservation strategies are formulated to conserve the BMA water bodies.

9.4.1. Decision on Inter-jurisdiction Lakes:

There are nine major lakes located in-between the two planning Authorities jurisdictions (Table-9.1) such as BDA, BIAAPA, HPA, MPA and APA. The bunds of these nine lakes are not located in the BMA villages, so the KLCDA should communicate to the HPA, MPA and APA about the custodian of these lakes. The decision on inter-jurisdiction lakes will be used to conserve the lakes through the identified custodian.

9.4.2. Notification of Water bodies and its Drain:

According to water bodies database for BMA prepared by EMPRI, there are 684 existing water bodies and about 313 water bodies which are prone to encroachments. Water bodies are encroached for various purposes like to build the superstructures, agriculture, etc. Even legally, there was no notification on the water bodies and its linking Rajakaluves. SSLR has notified the surveyed lakes of BMA and published it in its website along with the details of encroachment. As a priority, 395 lakes may be notified as the KLCDA lakes with the details of status, its custodian, encroachment, litigations if any, etc. The other existing water bodies such as the *Gokatte* and *Kunte* should also be notified in future and maintained as the "Surface Water Asset".

Further, the BBMP has notified the location of water bodies nallah according to the village map and the same should be done for the water bodies under BDA jurisdiction also, to identify and stop further encroachment.

9.4.3. Official Communication to the Authorities about Custodian of Water bodies:

Authorities may be notified of the present custodian/ ownership of the water bodies, therefore the water bodies under the custodian has not been considered as the encroached water bodies by SSLR i.e. Lalbagh tank. Further, some portions of few water bodies are leased to third (NICE Ltd.) party through the second party (KIADB) from the Revenue Department for the development of public amenities like road. These leases of the water bodies are reflected in RTC for only few water bodies.

Further, the custodian of lakes changed from one Authority (BDA) to another (BBMP) for maintenance or for the rejuvenation (BBMP to BDA) officially by Government Order or by gazette notification. But due to the missing of basic information on the lakes or due to fund crisis, the transferred lakes have not been taken control by the other Authority. As the KLCDA is the only Authority, which is 'Primary Custodian' of all the water bodies in the BMA can be given to any Authority or Agency to maintain the water bodies and any developmental activity on water bodies should be implemented after approval by the KLCDA. Three stages protocol that is followed for declaration of the lake custodian is as follows:

a. **Segregate the Type of Custodian**: Water bodies are given to custodian that is to Authorities/ Agencies/ Departments/ Private Ltd., etc. for different purposes such as for maintenance, rejuvenation, development of public amenities, etc. Therefore, the types of the custodian for water bodies should be identified based on the purpose of custodian and time needed to complete that specific purpose. Type of the Custodian is proposed into three categories are:
   i. ***Type-A Custodian***: The lease period will be of short term period i.e. one to four years. This type of custodian should be responsible for the rejuvenation of the water bodies and the custodian should report to KLCDA about the progress of the rejuvenation activity at the end of each financial year.
   ii. ***Type-B Custodian***: The lease period will be a medium term period i.e. four to 10 years. This type of custodian should be for maintenance of the water bodies under the public-participation and community involvements by NGO,

Corporates and Residential Welfare Associations. The status of the water bodies should be reported to KLCDA on a bi-annual basis.

iii. ***Type-C Custodian***: The lease period will be a long term period i.e. more than 10 years. This type of custodian will be for the maintenance of water bodies such as the BBMP, BDA, KFD, Horticulture Department, etc. or by lease for the development of public amenities such as roads, industries, etc. by KIADB. The status of the water bodies should be published to public at least once in a year.

b. **Gazetted Notification**: After the identification of the custodian, the list of the water bodies with location and extent would be published in gazette, which consists of the name of custodian, their types and purpose of the custodians. If the Karnataka Fisheries Department is the stakeholder of specific lake, then their name will also be included during the gazette publication.

The standard format should be prepared by the nodal Agency KLCDA for handing over of the water body to other department for maintenance or rejuvenation. If the water body is for handing over to the Authority for rejuvenation, then the "Lake Handover Form" should have the details about extent, present issues, encroachment details and any rejuvenation done earlier. Similarly, the "Lake Handover Form-R" should be used to handover the rejuvenated lakes to the Authority, which should have category-wise details on the rejuvenation activity with the budget break-up. The copy of Form should be maintained by KLCDA and updated to maintain the database on the specific lake.

c. **Confirm the Custodian of the lake/ water bodies**: After the gazette notification, the custodian should officially take the custody of the water bodies from KLCDA. The same should be informed to SSLR to appear in the RTC also to reveal that they are the custodian of the water body.

9.4.4. Protection of Water bodies land and it's Drain:

The study found that the 332 of the 682 existing water bodies are under the threat of encroachment. Even the draft report of Koliwad Committee (2016) also mentions that 20% of the water bodies' lands have been encroached in the Bengaluru Urban district. Encroachment of the water bodies have been reported earlier by various committees like Lakshman Rau Committee Report (1986), Ramaswamy Legislative Committee Report (2007), Balasubramanian Task Force Report (2011), Patil Committee Report (2011). The protection of water body from the encroachers as well from the further developmental activities can be done by the three modes of action such as recover the water body land, preserve it through fence and then avoid the tampering of fence by implementation of legal protection measures through institutional frameworks.

9.4.4.1. Recover the Water body land:

As the water bodies' lands have been encroached by both the Government Agencies and the private parties, there is a need for two different approaches for the recovery of the water bodies land. Evictions of the encroachment from the water bodies and collect the compensation for the water bodies land encroachment.

i. **Eviction of Encroachment**:

Encroachment on the water bodies by the private parties or Agencies should be evicted, because these encroachments have been done for their own profit and greed. Encroachment on drains by the private or Government Agencies should also be evicted immediately because of drain encroachment, the rain runoff is being influxed into the sewerage system and this in turn increases the pressure on the work efficiency of the STP particularly in the rainy season. The encroachment on the water bodies and the drains are resulting in flash floods during the rainy season. Further, if any human casualties are caused to the encroached parties or damage is caused to the encroached property, blame is placed on the water body custodian and administrative Authorities. As per the KLCDA Act, BDA Act or Municipality Act, these encroachments should be evicted.

Action on the responsible officers during the encroachment period should be identified based on the remote sensing analysis and punished by hugely penalising them or suspending them from their jobs for not doing their duty, i.e. protection of water bodies and drains.

ii. **Compensation**:

Encroachment on the water bodies by the Government Agencies or Authorities have been done for the use of public as the development in the BMA such as bus stand, park, road, grave yard, etc. The encroachment on the water bodies by the Government Agencies should be brought under the compensation for the usage of water bodies land. Two types of compensation should be introduced such as money or land.

a) ***As Money***: Most of the water body lands have been encroached for the construction of roads, i.e. Few lakes and *Kunte* land have been leased to NICEL through the KIADB for the construction of ring roads. These leased water body lands are already documented with the Authorities, if needed it can also be surveyed; then accordingly the compensation money for the use of water bodies land should be collected from the Government encroachers. Compensation rate can be based on the present property value scheduled by BBMP or BDA in their jurisdiction. The compensation collected from the encroachers should be utilised for the nearby lakes or any lake in the lake series of water bodies for conservation.

b) ***As Land***: Most of the water bodies have been disused and encroached for the urban developments by the Government Agencies and Authorities, as compensation, these Agencies and Authorities can provide the land to maintain the open space as playgrounds and tree parks under their maintenance. These lands will act as the lung space for the urban area as well as to maintain the micro-climate of the local area. These compensation lands should be developed as playground or tree parks based on the population density, wind, relative humidity and temperature of the disused water bodies location. These compensation lands will play the minimum critical role as played by water bodies such as the radiation absorption.

9.4.4.2. Fencing:

Fence is the structure designed to restrict or prevent the movement across a boundary of water bodies and it is one of the basic methods used to protect the land from the intruders. Fencing on the water bodies have been done to protect the water bodies from encroachment and it is a mandatory core activities during the rejuvenation. There was ***no policy or guidelines for the fencing of water bodies***, therefore the guidelines on the water bodies fencing should be developed by including the thickness of steel, height, width, pole distance, etc. There are two types of fences that are available in the market. They are engineering fences and bio-fences.

i. ***Engineering Fences*****:** These fences are made by the human effort using the hard substances. The quality of fence is depended on the durability, height of fence, security and signs. Green painted mesh or chain-link fence has been used by the Authorities as the engineered fence in the rejuvenated lakes for preservation due to its durability.

ii. ***Bio-Fences*****:** Fences made up of lining the natural plants particularly the herbs (climbers) and shrubs as well as trees as pole are also called as 'live fencing' to maintain the shallow water habitat. Bio-fences have many advantages such as to attract the herpetofauna and avifauna, minimise the soil erosion and will also play the critical role in the biodiversity of water bodies through succession. Bio-fences should be developed using the native plants i.e. 12 species are recommended by Hon'ble High Court Committee Report (Patil, 2011), which can be surveyed during the drought as well as runoff. The major limitation of the bio-fence is that it can be easily intruded by animals as well as trespassers.

Dual fences include the engineered and bio-fences of two rows should be encouraged in view of long term maintenance as well as to maintain the biota of the water bodies, particularly attract the reptiles. Dual fences will increase the durability as well as aesthetic value of the urban landscape water bodies, especially the foreshore.

Fences should be established with ***signs*** to protect the water bodies, it should have the Operation and Maintenance Plan for the installed fence at the site. The plan should have policies and procedures for the long-term maintenance and monitoring of the fences. The entire perimeter of the fence should be inspected bi-annually to ensure the fence remains intact, and effective at limiting access (IDEM, 2013).

9.4.4.3. Protect Rajakaluve:

Rajakaluve of lakes or Storm Water Drain (SWD) are notified and published the list of encroachers by BBMP (http://bbmp.gov.in/encroachment-details), which are in their jurisdiction. Further, the Real Estate Research Initiative of Indian Institute of Management Bangalore (IIMB-RERI) has launched the web-portal (http://www.rajakaluve.org/) as rajakaluve encroachment finder with support of BBMP. The same initiation should be taken in the BDA area to restrict the development immediate to the lake and rajakaluves as the protective measures. Even the Revised Master Plan (RMP-2015) stated that the buffer should be maintained as 'No Build Zone' in 50m for primary rajakaluves, 25m for secondary rajakaluves, 15m for tertiary rajakaluves from the middle of the rajakaluves and 30m for lakes. But, the Principal Bench of National Green Tribunal (NGT) had ordered (OA No.222/2014) that the buffer should be maintained as 50m for primary rajakaluves, 35m for secondary rajakaluves, 25m for tertiary rajakaluves from the middle of the rajakaluves and 75m for lakes. Presently, the judgment of NGT (dated 7th May 2016) is challenged by Government of Karnataka in Hon'ble Supreme Court.

Each and every citizen of our Country has the responsible to protect the water bodies under Article 51-A(g) of the Indian Constitution, which stated that 'it should be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures'. There are 14 Acts are existing as the legal framework for the preservation of the water bodies from the encroachment and recover the encroached land, which are tabulated in the Table-9.1.

Table-9.1. Details of Act pertaining to eviction of encroachment on water bodies and its drain

Act, year	Section (Clause)	Details of Act
The Indian Penal Code,1860	197	Imprisonment for life or imprisonment for a term of 7 years or upwards for defaulter for issuing or signing a false (R.T.C.) certificate required by law to be given or signed, or relating to any fact of which such certificate is by law admissible in evidence, knowing or believing that such certificate is false in any material point, shall be punished
	198	Whoever uses fake certificate is liable for punishment
	430	Prohibits the water diverting and punishes the offender with imprisonment of either description for a term which may extend to 5 years, or with fine, or with both
	434	Punishes the act of destruction or movement of any land mark fixed by public authority, with imprisonment of either description for a term which may extend to 1 year, or with fine, or with both
	447	Penalises criminal trespass with imprisonment of either description for a term which may extend to three months, with fine or which may extend to INR 500, or with both
	464	Making a false document or electronic record is liable for imprisonment of either description for a term which may extend to 2 years, or with fine, or with both
The Karnataka Town & Country Planning Act, 1961	76 (D)b	If any person removes any mark set up for the purpose of indicating any level are necessary to the execution under this Act, he shall be punishable with fine which may extend to INR 200 or with imprisonment for a term which may extend to 2 months
The Karnataka Land Revenue Act,1964	39	Deputy Commissioner may or shall evict any person wrongfully in possession of land under this Act
	94 A	Unauthorised occupation on government land is punishable
The Karnataka Municipalities Act,1964	2(a)	Construction or digging of new tank or pond should be done with prior permission from Municipal Council
The Wildlife (Protection) Act, 1972	29	Prohibits the diversion of habitat (land, water or vegetation which is natural home of any wild animal)
The Code of Criminal Procedure, 1973	152	A police officer may of his own authority interpose to prevent any injury attempted to be committed in his view to any public property, immovable, or the removal or injury of any public land mark or buoy

Karnataka Public Premises (Eviction of Unauthorized Occupants) Act, 1974	5	Eviction of unauthorized occupants from public premises
The Karnataka Municipal Corporation Act, 1976	58 (20)	Removal of obstructions and projections in or upon bridges and other public places
	288A	Prohibition of structures or fixtures which cause obstruction or encroachment upon or a projection over, or to occupy any portion of such channel, drain, well or tank
The Bangalore Development Authority Act, 1976	33A (1)	Prohibition of unauthorised occupation of any land belonging to the Authority to the use, which he is not entitled or has ceased to be entitled, shall on conviction, be punished with imprisonment for a term which may extend to 3 years and with fine which may extend to INR 5000
The Karnataka Prevention of Dangerous Activities of Bootleggers, Drug-Offenders, Gamblers, Goondas, Immoral Traffic Offenders and Slum-Grabbers Act, 1985	-	Prohibits illegal possession of any land by any person
The Karnataka Urban Development Authorities Act, 1987	74 (1) & 74 (2)	Prohibits entry, usage or occupation of any land belonging to the Authority by an unauthorised person and punishable with imprisonment for a term which may extend to 3 years and with fine which may extend to INR 5,000 and with a further fine which may extend to INR 50/ acre of land or part thereof for every day on which the occupation continues after the date of the first conviction for such offence
Regulation of Unauthorised Construction in Urban Areas Act, 1991	4 (3)	Unauthorised constructions made in forest land or on tank bed shall not be regularised
The Karnataka Land Grabbing Prohibition Act, 2011	4 (1) & 5	No person shall commit or cause to be committed land grabbing, by himself or through any other person. The offender who commits any offences in connection with land grabbing is punishable with imprisonment for a term that shall not be less than 1 year, but which may

		extend to 3 years, and with fine which may extend to INR 25,000 on conviction
The Karnataka Lake Conservation and Development Authority Act, 2014	5 (1)	Functions of the Authority to exercise regulatory control over all the lakes within its jurisdictions including prevention and removal of encroachment
	14 (1)	use the lake for any purpose other than storage or impounding of water are prohibited
	14 (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 are prohibited
	14 (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 are prohibited
	15 (1)	to permanently demarcate its boundaries by custodian
	15 (2)	issue general or specific directions to custodian to remove encroachment or unauthorized occupation of such lake
	24 (1)	According to Karnataka Public Premises (Eviction of Unauthorized Occupants) Act, 1974, the encroachment on lake be summarily evicted
	25	Penalties for Section-4 offence will be minimum 3 years may extend upto 5 years with a fine minimum INR 10,000 to 20,000
	26 (3)	One year imprisonment with INR 10,000 penalty for destroy the piller or posts to demark the lakes boundary
	27	Penalty for failure to report unlawful occupation of lake one year imprisonment with INR 10,000
	29	Enhanced penalty after previous conviction under section-25 be punishable with imprisonment for a term which shall not be less than five years and with a fine of rupees one lakh.
	31	Offences by Companies/ residents association shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly
	32	Offences by Government department, shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly

9.4.5. Protect Water bodies from Pollution:

Most of the water bodies in BMA have been polluted either by solid waste or through the influx of liquid waste generated from the urban population through discharge of sewage and effluents. Thus there is urgent need to protect the water bodies from the pollutants. Even Government have taken many initiatives such as implementation of solid waste management and plastic ban rules, and construction of many STP's to treat the sewage water flow into the water bodies, but still there is a gap in the protection of water bodies from pollutants.

9.4.5.1. Prevention of Wastewater inflow:

The study found that the 198 BMA water bodies have the influx of domestic sewage, which includes even the rejuvenated lakes. The inflow of sewage in to the water bodies are from the non-point source pollution that is received through the storm water drain or nallah from different parts of the City or area. Sewage (waste water) has played major role in the deterioration of the water quality, odour and eutrophication of the water bodies, enhance the growth of aquatic weeds, foams and also fire. Diversion of waste water from the water body and installing the STP to treat wastewater before it enters into the water bodies are presently followed. These two approaches have their own limitations and advantages. The limitations are;

i. **Diversion:**

The drainage system of the Bengaluru City includes the primary and secondary drains comprising of 841 Km length. The sewage flows into the water bodies through these drainage systems. When the sewage is diverted to the downstream, it may be the solution for that specific water body but the diverted sewage has flow to the downstream water bodies. Moreover, for the sake of diverting sewage inflow from water bodies, the diversion of storm water drain or nallah has been done during the rejuvenation of the water bodies. The diversion of storm water channel has led to the dry condition of the water bodies, so the *diversion of the nallah or the storm water channel should be prohibited* and should not be included in the water bodies rejuvenation activity.

The less quantity of sewage inflow is not harmful to the water bodies, when there is huge water body with biota such as fish and aquatic plants. Because, the concentrated nutrients and organic solids in sewage water have been diluted and utilized by the aquatic biota. BWSSB is the Authority, which is responsible to handle the generated waste water in the BBMP area but due to negligence, most of the individual residential domestic sewerage system has been connected to the drainage system. Therefore the sewage in the drainage system is an unavoidable condition in the present scenario of the

Bengaluru City. But in the long-term implementation of drain conservation plan, the inflow of wastewater into the water bodies should be avoided.

Therefore, the best option to mitigate the inflow of sewage into the water bodies should be identified such as *Dual Purpose Drain* constructed in the Kengeri, Srigandhadakavalu (Figure-9.1) and Herohalli lakes, which also act as the silt trap. These drains have the constructed ridge, which will divert the concentrated sewage water from the water bodies during the summer season and the same has been allowed for the rain water, when the level of water flow is high. The frequent cleaning of silt trap and maintenance is the only option to get better results.

Figure-9.1. Dual purpose drain in Srigandhadakavalu lake

ii. Commissioning of Centralised Sewage Treatment Plan (STP) or Wastewater Treatment Plant (WWTP) with Underground Drainage (UGD):

In Bengaluru Metropolitan Area, the sanitation facilities are provided by Bangalore Water Supply and Sewerage Board (BWSSB) in BBMP jurisdiction area (800.29 km^2). The remaining 506.71 Km^2 Bengaluru agglomeration area have sanitation facility provided by Panchayat's. About 1400MLD sewage is generated in BBMP area, which is collected by the 6800 Kms length of sewer system with 3367 Kms of sewerage network laterals and 302 Kms of trunk sewers. The actual sewage generation rate could be higher as there was no data on the usage of groundwater quantity. But due to the Cities population growth, the capacity of sewers became inadequate and old sewers are leaking that resulted in the inflow of sewage in water bodies i.e. 206 BMA water bodies have inflow of sewage. Therefore, the existing old UGD pipe lines should be replaced and rehabilitated to convey the entire sewage generated by population of City. The trunk sewers or UGD should connect to the operating 18 STPs to treat the 846 MLD sewage and 18 STPs are under construction to treat the 731.5 MLD sewage (Figure-9.2). Recently, STPs in Bellandur Amanikere (90MLD), Doddabele (20MLD), Horamavu Agara (20MLD) and Kadugodi (6MLD) were inaugurated on 10th November 2017. Presently, there are four types of STPs operated in BMA area are Activated Sludge Process (ASP), Up-flow Anaerobic Sludge Blanket (UASB), Sequential Batch Reactor (SBR), Membrane Bio Reactor (MBR), Fluidized Aerobic Bio Reactor (FAB).

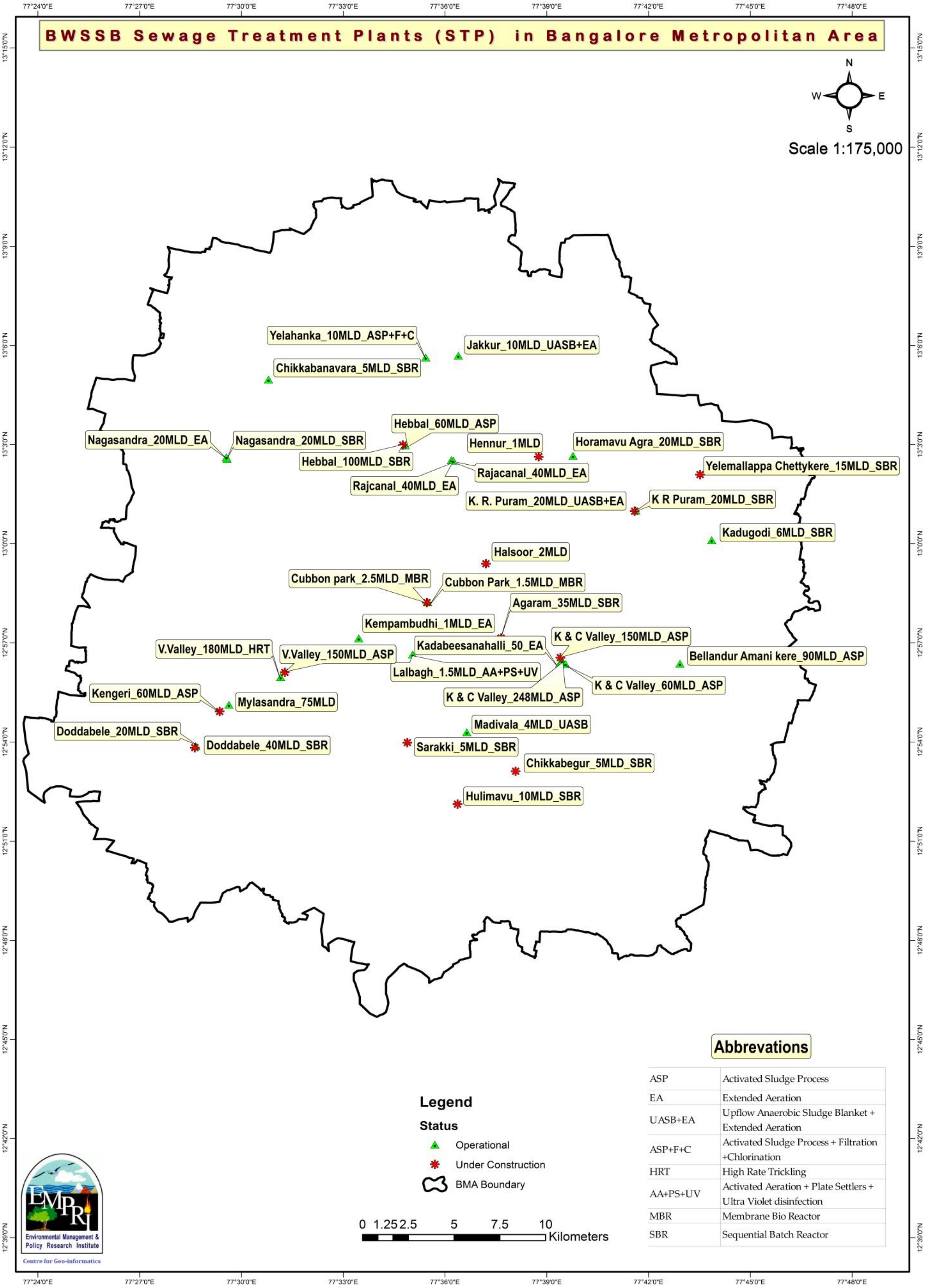

Figure-9.2. Location of STP with its treatment technology in BMA

Agglomeration area of Bengaluru (506.71 Km^2) area should also commenced with the UGD pipelines that connect to the STPs. The commencement should be initiated by the BWSSB or by Karnataka Urban Water Supply and Drainage Board (KUW&SDB). The commencement of UGD pipelines that connected with the STPs in the entire BMA area will be the stable solution to stop the inflow of sewage into the lakes. As the ultimate aim of zero discharge, the provision should be made to treat the entire generated sewage of 2195 MLD by the projected population of 20.3 million for 2031.

Therefore, the BBMP lakes should be protected from the sewage influx through the commissioning of decentralised STPs in ward level, which can be installed in the Government spaces such as parks. During installation, the existing statutory norms should be followed in pertaining to the buffer zone. The STPs with appropriate treatment technology (Table-9.2) may be built in underground that requires low maintenance, limited space, energy efficient and the space above ground may be developed aesthetically. The comparative performance of STPs treatment technologies is tabulated in the Table-9.3. Further, the efforts should be taken by BWSSB to operate the non- functional STPs in the BBMP area. The treated water shall be used in 423 BBMP parks (0.38 Km^2), large campuses such as Universities, IT Parks, etc. that demands substantial water for maintenance.

iii. Monitor the STP:

STP (Sewage Treatment Plant) or WWTP (Waste Water Treatment Plant) is much needed in the urban scenario to treat the generated domestic sewage for secondary purposes, which is reused to protect freshwater from pollution and to utilise the nutrients value of sewage for irrigation. The CPCB (2005) has recommended to the State Government to setup the STP to prevent the water bodies pollution. But the actual sewage generation in City is 1400MLD and have the STP to treat only 520MLD of sewage and the remaining 880MLD flows to the surface water bodies. Even BWSSB (2017) additional 520MLD wastewater treatment plant also leaves out the 360MLD wastewater into surface water bodies. Even from the few working STPs, the treated water flows to the sewage flowing drain. Therefore the STP should be monitored by the STP Monitoring Committee (STPMC) members, which include the members from KSPCB, KLCDA, BDA and BBMP as stakeholder members.

iv. Inflow of STP Treated Water:

CPCB (2005) found that 50% of the STP's in Karnataka are not achieving the general standards for releasing the treated water into the environment including water bodies. It is mandatory to setup the STP for the apartments, which have more than 50 flats and

Table-9.2. Advantages and disadvantages of various Sewage Treatment Technologies

S.No.	STP Process	Area Need (Ha./MLD)	Advantage	Disadvantages	Applicability
1	Activated Sludge Process (ASP)	0.15-0.25	Good process flexibility; Performance is not affected by the normal variations in wastewater characteristics and seasonal changes; Requires less land; Reliable operation; Low odor emission; Energy production	High recurring cost; Consumes high energy; Requires uninterrupted energy supply; performance is adversely affected due to interruption in power supply even for a short period; foaming, particularly in winter season, may adversely affect the oxygen transfer and hence performance; Requires elaborate sludge digestion/drying/disposal arrangement; skilled operators needs; less nutrient removal	Used option for treatment of domestic wastewater for medium to large towns where land is scare
2	Upflow Anaerobic Sludge Blanket (UASB)	0.2-0.3	Sludge handling is minimized; interruptions in power supply have minimal effect on plant performance; can absorb hydraulic and organic shock loading	Post treatment is required to meet effluent standard, which in turn may make treatment scheme as energy intensive or may require large land area; effluent is anoxic and invariable exerts substantial initial/instantaneous oxygen demand which may have adverse impact on receiving inland water bodies or when used for irrigation; stability in performance is questionable unless sludge wash out is prevented; faecal and total coliform removal is poor; aesthetically the effluent has poor acceptability due to its black colour; exploitation of biogas generated is unsustainable during domestic sewage treatment	The suitability of this technology may be doubtful as a stand-alone secondary treatment option
3	Fluidized Aerated Bed (FAB)	0.06	Exclusion of primary treatment step of sedimentation; requires small space; effectively treats dilute domestic wastewaters; elimination of the need for sludge recirculation and monitoring of	Reliance on patented filter media; reliance of flocculants, polyelectrolyte and chemical disinfectant (optional); requires skilled manpower; choking of reactor due to floating plastic matter	Applicable for small to medium flows in congested locations; sensitive locations; decentralized

S.No.	STP Process	Area Need (Ha./MLD)	Advantage	Disadvantages	Applicability
4			MLSS in the reactor; capacity to handle shock loads; low head loss in the fluidized filter bed; sludge digestion is not required as low & stabilized sludge is produced; simple and reliable operation; absence of odour and improved aesthetics; absence of emission of corrosive gases		approach; reliving existing overloaded STPs
4	Sequential Batch Reactor (SBR)	0.1-0.2	Small footprint because of absence of primary, secondary clarifiers, & digesters; Excellent effluent quality; Biological nutrient (N & P) removal; high degree of coliform removal; less chlorine dosing required for post disinfection; ability to withstand hydraulic & organic shock loads	Higher level sophistication is required; highly skilled team to design and construct and skilled operators are required; high maintenance; Potential of discharging floating or settled sludge during decantation; potential plugging of aeration devices during selected operating cycles; potential requirement for equalization after SBR, depending on downstream processes; high energy consumption; requires continuous power supply	-
5	Membrane Bio Reactor (MBR)	0.04-0.05	Small footprint due to low hydraulic retention time; less and stabilized sludge is produced; high effluent quality in terms of low turbidity, TSS, BOD & bacteria; ability to absorb shock loads	High construction cost; very high operation cost; Periodic cleaning & replacement of membranes; High membrane cost; high automation; fouling of membrane; no energy production	For limited space
6	Waste Stabilisation Pond System (WSPS)	0.80 to 2.3	Simple construction offers low cost technology option; High quality effluent at least operating costs; low skill requirement for operation of the plant, fish yield from aquaculture ponds around 4-7 tonnes/ha/yr.	Requires significant amount of land; high cost of lining; likelihood of odour nuisance & mosquito breeding in poorly maintained WSPs; contamination of ground water due to porous and fractured strata if unlined	Areas with easily available land; areas with aquaculture preference; areas with unreliable, low or expensive power supply

S.No.	STP Process	Area Need (Ha./MLD)	Advantage	Disadvantages	Applicability
7	Trickling Filter (TF)	0.25 to 0.65	Requires lower skilled manpower; Rugged system, less prone to hydraulic and organic over loading; Reduced requirement for process monitoring; Sludge with better settling characteristics	Blockage of ports in distribution arm; Blockage of bio-filter due to excess biomass growth or floating matter; Frequent mechanical breakdown of the turntable; Odour and filter flies may be unavoidable	Standalone treatment for sewage if operated at slow rates; As a high rate roughing filter for high BOD wastewater; in combination with ASP for good and consistent performance
8	Submerged Aeration Fixed Film (SAFF) Technology	0.05	Requires small space; Ability to effectively treat dilute domestic wastewater; low and stabilized sludge production eliminating the need for sludge digestion; absence of odour and improved aesthetics; absence of emission of corrosive gases	Clogging of reactor due to absence of primary sedimentation; Reliance on proprietary filter media; High reliance on external energy input; Requires skilled manpower	Applicable for small to medium flows in congested locations; sensitive locations; decentralized approach; reliving existing overloaded trickling filters
9	Cyclic Activated Sludge Process (CASP)	0.1-0.15	Can be designed to remove N and P along with carbon removal; Absence of odour and improved aesthetics; Absence of emission of corrosive gases	No provision for sludge management; No provision of primary treatment; High reliance on external energy input; Requires skilled manpower	Applicable for small to medium flows in congested locations; sensitive locations; decentralized approach; reliving existing overloaded trickling filters
10	Duckweed pond	2 to 6	Compared to other aquatic plants duckweed is less sensitive to low	High requirement of land, pathogens are hardly remove due to low penetration of light; duck	Low strength domestic wastewater

S.No.	STP Process	Area Need (Ha./MLD)	Advantage	Disadvantages	Applicability
	system (DPS)		temperatures, high nutrient levels, pH fluctuations, pest & diseases; reduced suspended solids in effluent due to elimination of algae; significant removal of nutrients simultaneously; complete cover prevents breeding of mosquitoes and odour nuisance; Least cost of O & M; economy generation from sale of raw or processed weed for fish; duckweed as an excellent feed for aquaculture; Easy to harvest; Yield of highly protein containing vegetative material as animal feed	weed die off in cold weather conditions.	or after primary sedimentation with influent BOD< 80 mg/l; in rural & semi urban settlements with easy land availability; in combination with existing WSP; as a polishing pond for an existing activated sludge plant or other technology based STPs
11	Facultative Aerated Lagoon (FAL)	0.27 to 0.4	Simple operation of the plant requiring lower skilled manpower; minimum civil, electrical & mechanical installation; scheme devoid of primary & secondary settling tanks as well as sludge digestors; lower energy costs compared to other aerobic processes; lower O & M cost	High cost of lining and possibility of ground water contamination in porous and fractured strata	Standalone system for sewage treatment; as an up-gradation option for overload WSPs; pre-treatment unit for WSP
12	BIOFOR Technology (Biological Filtration and Oxygenated Reactor)	0.04 (excluding land requirement for sludge drying beds)	Compact layout as a result of high rate processes; higher aeration efficiency through co-current diffused aeration system; space saving as secondary sedimentation is dispensed; able to withstand fluctuations in flow rate & organic loads; compliance with stricter discharge standards; Effluent suitable for	Requires continuous and high chemical dosing in primary clarification; undigested sludge from primary clarification requiring post treatment	-

S.No.	STP Process	Area Need (Ha./MLD)	Advantage	Disadvantages	Applicability
			industrial applications and for UV disinfection without filtration; absence of aerosol & odour nuisance in the working area; absence of corrosive gases in the area; requires less man power		
13	High Rate Activated Sludge Biofor-F Technology	0.08 (including land for sludge treatment and handling)	Compact layout as a result of high rate processes; higher aeration efficiency through diffused and tapered aeration system; space saving as primary sedimentation is dispensed; compliance with stricter discharge standards; effluent suitable for high end industrial applications; stable digester performance and consistent gas production; almost self-sufficient in energy requirement due to gas engine based cogeneration system; absence of aerosol and odour nuisance in the working area	High cost	-
14	Moving Bed Biofilm Reactor (MBBR)	0.15-0.25	Needs less space since there is no primary clarifier and detention period in reactor is generally 4-5 h; Ability to withstand shock load with equalization tank option; High operator oversight is not required	High operating cost due to large power requirements; Not much experience available with larger capacity plants (>1.5 MLD); Skilled operators needed; No energy production; Effluent quality not up to the mark in India; Much less nutrient removal; Designed criteria not well established	-

Source: Tare and Bose (2009); NGRBA (2010)

Table-9.3. Comprehensive analysis of performance of various sewage treatment technologies

S. No.	Sewage Treatment Technologies	Performance Rate	Energy Requirement	Resource requirement & associated costs	Land requirement	Remarks
1	WSPS, slow rate TF	Good	Low	Low	High	May be adopted where land availability is not a problem
2	ASP, UASB system with ASP	Good	High	High	Moderate	May be adopted where land is constraint
3	Various advanced aerobic process such as BIOFOR, MBBR/ FAB, SAFF, SBR	Very Good	Very high	Very high	Low	May be adopted wherever land is major constraint
4	FAL, High rate TF with both grave & plastic media	Moderate	Moderate	Moderate	Moderate	May be adopted where other technologies are not adoptable due to cost considerations and land constraints

Source: Tare and Bose (2009)

reuse the treated sewage within their premises (No. FEE 316 EPC 2015 dated: 19.01.2016). Therefore the sewage generated within the BMA has been treated at micro-level as well as at the macro-level through STP. But as these *STP's are not working efficiently*, the raw as well as the partly treated sewage is flowing in to the water bodies through the storm water drain or directly in to the lakes and cause eutrophication.

Dual-Barrier system should be implemented, before letting the STP treated water into water bodies. First one is the treated water will be allowed to flow in the drain for atleast 100m, where the pathogenic microorganisms will be killed by the natural sunlight during the day time and then treated sewage water should pass through the constructed wetland to remove the heavy metals and other excessive nutrients in the water. Monitoring of the STP water quality through the online monitoring system should also be encouraged for both the micro and macro level STP's.

v. Install Real-Time Water Quality Monitoring (RTWQM) Buoy:

Only 65 of 395 lakes have been monthly monitored for the water quality by the KSPCB, whereas the water quality monitoring mechanism for the BMA water bodies is weak due to the lack of logistics, manpower and resources in the KLCDA. So there is a need for the alternate mechanism on self-monitoring methodology, which will be the RTWQM. RTWQM is a standalone unmanned water quality monitoring system equipped with GPRS/ GSM modem for transmission of real time data to a Central Receiving Station (CRT), which should be located in the KLCDA office. CRT should have the capability to receive, analyse and archive the data received from RTWQM with alarm system (if needed).

The frequent direct pollution point (may include the STP treated water flow) or the inlet of the lakes, which have been polluted should be identified based on the priority and need. In the identified lakes, the real time monitoring buoy should be installed with the sensor based monitoring of basic parameters such as pH, turbidity, TDS, dissolved oxygen, phosphate or nitrate or ammonia (indicator of sewage inflow) with the monitoring frequency of at least 30 minutes. Multi-parameter Sondes (Multi-sensor) feature an array of ports for attaching the build-in optical sensors in buoy along with data logger based on solar power. Even CPCB issued directions to the SPCBs for setting up the real time monitoring systems in February, 2014. There are two types of buoy in the usage are follows;

a) **Mobile Buoy**:

The mobile buoy (Figure-9.3) is floating and controlled by the computer, which send a series of commands to microcontrollers over the global system for mobile communication and move to the user location (Mohd Akmal Helmi *et al*., 2014). The buoy moves to the desired coordinates using the solar or charged energy that relies on GPS reading and measure the interested physico-chemical parameters through sensor, which is attached to buoy. The advantage of the mobile buoy is that one buoy will measure the inlet, outlet and even center of lake water parameters with time and coordinates. Further, for calibration of the sensor and to charge the battery in buoy, the user will not get in to the water bodies. But the major limitation of the mobile buoy is buoy safety from theft, waves and wind will impact the mobility of the buoy.

Figure-9.3. GPS controlled mobile buoy

b) **Moor Buoy**:

Moor buoy (Figure-9.4) is the floating platform that supports the real-time monitoring instruments such as sensors and data loggers, which will be anchored with the single or two point mooring based on the application. Moor buoy usage in the lentic water bodies have great success in the real-time monitoring and therefore moor buoy has been recommended for the real time-monitoring of the water bodies particularly in the inlet of the BMA lakes.

Figure-9.4. Moor or fixed buoy

Verification of the data generated through RTWQM should be checked randomly by manual monitoring and analysis by KLCDA/ KSPCB to assess the efficacy, accuracy, precision and reliability of installed equipment. Data management and quality check should be validated according to water quality standards and policy should be in place to cover the aspects of calibration procedures with schedule, maintenance procedure with schedule, data transmission and validation procedures.

vi. Usage of treated Wastewater:

Wastewater is one of the major pollutants of the BMA water bodies and the use of wastewater by treatment is the only source for the mitigation of liquid waste pollutant in the water bodies. Wastewater reuse offers a potential triple dividend to urban users, farmers and the environment (FAO, 2010). The urban treated wastewater generated in the BMA has been used in two ways such as within the BMA or used by the downstream farmer for irrigation. But the treated wastewater used for the irrigation by the downstream farmers also has the disadvantages such as evaporation, infiltration of treated water and care should be taken to influx of wastewater with the treated wastewater.

The usage of treated wastewater in the urban area should be encouraged for the secondary purposes such as gardening and flushing. BWSSB has established 14 STP around Bengaluru for treating the 721MLD of wastewater and 339MLD treatment plants are in construction. Major establishments such as Bengaluru International Airport, BEL, Axle Plant Railway, ITC Ltd, etc. are using the treated water for the secondary usage and further, the Cubbon and Lalbagh parks are provided with the treated water. Further, the apartments which have 20 and more flats should have their own STP for the treatment of wastewater generated by them and additionally, this treated water should be utilised by the apartment people itself for the toilet flushing as mandatory through the dual piping system (BWSSB/EIC/CE(M)/16172/2015-16 dated: 03.03.2016). But the Harsha (2012) found that the contaminants of the Bangalore wastewater are diverse ranging from normal domestic sewage load to industrial waste comprising heavy metals, pharmaceuticals and pesticides (emerging contaminants) and therefore there is no one single method that can remove the entire range of contaminants and ensure that the water is fit for domestic consumption.

Establishment of STP and dual piping system in the apartment and commercial building premises should be encouraged. Monitoring the efficiency of STP is the major limitation in this scheme. One of the best examples for this is Bellandur lake in the Bengaluru East taluk. Therefore a report on STP efficiency should be submitted to BWSSB at least annually.

vii. Regulating the Phosphate Based Detergent:

Laundry detergent or washing powder is the mixtures of chemical compounds used to clean the laundry and also used as dish washer. Pentasodium triphosphate (PSTP) is the predominant chemical form used in detergent to form soluble and strong complexes with calcium and magnesium ions (hard water) in water (Gilbert and Dejong, 1977). The other chemical forms used in the detergents are sodium tripolyphosphate (STPP), tripolyphosphate (TPP) and advanced surfactants other than phosphates are linear alkyl benzene sulfonate such as sodium, ammonium laurate, lauryl sulfate. Sodium triphosphate comprises of 50% by weight of detergent which becomes soluble phosphates after the use and this when discharged into water bodies has resulted in the eutrophication. Even STPs won't remove phosphate as efficiently. The major surfactant for the frothing and fire on the Bellandur lake is due to the presence of high concentration phosphate (UDD, 2016). Phosphates in the detergent became an environmental concern in 1950 and become public concern during 1970's, which forced the USA (1970), Canada (1973), Japan and few European Union Member States to reduce the STPP amount used in detergents (Glennie, 2002).

Regulating or banning the usage of phosphates in the detergent will reduce the capital and operation costs on wastewater treatment, because the effort taken to reduce the phosphate level in STP will increase the levels of chlorides and TDS (Alexander, 1977). Ban on phosphate based detergent will reduce the phosphate concentration in the water bodies up to 40%, which will increase the quality of water in the urban water bodies. Zeolite A is the replacement option for the Sodium triphosphate, which is used in the commercial market for production of phosphate free detergents. Studies conducted by Maki and Macek (1978) on impact of Zeolite on environment had found that the insoluble Zeolite is non-toxic for environment, which does not contribute to eutrophication potential and the same can be removed through the activated sludge process from sediment.

The usage of phosphate based detergent can be regulated by implementing the following suggestions.

a. Awareness should be created on the impact of phosphate based detergent usage, particularly in the Bellandur and Varthur lakes catchment area.
b. Regulate the usage amount of phosphate based detergent as 0.2-0.5mg/ wash.
c. Encourage the voluntary participation of detergent companies to reduce the concentration of phosphates in the detergents and market the phosphate free detergents.
d. Ban on phosphate usage in the detergent should be implemented through the amendment in the legislative frameworks such as EPA and water act, also in the BWSSB Act, Municipal corporations Act, etc.

9.4.5.2. Preventing the Solid Waste Dumping:

According to this study, about 303 water bodies are being polluted by the solid waste dumps, which include the domestic garbage, construction and demolition waste (C&D), agriculture waste and industrial wastes, such as plastic and polystyrene packing materials. These solid wastes are polluting the water bodies by its degrading products for example; domestic garbage will add the excess nutrient load to the water bodies, whereas the C&D and agriculture waste will increase the turbidity of the water bodies. All type of solid wastes will impact on the biota of the water bodies and degrade the water quality of the water bodies.

Domestic garbage is one of the major solid wastes, which are frequently observed in the water bodies area. The segregation of garbage at source is mandatory in the BBMP jurisdiction, the segregated wastes are collected by the BBMP at Ward level. But in the BDA jurisdiction, Grama panchayat has the responsibility to collect the generated wastes from the households. Even though the facility has been provided by the local bodies, domestic garbage waste dump is common in the water bodies and its vicinity but the local bodies itself use the water body vicinity to segregate the domestic waste which has led to the water bodies pollution by solid waste. Therefore, prevention of garbage dump in the water bodies will be possible only by community participation and implementation of institutional frameworks.

Construction and Demolition waste (C&D) is also one of the major solid waste pollutants of the water bodies. C&D waste has been generated by construction of apartments within the jurisdiction of BBMP and construction of superstructures in the developing BDA areas. C&D waste dump yard has been allotted by the local bodies which have been used only by the biggest project builders, but the small project and individual superstructure constructers have not utilized the facility due to the cost escalation in the transport of wastes. Ultimately the C&D waste generated by the small builders are dumped in the open area of BMA, particularly the area of water bodies and its drain. Therefore to control the dump of C&D waste generated by builders, the *pre-allotted dump yard* should be nominated to the builders during the granting of license for construction based on the estimated waste generation. Apart from these, the existing C&D waste dump should be cleared from the water body and its vicinity by the custodian and should be regularly monitored.

Agriculture waste including manure, dried leaves are heaped in the vicinity of water bodies for compost. The leachate generated from the agriculture waste heap has been polluting the surface, sub-surface and also groundwater. Even though the agriculture waste heap is temporary, it plays the major role in water quality by increasing the turbidity, particularly during the monsoon season. Therefore, the *awareness* about the importance of lakes should be given to people in the neighborhood of the water bodies to stop the dumping of any wastes in the vicinity of the water bodies and its drain.

Industrial wastes include the granite slurry and plastics as packing materials are observed in the vicinity of water bodies and its drain. The industrial wastes also called as trade effluent such as dye waste and granite slurry are regulated by KSPCB. About 350-400 MT/ day of plastic wastes have been generated in Bengaluru City (BBMP, 2016), which are spread in and around the water bodies and block the water infiltration. Therefore, the Department of Forest, Ecology and Environment, State Government of Karnataka has banned certain type of plastics usage in Karnataka (No. FEE 17 EPC 2012, Bangalore Dated: 11.03.2016) under the Plastic Waste Management Rules, 2016 and the same has been implemented through the various Government Agencies (No.Comm/PR/774/2016-17 dated: 04.05.2016). The legislative frameworks for the solid waste dump prevention in the urban open area are tabulated in the Table-9.4.

Cleaning of Plastic Wastes in Puttanahalli Lake

EMPRI conducted the plastic cleaning camp on 14th March'2017 in the Puttenahalli Lake located in Bengaluru South taluk to promote the awareness about the ban on plastics and hazards using plastic. Puttenahalli Neighborhood Lake Improvement Trust (PNLIT), BBMP, Hasiru Dala, rag pickers are also involved with the EMPRI staff to collect the plastic wastes such as plastic carry bags, sachets from the rejuvenated lake. Rally conducted by EMPRI from the Doresaniplaya Forest Campus, JP Nagar 5th Phase to the Puttenahalli lake also give awareness about the plastic ban to the local people.

Table-9.4. Legal framework to prevent the solid waste dump in the water bodies

Act, year	Section (Clause)	Details of Act
The Indian Penal Code, 1860	277	Prohibits fouling of reservoir water and punishes the offender with imprisonment of either description for a term which may extend to 3 months, or with fine which may extend to INR 500 or with both.
The Indian Fisheries Act, 1897	5 (1)	Adding poison, lime or noxious material into any water with intent thereby to catch or destroy any fish is punishable with imprisonment for a term which may extend to 2 months, or with fine which may extend to INR 200

The Karnataka Municipalities Act, 1964	234	The defaulter will be punished with INR 50 fine for fouling the water coming under municipal council
	235	Prohibits washing of clothes by washer men, except in places which is solely dedicated for that purpose
	238	Prohibits storage of night soil or manure or substance and emitting an offensive smell is liable for punishment with a fine up to INR 25
	240	Feeding of any animal which is kept for dairy purposes or is intended for human food on excrementitiously matter, stable refuse, filth, or other offensive matter, or permits such animal to feed or to be fed on such matter, shall be punished with fine which may extend to INR 50
	242 (b)	Punishes the person with fine, which may extend up to INR 100 for making any grave or burns or buries any corpse at any place not set apart for such purpose
	242 (f)	Punishes the person with fine, which may extend up to INR 100 for storing or using night soil, cow-dung, manure, rubbish or any other substance emitting an offensive smell without written permission form Municipal Commissioner
	242 (g)	Punishes the person with fine, which may extend up to INR 100 for using or permits to be used as a latrine any place not intended for that purpose
The Bangalore Water Supply and Sewerage Board Act, 1964	74	States that the sewage and rain water drains to be distinct
	75	Prohibits the entry of sewage into any watercourse before any treatment
The Water (Prevention & Control of Pollution) Act, 1974	24	Prohibits use of stream or well for disposal of polluting matter
	25	Restricts the construction of any industry, operation or process, or any treatment and disposal system or an extension or addition thereto, which is likely to discharge sewage or trade effluent into a stream or well or sewer or on land
Bangalore Water Sewerage Regulations, 1974	4A	Adoption of dual piping system and providing modular STP is mandatory for the apartments have 20 or more flats/ commercial building constructed in 100sq.m. or above.
	4A (4)	Failed to implement the STP and dual piping system in residential apartments should attract 25% of water and sanitary charges for 3 months and 75% after that till the STP and dual piping system provide
	4A (5)	Failed to implement the STP and dual piping system in commercial buildings should attract 50% of water and

		sanitary charges for 6 months and 100% after that till the STP and dual piping system provide
The Karnataka Lake Conservation and Development Authority Act, 2014	14 (1)	Use the lake for any purpose other than storage or impounding of water are prohibited
	14 (4)	Dump debris, municipal solid wastes, mud or earth soil or liquid wastes or any pollutants into the lake by using vehicle are prohibited
	16	Vehicle or any other material or object used in committing any such offence such as dumping in lake will be seizure
	25	Punishable with imprisonment for a term shall not be less than 3 years, which may extend to 5 years and with a fine of not less than INR 10,000 but which may extend to 1 lakh
	29	Who convicted of any offence under section 25 is again found guilty of an offence involving a contravention of the same provision, shall on the second and on every subsequent conviction be punishable with imprisonment for a term which shall not be less than 5 years and with a fine of rupees 1 lakh
The Karnataka Municipal Corporation Act, 1976	13G (6)	Functions and duties of Area Sabha to identifies deficiencies in the sanitation arrangements and suggest remedial measures
	13G (8)	Duties to impart awareness on matters of public interest such as cleanliness, preservation of the environment and prevention of pollution
	58 (3)	Obligatory functions of the corporations as the collection, removal, treatment and disposal of sewage, offensive matter and rubbish and, the preparation of compost manure from such sewage, offensive matter and rubbish
	58 (4)	Construction, maintenance, cleaning of drains, drainage works and of public privies, water closets, urinals and similar conveniences
The Karnataka Municipal Corporation Act, 1976	58 (6)	Maintenance of all open spaces and other property vesting in the corporation
	58 (16)	Reclamation of unhealthy localities, the removal of noxious vegetation and generally the abatement of all nuisances
	58 (27)	Establishing and maintaining compost plants for disposal of sewage
	59 (4)	Discretionary functions of the corporation to organize, maintenance or management of chemical or bacteriological laboratories for the examination or analysis of water, food or drugs, for the detection of diseases or for research connected with public health

	59 (21B)	Urban forestry, protection of the environment and promotion of ecological aspects
	223 (1)	No person shall throw, empty or turn into any corporation sewer or into any drain or sewer communicating with a corporation sewer
	223 (1b)	Any chemical, refuse or waste, or any liquid of a temperature higher than 45°C, being refuse or a liquid when so heated, is either along or in combination with the contents of the sewer, dangerous, or the cause of a nuisance, or prejudicial to health has been prohibited
	230	There shall be one drain for filth and polluted water and an entirely distinct drain for rain water and unpolluted subsoil water or both rain water and unpolluted sub-soil water each emptying into a separate corporation sewer or corporation drain or other suitable places
	232	No sewage shall be discharged into any water-course until it has been so treated as not to affect prejudicially the purity and quality of the water into which it is discharged
	255	Provision for providing or appointing proper and convenient situations or places for the temporary deposit of rubbish and filth and for the final disposal of filth and carcasses of animals
	263 (3a)	Deposit the carcasses of animals, rubbish or filth in any street or in the verandah of any building or on any unoccupied ground alongside any street or any public quay, jetty or landing place or on the bank of a water course or tank has been prohibited
	324 (1)	If any tank, pond, well, stream, dam, bank or other place be deemed by the Commissioner to be for want of sufficient repair, protection or enclosure, dangerous to the passers by or to persons living in the neighbourhood, the Commissioner may by notice require the owner to fill in, remove, repair, protect or enclose the same so as to prevent any danger therefrom
The Karnataka Municipal Corporation Act, 1976	330	Any public well or receptacle for stagnant water is likely to be injurious to health or offensive to the neighbourhood, Commissioner shall cause the same to be cleansed, drained or filled up
	331	Prohibition against contaminating water supply by bathing, washing animal or things, throwing anything or damaging drain and a fine of INR 50
	1431A	Penalties for failure to comply with the solid waste

		management scheme which may extend to INR 1000
Environmental Protection Act, 1986	3-2 (iv)	Lays down standards for discharge of environmental pollutants from various sources
	3-2 (v)	Restriction of areas in which any industries, operations or processes or shall not be carried out or shall be carried out but subject to certain safeguards
	3-2 (xiii)	Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution
	7 & 15	Prohibits discharge of environmental pollutant in excess of standards as prescribed in the standards and the offender is liable for punishment with imprisonment which may extend to 5 years or with fine which may extend to INR 1 lakh and in case the failure or contravention continues, with additional fine which may extend to INR 5,000 for every day after the conviction for first such failure or contravention
The National Environment Tribunal Act, 1995	3(1)	If there is any harm, damage or destruction to the fauna or flora has resulted from an accident, the owner shall be liable to pay compensation for such death, injury or damage and cost of restoration can also claimed in case of harm or damage to environment including pollution of soil, air, water, land and eco-systems
Granite Conservation and Development Rules, 1999	31 (2)	Overburden, waste rock and non-saleable granite generated during prospecting or mining operations for granite shall be properly secured to prevent the escape of material in harmful quantities which may cause degradation of the surrounding land or silting of water courses
	34	Every holder of a prospecting license or a lease shall take all possible precautions to prevent or reduce to a minimum the discharge of toxic and objectionable liquid effluents from granite quarry, workshop or processing plant, into surface or ground water bodies, and usable lands. These effluents shall conform to the standards laid down in this regard
Municipal Solid wastes (Management & Handling) Rules, 2000	5 (1)	Municipal authority shall be responsible for the implementation of the provisions of these rules and for the necessary infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid waste directly or by engaging agencies or groups working in waste management including' waste pickers
	5 (2)	Sites for landfills, processing and disposal facilities of

		municipal solid waste shall be incorporated in the Town Planning Department's land-use plans
	6 (1)	State Pollution Control Board shall monitor the progress of implementation of Action Plan and the compliance of the standards regarding ground water, ambient air, leachate quality and the compost quality including incineration standards or any other such condition
	6 (1j)	Management of municipal solid waste to create awareness among all stakeholders about their responsibilities
	6 (1k)	Open burning of municipal solid waste is not permitted
Wetland (Conservation and Management) Rules, 2010	-	Restricts activities like reclamation of wetlands, setting up of or expansion of industries, manufacturing or storage or disposal of hazardous substances, solid waste dumping, discharge of untreated wastes and effluents from industries or cities or any such activity likely to have an adverse impact on wetland ecosystem, construction of permanent structure except for boat jetties within fifty meter from the mean high flood level observed in past 10 years
Guidelines for Idol Immersion, 2010	2.1 (i)	Idols should be made from natural materials may be encouraged, allowed and promoted
	2.1 (ii)	Use of toxic and non-biodegradable chemical dyes for painting idols should be strictly prohibited
	2.1 (iii)	Worship material like flowers, *vastras* (clothes), decorating material (made of paper and plastic) etc. should be removed before immersion of idols
	2.1 (iv)	Public should be educated on ill effects of immersion in the holy water bodies through mass awareness programme
	2.1 (iv)	Synthetic liner may be placed in the bottom, well in advance
	2.2 (iii)	At the immersion sites, burning of solid wastes, so generated comprising of used flowers, clothes, decorating materials, etc. should be prohibited
Guidelines for Idol Immersion, 2010	2.2 (iv)	Within 48 hours of the idols immersion, the left over material at idol immersion points on the banks of rivers, lakes, beaches, etc. should be collected by the local bodies for disposal
	2.2 (v)	After the completion of immersion, supernatant water may be allowed to flow in river, pond and lake, as the case may be, after checking for colour and turbidity. Lime may be added in temporary confined ponds
	2.3	Immersion of idols in lakes or ponds, all the flowers, leaves and artificial ornaments of idols should be removed and

		idols may be immersed into a corner of pond using removable synthetic liners in the bottom. Post immersion, liners may be taken out along with remains of idols and lime should be added to the pond water for settling the solids. Desludging of the pond should be undertaken afterwards
Plastic Waste Management Rules, 2016	4 (1a)	Manufacture, importer stocking, distribution, sale and use of carry bags, shall be subject to the condition that the carry bags and plastic packaging shall either be in natural shade which is without any added pigments or made using only those pigments and colourants which are in conformity with IS-9833:1981 titled as “List of pigments and colourants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water”
	4 (1c)	Carry bag made of virgin or recycled plastic, shall not be less than 50μ in thickness
	4 (1f)	Sachets using plastic material shall not be used for storing, packing or selling gutkha, tobacco and pan masala
	4 (1h)	Carry bags made from compostable plastics shall conform to the IS-17088:2008 titled as Specifications for Compostable Plastics
	5 (1b)	Plastic waste management by the urban local bodies in their respective jurisdiction shall be encourage the use of plastic waste (preferably the plastic waste which cannot be further recycled) for road construction as per Indian Road Congress guidelines or energy recovery or waste to oil etc.
	6 (2b)	Local body shall be responsible for ensuring that no damage is caused to the environment during plastic waste recycling
Plastic Waste Management Rules, 2016	6 (2e)	Create awareness among all stakeholders about their responsibilities in handling of plastic waste
	6 (2g)	Ensure that open burning of plastic waste does not take place
	8 (1a)	Waste generator shall to take steps to minimize generation of plastic waste and segregate plastic waste at source
	8 (1b)	Not to litter the plastic waste and ensure segregated storage of waste at source and handover segregated waste to urban local body
	14 (1)	Retailers or street vendors shall not sell or provide commodities to consumer in carry bags or plastic sheet or multilayered packaging
	14 (2)	Every retailers or street vendors selling or providing

		commodities in plastic carry bags or multilayered packaging, which are not manufactured or labelled or marked in accordance with these rules shall be liable to pay such fines as specified under the bye-laws of local bodies
Construction and Demolition Waste Management Rules, 2016	4 (1)	Every waste generator be responsible for collection, segregation of concrete, soil and others and storage of construction and demolition waste generated, as directed or notified by concerned local Authority in consonance with these rules
	4 (2)	Generator shall ensure that other waste (such as solid waste) does not get mixed with this waste and is stored and disposed separately
	4 (4)	Every waste generator shall keep the construction and demolition waste within the premise and ensure that there is no littering or deposition of construction and demolition waste so as to prevent obstruction to the drains
	6 (8)	Local Authorities duty to keep track of construction and demolition waste generation within its jurisdiction and establish a data base and update once in a year
	6 (10)	Create a sustained system of information, education and communication for construction and demolition waste through collaboration with expert institutions and civil societies and also disseminate through their own website
	8 (1)	State Pollution Control Board shall monitor the implementation of these rules by the concerned local bodies and the competent authorities, and the annual report shall be sent to the CPCB and the State Government for generating State level comprehensive data before the 31st July for each financial year
	11	The Bureau of Indian Standards and Indian Roads Congress shall be responsible for preparation of code of practices and standards for use of recycled materials and products of construction and demolition waste
	Shedule-1 (11a)	Provision of storm water drains to prevent stagnation of surface water in storage and processing area
	Schedule-III	Compliance criteria is 12 months for the formulation of policy by State Government and KSPCB should monitor once in 4 months
Solid Waste Management Rules, 2016	4 (1a)	Every waste generator shall segregate and store the waste generated by them in three separate streams namely bio-degradable, non-biodegradable and domestic hazardous wastes in suitable bins and handover segregated wastes to

		authorised waste collectors as per the direction by the local authorities
	4 (1c)	Generated construction and demolition waste should store separately, in his own premises and shall dispose off as per the C&D Waste Management Rules, 2016
	4 (2)	No waste generator shall throw, burn or burry the solid waste generated by him, on streets, open public spaces outside his premises or in the drain or water bodies
	4 (5)	Every street vendor shall keep suitable containers for storage of waste generated during the course of his activity and shall deposit such waste at vehicle as notified by the local body
	6 (1b)	Ministry of Urban Development shall coordinate with State Governments to formulate national policy and strategy on solid waste management including policy on waste to energy in consultation with stakeholders within 6 months from the date of notification of these rules
	6 (1d)	Ministry of Urban Development shall coordinate with State Governments to promote research and development in solid waste management sector and disseminate information to States and local bodies
	6 (1e)	Ministry of Urban Development shall coordinate with State Governments to undertake training and capacity building of local bodies and other stakeholders
	14 (a)	Central Pollution Control Board shall formulate the standards for ground water, ambient air, noise pollution, leachate in respect of all solid waste processing and disposal facilities
Solid Waste Management Rules, 2016	14 (f)	CPCB shall monitor through State Pollution Control Boards for the implementation of these rules by local bodies
	15 (g)	Local authorities should direct waste generators not to litter i.e throw or dispose of any waste or burn or burry waste on streets, open public spaces, drains, water bodies and to segregate the waste at source as prescribed under these rules and hand over the segregated waste to authorised waste collectors, who authorised by the local body
	15 (zg)	Local authorities should create public awareness through information, education and communication campaign and educate the waste generators on not to litter; minimise waste generation; reuse the waste to the extent possible; practice segregation of waste into bio–degradable, non-biodegradable, sanitary waste and domestic hazardous

		wastes at source; practice home composting, vermi-composting, bio-gas generation or community level composting; wrap securely used sanitary waste as and when generated in the pouches provided by the brand owners and place the same in the bin meant for non-biodegradable waste; storage of segregated waste at source in different bins; handover segregated waste to waste pickers, waste collectors, recyclers or waste collection agencies; and pay monthly user fee or charges to waste collectors authorised by the local body for sustainability of solid waste management

9.4.6. Conservation of Water bodies:

9.4.6.1. Formulation of lake rejuvenation policy

NLCP (National Lake Conservation Policy, 2008) guidelines published by the National River Conservation Directorate have been followed by States in India for lake conservation. The guidelines of NLCP and NWCP (National Wetland Conservation Plan) were supersede by the National Plan for Conservation of Aquatic Ecosystems (NPCA, 2016) guidelines. The KLCDA conservation plan has focused on the Urban lake conservation by considering the following gaps during the rejuvenation of BMA lakes.

a) ***Term Plan for Conservation***: Lakes have been selected for the rejuvenation based on invasion of pollutants; accordingly, all the BMA lakes have been identified for the rejuvenation by the custodians. But even after the rejuvenation, there is no improvement in the water quality of the water bodies. So during the DPR approval, it should be fixed to improve the water quality of the water body such as from Class-E to Class-D or Class-D to Class-B, etc. The conservation plan should ensure that the water quality after implementation of the project is restored to the criteria for Designated Best Use classification for Class-B waters. If the term plan is not fixed based on the water quality, there is no use of the lake rejuvenation.

b) ***Silt Trap and Screen barrier:*** The lake rejuvenation plan should also include the installation of silt or sediment trap and screen barrier. This trap is an embankment built across in the stream of lakes to trap the silt that flows through the urban rainfall runoff. The screen barrier will stop the entry of floating objects such as plastic, organic wastes, etc. into the lake.

c) ***Unscientific Desiltation***: Today, the de-siltation activity has become basic core-activity for the rejuvenation of water bodies in the DPR without considering the scientific inputs. According to NLCP, de-siltation processes have an impact on its flora and fauna and may lead to destruction of habitat for migratory birds. De-siltation component in the proposals must be supported by bathymetry of the lake as per the standard methodology and its planning and execution to be carried out scientifically under expert guidance. Therefore, the de-siltation activity should be considered under the rejuvenation plan and prevent the destruction of shallow characteristics of the lakes and avoid making it as the engineered swimming pool (Figure-9.4).

Figure-9.4. Unscientific desilation in lake

d) ***Absence of Aerators:*** Most of the water bodies have lost their biota due to the decrease in DO concentration as a result of anthropogenic activities. But during the rejuvenation of the water bodies, the plan to maintain the DO concentration has not been considered. The negligence has come to light, when the fish kill were observed in the rejuvenated lakes. Therefore the aeration should also be considered as the core rejuvenation activities and action should be taken to install the aerators and fountains powered by wind or by solar.

e) ***No Management Plan for Constructed Wetlands***: The purpose of artificial wetland construction in the water bodies is to absorb the inflow of pollutants through the hydrophytes. As there is no data on the pollutant absorption rate by the native species of hydrophytes, the wetlands are constructed as default in the rejuvenated lakes without considering the inflow rate of pollutants. Due to the improper planning of the constructed wetland by size, density and species; the wetlands have lost its credibility. Small floating wetlands have been tried in few lakes, which are worth considering. The artificial constructed wetlands should be planned based on the quantity and velocity of sewage inflow.

f) ***Bio-strengthening of Bund***: Presently, the BMA lake bunds are strengthened by stone pitching under the rejuvenation process. In many lakes, these stone pitching falls down during the monsoon season due to the rainfall runoff. Stone pitching for strengthening inner side of lakes bund has reduced the biodiversity in lakes and also reduces the capability of self-rejuvenation process. Therefore, the engineered strengthening using stone pitching on the inner side of the lake bunds should be discouraged and the bio-strengthening using the native shrubs and herbs should be encouraged. Bio-strengthening of bund may take the time to generate over the bund, but the roots of plants on the bund will hold the bund sands, and will also result in the reduction of siltation.

g) ***Best Management Practices (BMP)*:** KLCDA should declare the BMP for different core activities and also for the non-core activities of the rejuvenation process. The declared BMP will be standardised base for the rejuvenation activity which can be used to improve the quality of rejuvenation as well as conservation of water bodies.

9.4.6.2. Storm Water Drain Rejuvenation:

The drains of the water bodies have not been considered during the lake rejuvenation. Encroachment and diversion of drains of the water bodies are common in BMA and the existing drains also carry the sewage rather than the storm water. The storm water drains are like veins, which feed (bring) water to the water bodies. Hence the encroachment on the drains should be evicted and the disused drains should be renovated to bring the water to the water bodies. Further, inflow of sewage into the drain should be stopped by the Order-wise drain survey. The controlled sewage flow can be treated in storm water drain using the bioremediation process or by using the soil mixed steel wool method or using the advanced techniques of bio and nano-technologies. Upstream and downstream drains should also be considered as core activity during the lake rejuvenation.

9.4.6.3. Lake Series Rejuvenation:

BMA water bodies are degraded due to many factors and all the water bodies have not been considered for the rejuvenation due to available limited resources. Due to the selection of random lakes for the rejuvenation based on the size and encroachment, it has resulted in failure to prevent the inflow of liquid waste (sewage). Further, the sewage, which has been diverted to protect the rejuvenated lake has resulted in polluting the downstream water bodies. Therefore, rather than selecting the random lakes based on the size, the series of lakes should be considered to include the storm water drain for the rejuvenation to prevent the pollution of downstream water bodies. The priority of the lake for rejuvenation should also be based on the need such as rejuvenating for biodiversity park or avifaunal park or lake location i.e. in the flash flood prone areas. According to the NLCP, the State Government/ local bodies should revise the lake priority list at an interval of 5 years. The lake selection criteria for rejuvenation has been formulated under NLCP based on the hydrological criteria such as size of the lake and water retention period; scientific criteria such as solid and liquid waste in lake, etc.

9.4.6.4. Monitoring of rejuvenation activities:

As there is no monitoring on the water bodies rejuvenation activities, the activities approved in DPR have been changed during the rejuvenation. The same has been reported to the Hon'ble High Court of Karnataka (KLCDA, 2016) and even CAG report (2015) also mentioned that more budget has been spent for the non-core activities such as beautification of lakes. Therefore, the monitoring committee should be formulated by KLCDA comprising of different stakeholder such as custodian, stakeholder, RWA (if any), officers and subject experts during the approval of DPR to monitor the lake rejuvenation activities.

9.4.6.5. Community Participation:

Water bodies have been rejuvenated to conserve them for a long period but due to lack of resources, the custodians are unable to conserve the water bodies. Therefore, the cooperation of people should be taken to conserve the urban water bodies through the community participation. Now a day, due to the awareness created by the local bodies and the Government, volunteers are coming forward to maintain the water bodies. RWA, NGO, corporates under CSR (Corporate Social Responsibility) are already involved in the management of few BMA water bodies. This should be encouraged to minimize the burden on the local bodies as well as on KLCDA.

i. **Annual Monitoring Report:**

As NGO, Corporate, RWA are involved in the management or to conserve the BMA lakes that have not been monitored by custodian or KLCDA. Alternatively, rather than monitoring the community participants for the activities taken to conserve the water bodies, they can be asked to submit an annual monitoring report to KLCDA through the custodian. Other option is to formulate the monitoring Committee for the monitoring of the community participation in the maintenance of the water bodies. Community participants or the monitoring committee should submit annual monitoring report to custodian as well as KLCDA that will include the present status of lakes, impact of various activities, etc.

9.4.7. Use the Water bodies:

History of Bengaluru water bodies have revealed that the lakes have been polluted due to the introduction of piped drinking water supply system. When the direct use of the water bodies is minimized by the local people, it has resulted in water bodies degradation due to negligence. The three best ways to use the existing water bodies in Bengaluru are elaborately discussed below.

i. **Water Security Plan (WSP):**

The objective of the WSP is to ensure that surface and groundwater resource are conserved, protected, enhanced and managed to meet the demands of population and environment. Due to the climate change, the Bengaluru City has been receiving surplus short intensity rainfall which resulted in the flash flood and reduction in rainfall frequency has resulted in water scarcity by dramatic reduction in groundwater level. The importance of the WSP should be estimated based on the estimated groundwater exploitation and water footprints in the lake catchment area (Micro-watershed) or the down-scaling should be done for the BMA based on the published report. The WSP for BMA will ensure the quantity of water to be conserved in the water bodies to maintain the micro-climate, as well as to maintain the groundwater quantity to meet the population demand.

ii. Water Management Plan (WMP):

WMP is the method of utilization of freshwater and recycled water in a sustainable manner to maintain the water balance within a specific area or water shed level. The concept of WMP can be applied to the layouts as an "Eco-smart layout", which includes proper utilization of water, using renewable energy and thereby maintaining the ecosystem in a sustainable manner. The objective of the WMP is to reuse the wastewater after treatment to address issues of water scarcity, and surplus water to be diverted to the lakes. This whole process involves studies on population projection, water demand, solid waste and sewage generation. The concept suggested by EMPRI (2013) was to ensure the network of underground drainage (UGD) in the entire layout with strategic location of STP. Dual water supply system in the layout will facilitate the recycled water usage for secondary purposes and establish the rainwater harvesting structures for water management in the layout area.

iii. Augment for Supply of Drinking Water:

Demand for drinking water in the Bengaluru city is increasing due to population density. Therefore the identification of the source/ new schemes for the augmentation of drinking water supply for the Bengaluru City should be done by the local bodies. One of the available surface sources in the BMA is the 24 existing biggest lakes (extent above 100 acres), which can be earmarked to store the water during the monsoon season to supply water for atleast 3-6 months during the water scarcity period after the water treatment process.

iv. Pisciculture:

Breeding, rearing and transplantation of fishes by the artificial means is called pisciculture or fish farming. Karnataka Fisheries Department is the nodal agency for leasing the tanks or freshwater bodies for the pisciculture activities, therefore the fisheries Department should help KLCDA to identify the lakes for the standardised pisciculture activity. Pisciculture in the BMA water bodies will increase the socio-economy of the lake. Additionally, aquaponics as the advanced technology should be promoted and facilitated by the fisheries department to manage the waste generated by fish will be utilised and cleaned by the hydroponics (cultivated plants in water) as the symbiotic process.

9.4.8. Monitoring and Management of Water bodies:

Rejuvenated lakes should be monitored and managed as a part of water bodies conservation. Authorities and custodian of the water bodies have taken many initiatives to monitor and manage the water bodies, its drain and to preserve the water quality within standards prescribed by BIS. But still there are gaps in the monitoring and management of water bodies in BMA with the custodians are follows:

9.4.8.1. Lake Warden:

KLCDA Act envisages to encourage the community participation and voluntary agencies for the protection of lake and conservation through the nominated persons or groups called as 'Lake Warden" (GO. No. FEE 99 ENV 2016 dated: 19.05.2016). The appointed lake warden or chief lake warden for the biggest lakes have the duty to protect, conserve the water bodies, which has been assigned to them. There is no monitoring mechanism to monitor the work efficiency of the lake warden and even the custodian is also not sure that the appointment of lake warden has improved the water quality. Therefore the pre-formulated quarterly report format should be prepared by KLCDA, which should be filled by the lake warden and submitted to custodian. Custodian of the water bodies should compile it and submit it as an annual report to the KLCDA to know the improvement of water bodies status in BMA.

9.4.8.2. Weed Management:

Weed management in the eutrophic water bodies are important in the present situation. Weed management can be done by two approaches namely preventive and control approaches (Lidia Lancer and Kevin Krake, 2002).

A. Preventive Approach:

Preventive measure is also a safety measure, which is better than the weed control. Two techniques that are used in the preventive approach are quarantine and physical barrier.

i. ***Quarantine***: It is restriction imposed by duly constituted Authorities to regulate the movement of plants, plant products that spread as weed may be prevented or restricted. As quarantine are legislative tools that are used to mitigate the weed transmission from one area to other area.

ii. Physical Barrier: Boom barrier (Figure-9.6) is a temporary floating barrier used to prevent the spread of weeds to the other areas of the water bodies or other water bodies. Floating weed and debris will be collected within the boom, which will be easily cleaned from the water bodies.

Figure-9.6. Physical boom barrier used to prevent the weed spread
Source: https://www.elastec.com/wp-content/uploads/2016/11/gallery-permafence-aquatic-plant-control-boom.jpg

B. Weed Control Approach:

Weeds are brought under control to manageable limit to avoid the economic loss and the impact on aesthetic value of water bodies. Approach for the weed control in and around the water bodies are generally called weeding. The removal and eradication of weeds from the desired (water bodies) area with minimum damage to the preferred plants is weed control. The four techniques used in the control of weed are physical (include manual and mechanical), chemical, biological and physiological weeding. As each weeding process has its own advantage and disadvantages, the appropriate weeding technique should be used for removal and eradication of the weeds in and around the water bodies.

i. Physical Weed Control:

The two types of weed control are in the practice of the physical weed control are manual and mechanical weed control. The major disadvantage of the physical weed control is that roots falls in the aquatic habitat, they become colonized and the decomposed plant parts in the aquatic system may deplete the dissolved oxygen in the water, which impact on the other biota. About 30-40% of aquatic weeds should be maintained in the sewage influx lakes to absorb the excess nutrients and heavy metals through bio-absorption process.

a) ***Manual Weed Control***: Techniques like removing, cutting, mowing, raking, digging and pulling are used to remove the isolated weeds such as cattails, sedge and grasses in the shore of the water bodies. Presently, the manual weed control is the only option to clear the weeds from the water bodies in BMA. The weed cleaners are using the coracle to collect the aquatic (floating) weeds and backhoe loaders to destruct the aquatic bank weeds. Even though the manual weed control is effective, the limitations such as labour non-availability, time-consuming and budget giving for progress as tedious. In the large BMA lakes, the manual weed control will not be effective and it should be discouraged. Even the drawdown of water from the weed infested water bodies should be discouraged.

b) ***Mechanical Weed Control***: Manual removal of weeds is practical only for the small quantities of weeds near the shore or in the small water bodies. But in the present scenario of BMA, weed infestation and growth is due to the inflow of sewage and these weeds can be controlled by use of the technology like machines. Mechanical weed control is time consuming but the capital cost will be more. The most advance technology used in the mechanical weed control is Special Purpose Vehicle (SPV) such as amphibian machine (Figure-9.7), Doro cutter, reed rake, etc. will also combined with the de-siltation such as Doro digger has been marketed by the Matprop Technical Services Pvt. Ltd., Earthen Cube, Kochi, Kerala. It is worth investing in SPV to control the weed and manage the water bodies in effective manner.

Figure-9.7. Special purpose vehicle for weed control

ii. Chemical Weed Control:

Chemical weeding is done by the use of herbicides, which is most effective and time-efficient method but it also has adverse effect on other biota of the water bodies i.e. amphibians, insects, fish, etc. Chelated copper compounds, copper sulfate, diquat, endothall, fluridone, glyphosate, simazine and 2,4-D are the common chemical herbicides are used commercially worldwide (Lidia Lancer and Kevin Krake, 2002). All these chemicals are toxic to the other biota in the habitat, particularly fishes. Therefore chemical weeding should be avoided in the water body and its vicinity.

iii. Biological Weed Control:

The herbicide cost and its effect on the surrounding plants have led the way for the development of biological controls, which are the use of natural enemies such as the predators, pathogens and parasites to control the weeds. Biological weed control was used in Bellandur tank during the year 1983-84 by the Commonwealth Institute of Biological Control (CIBC) with the Indian Institute of Horticultural Research (IIHR). The Exotic weevil (*Cyrtobagous salviniae*) was released for the control of water fern (*Salvinia molesta*). Within 11 months of the release of the weevil in the tank, the salvinia plants collapsed and the lily growth reduced. About 25,000 water hyacinth mite (*Orthogalumna terebrantis*) were released in Agram, Kengeri and Byramangala tanks to confines the water hyacinth were initiated in 1986 and substantial clearance of water body was observed after 2 years. According to Van Dyke *et al*. (1984), herbivorous grass carp fish is effective for controlling hydrilla.

The biological control of weeds has been working well only on one type of the weeds and resulting in the reduction of one weed but other weed is dominating. Further, the time taken to control the weeds are more and the cost behind the biological control is also more but the biological control may be a permanent solution to control the aquatic weeds. As for as the long term measures are considered, the biological control of weeds in water bodies can be encouraged.

9.5.8.3. Regular Water Quality Analysis:

There are 395 lakes in the BMA, within that only 65 lakes have been monitored monthly by the KSPCB i.e. 16.5% of water bodies. Remaining 331 lakes should also be monitored for the water quality by the KLCDA. Further, the water samples from the inlet and outlet of lake are only collected for the analysis, which won't be reflecting the entire lake water quality. There are three zones (Figure-9.8) in the lakes viz…riverine zone (inlet), transitional zone (center of lake) and lacustrine zone (outlet), which is diverged in the distribution of biota as well as the concentration of nutrients and pollution (Chapman 1996). Therefore, three water samples per lake should be collected and analysed to know the exact water quality of the lake.

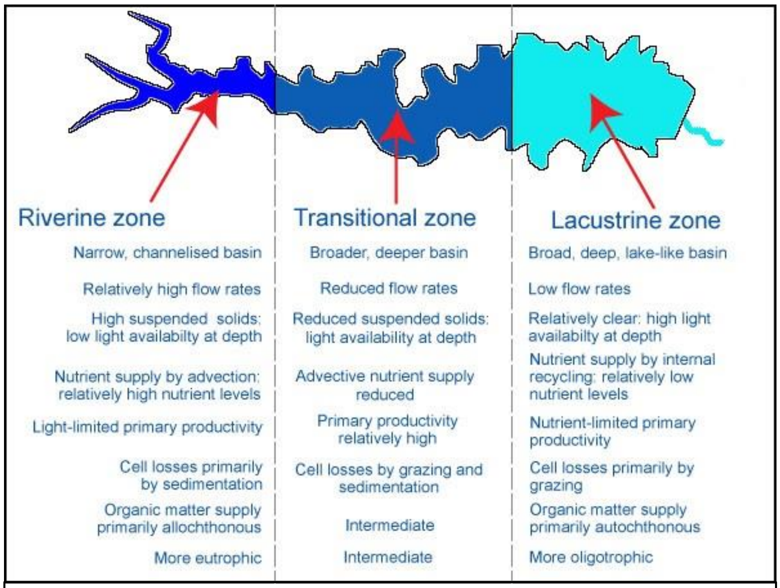

Figure-9.8. Zones of lake

The major challenge in water sample collection is collection of water sample from the transitional zone (center of lake). Presently, there was no provision to collect the water samples from the center of lake, but in few lakes the coracles used for fishing can be utilised for the sample collection. Therefore, it is recommend to KLCDA or KSPCB or the custodians to procure the Boat/ coracle for collection of water sampling. Broadly, two types of boats are used in the freshwater sampling (a) inflatable boat (Figure-9.9) made with rubber and inflated with air; the toughest rubber base will be suitable for the BMA lakes environmental condition, cost effective and this boat is also easy to transport. (b) Unmanned Surface water Vehicle (USV) is an autonomous water sampling boat (Figure-

9.10), which is costlier and needs carrier to transport boat from one lake to other and will be suitable only for weed free water bodies.

Figure-9.9. Inflatable boat that can be used for lake water sampling

Figure-9.10. unmanned surface water vehicle used for automated water sampling in lake

Drone sampler (Figure-9.11) or Unmanned Aircraft System (UAS) is the advanced technology used for the water sample collection, which will also use to monitor the biggest lakes through videography. Drones have the sensors to analyse the basic field parameters and it will collect the water samples through vials. The limitation of the drone is that the technology is eminent only in the developed countries and the advantage is that it is easy to collect the water samples by controlling from office itself and it is cost effective. Further, the drones are also used to monitor the lake habitat such as the roosting area of birds in island. As Bengaluru is the IT capital of India, the use of drone for the group of lakes will be the cheapest mode of monitoring and water sample collection tool for KLCDA or KSPCB.

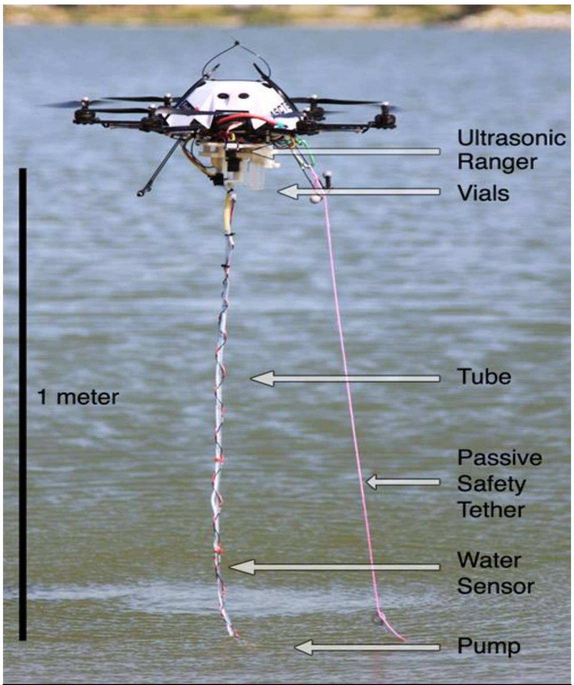

Figure-9.11. Drone water sampler

As most of the water bodies have sewage inflow in the BMA, the inflow and outflow measurements of lake waters (dry weather as priority) should also be included in the water quality analysis parameters. The result of the inflow water quantity and quality has shown direct impact on the water quality of lakes, particularly riverine zone. Apart from recording the inflow and outflow of lake water, the lake water level should also be recorded for the biggest BMA lakes on daily basis.

KSPCB has been annually publishing the water quality result for 65 BMA lakes, which revealed that the water quality of each lakes has been degrading continuously. These water quality results are used only for documentation rather than planning and implementing of actions to conserve the water bodies. Therefore the KSPCB as well as KLCDA formulate the *action plan to improve the water quality* step by step i.e. to improve the water quality from Class-E to Class-D or hyper-eutrophic condition to mesotrophic condition or highly polluted to moderately polluted based on the degree of pollution within the prescribed time period.

9.4.9. Research Studies to be undertaken:

Each and every water body is unique in its biota. All the water bodies in the BMA are artificial, located above 500msl elevation in the tropical climate condition. Some of the gaps in research are identified during the study period are discussed as follows;

9.4.9.1. Baseline Study:

The condition or present status of the BMA water bodies are inventorised by EMPRI in this study, but still there is gap in the baseline studies such as no bathymetric maps for the BMA lakes. Only the bathymetric maps are generated during the DPR preparation for the rejuvenation but the bathymetric maps should be prepared for the biggest lakes. The scientific methodology was not followed to generate bathymetric map for the lakes during rejuvenation also, therefore the Trapezoidal Rule, Simpson's Rule (Figure-9.12), and Simpson's 3/8 Rule should be used to generate bathymetric map for lakes (Ramachandra *et al*., 2002). The exact water holding capacity of the lakes can be calculated by the generation of bathymetric maps.

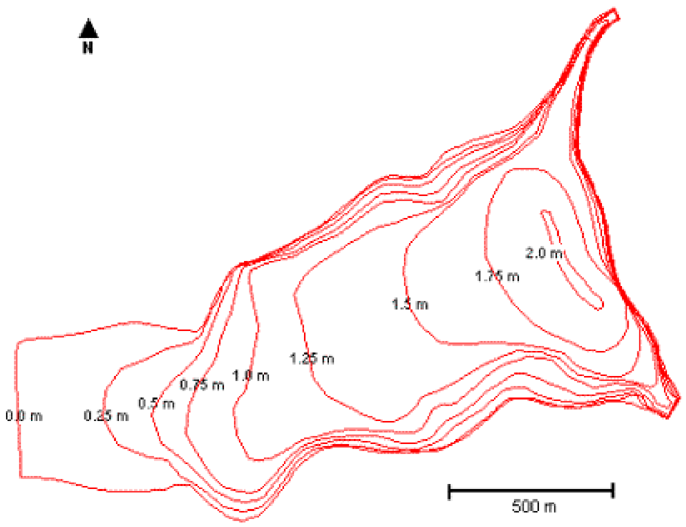

Figure-9.12. Bathymetric map of Varthur lake

9.4.9.2. Water Infiltration Rate:

The amount of water that seeps into soil during the rain is called as infiltration and whereas, the velocity of water infiltrated into soil depth is known as the infiltration rate. Infiltrated water will recharge the groundwater. The infiltration rate is influenced by the soil texture and structure. Water infiltration rate for the soil is available but the impact of soil structure on infiltration rate is unknown in the BMA. Therefore the research study on infiltration rate of water in the micro-catchment area can be taken up, which will be used to maintain the micro-climate and water stress, based on the water holding capacity of the water bodies.

9.4.9.3. Water Balance:

Water balance or budget is used to describe the flow of water in and out of lake in two states such as liquid and gas. Water temperature, vegetation and wind are the three factors, which commonly influence the water balance. Water balance of the lake is estimated by calculating the loss of water through the evapotranspiration and infiltration that is saturated by inflow of fresh water and treated wastewater. Therefore the study on lake water balance can be initiated to estimate the total inflow and total outflow of water.

Apart from the water balance study, the water sustainable plan may also be prepared for BMA with segregation of macro-watershed area. Account of all the water that flows in and out of the specific area i.e. BMA is called as 'Water Sustainability Plan'. Water sustainability plan has been calculated based on the water availability and use water as footprints (Hoekstra *et al*., 2011), which include green (gaseous water), blue (surface and groundwater) and grey water (reuse of sewage). The study on water sustainability plan would help the custodian, KLCDA as well as the local bodies to maintain the water balance in the BMA water bodies.

9.4.9.4. Socio-Economic Study:

The study of relationship between the economics of the water bodies and the social behavior of the neighborhood is called socioeconomics study. Even in present scenario as sewage influx to lake, there are direct and indirect dependence on water bodies for their livelihood. If the socio-economic study of each and every water bodies is done to know the economic value of the water bodies, then it would help decision-making during the rejuvenation process. In most of the studies, the contingency value technique (Ramachandra *et al*., 2011) has been used through Participatory Monitoring and Evaluation (PM&E) method (Chandrashekar *et al*., 2011). The study with historical water quality data can also be used to identify the causes for depreciation of lake economic values.

9.4.9.5. Identify the Regional Bio-Indicators:

The quality of water bodies has also been monitored by assessment of the biota in and vicinity of the water bodies, which is also called as 'Bio-monitoring Technique'. The species used to monitor the water quality or impact of pollution or any impact assessment is called as 'Bio-indicator', which is used for the rapid assessment of water bodies when compared to water quality analysis report. Some of the bio-indicators used worldwide to assess the water quality or pollution level are snails (benthos), fishes, density of hydrophytes, algae, water strider (aquatic insect), mayflies (aerial insect), ants (terrestrial insect) and even aquatic birds. Palmer's Algal Index is one of the statistical methods used to measure the degree of water quality pollution by organic concentration based on the presence of certain planktons. There are few species, which quietly respond to the water quality pollution that should be identified for the BMA water bodies.

9.4.9.6. Catchment Area Plan:

Catchment area is the demarcated area of the water bodies for the source of water through rainfall, which has been collected as runoff through slope in the water bodies. Silt Yield Index (SYI) and Pollution Yield Index (PYI) are the tools used to estimate the pollution load of the water bodies in the catchment area. Therefore well-designed Catchment Area Treatment Plan (CATP) as management technique is essential to mitigate the adverse effects of soil erosion. CATP should be prepared by KLCDA or the local bodies in macro-watershed level with the help of water shed Department and the same should be reflected in the CDP (Comprehensive Development Plan) of the planning Authority. Whenever CDP revise, the CATP should also revise in order to manage and conserve the water bodies based on the present situation.

9.4.9.7. Lake Sediment Analysis:

Most of the pollutants in the water bodies get accumulated in the bottom as sediment due to its higher molecular weights. Most of the heavy metals which come to the water bodies gets settled in the sediment due to its molecular weight and even major concentration of the nutrients such as sulphate, potassium, silicate, phosphate, etc. are accumulated in the sediment. Therefore, the pollutant is concentrated in the sediment. Pollution of lake sediment will be exposed during the eutrophication process only. So the sediment of water bodies should be analysed at least annually to prepare base data on heavy metals accumulation in the BMA lakes. Further, the denitrification process should also be employed for the breakdown and the accumulated complex nutrients or pollutants in lake sediments.

9.4.9.8. Cost-effective real time monitoring:

Real time monitoring of the water quality has to be done as per the direction of MoEF&CC for the outflow of treated water. But the cost of sensors and utilities used for monitoring are very high, hence there is need to use the cost-effective sensors and utensils. Recently the Intel has collaborated with the DST (Department of Science and Technology) to develop the cost-effective water quality analysis sensor by stabilization of the parameters with the floating buoy and power backup through the green energy. To initiate the same for the BMA water bodies, the KLCDA or local Authorities or KSPCB can fund to any research organization to bring out the cheapest real time monitoring of water quality.

9.4.10. Relational Database on Water bodies:

The basic database on the water bodies of BMA generated by CLC, EMPRI should be upgraded to know the current status of the lakes through the establishment of Database Management Cell (DMC). The database may be web linked and shared between the Authorities for the day-to-day updating the status of the water bodies. Relational Database Management System (RDBMS) is used to share the water body information with the custodian, stakeholder and with the restricted access for the public. Further, the ICT (Information and Communication Technology) can also be employed to maintain the complaint records, rejuvenation funds, community participation for the water body rejuvenation, etc.

9.4.10.1. Bridge the Gaps in Database:

There are gaps in the BMA water bodies database, such as the absence of historical data about the BMA water bodies, details of rejuvenation process with budget breakup, period of custodian, metrological data and flash flood prone area water bodies. The gaps in the BMA water bodies database can also be filled based on the paleo-limnological study, socio-economic development based on the green economy from the traditional usage of water bodies.

i. ***Lake History***: The history of lakes in the BMA throws light on the purpose, origin and creation of the water bodies. Most of the water bodies in BMA have cultural values that have been integrated with the traditional maintenance of water bodies. Historically well-known lake in Bengaluru city is Sampangie lake, which is known for Karaga for the community *Vannhikula Kshatriyas*. Therefore the history of lakes will be useful for future generation to know the importance of water bodies in the BMA.

ii. ***Rejuvenation*** is the method employed to bring back the disturbed or degraded lakes to normalcy. Accordingly, most of the lakes in the BMA are rejuvenated by fencing or strengthening of bunds or sewage diverting. The data on rejuvenation (core and non-core) activity were not available with the other Authority for decision making on the degradation of lake. Hence, compiling the data such as why the lake was rejuvenated, who rejuvenated, which year, who prepared the DPR, who is contractor, what are the rejuvenation activities done, budget breakup, etc. should be done.

iii. ***Meteorological Data*****:** As surface water bodies are impacted by the meteorological changes such as ambient temperature, relative humidity, pan evaporation and rainfall; which helps in estimating the water quantity in the water bodies. Therefore, the metrological data from the KSNDMC (Karnataka State Natural Disaster Monitoring Centre) should be included in the data base of KLCDA and upgraded every year.

iv. ***Flood Prone Area***: Urban flash floods are occurring in Bengaluru due high intensity rainfall, increase of build-up area, encroachment on drains and water bodies, etc. KSNDMC has demarcated 174 low lying areas in Bengaluru (Figure-9.13) as the flood prone area (http://www.Bengaluruvarunamitra.info/Default/Index?service=Vulnerable Spots). BWSSB and BBMP have involved in the cleaning of drains and constructing the flood safety walls to mitigate the impact of the flash floods in the City. Based on these data, KLCDA may identify the water bodies in the flood prone area and preserve it to collect the flood water. The importance of the water bodies in flash floods prone area should be informed to the community through the mass awareness programme.

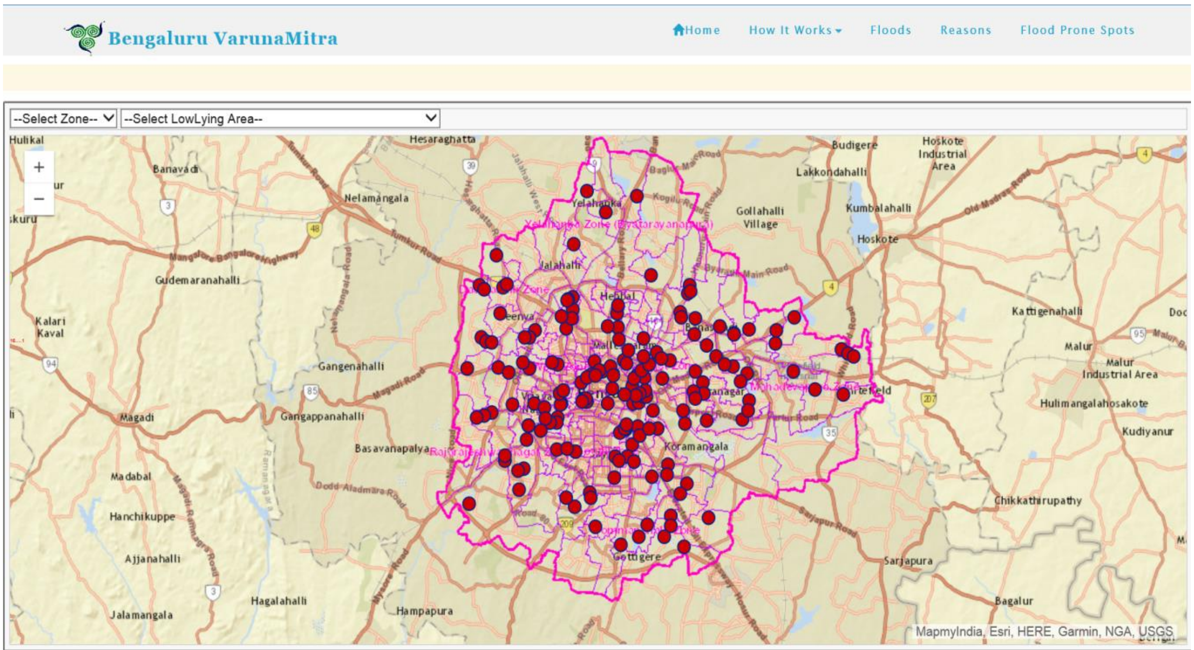

Figure-9.13. Flash flood prone areas in Bengaluru (***Source***: KSNDMC, Bengaluru VarunaMitra)

9.4.10.2. Mobile Application:

Mobile applications are mostly to provide the users as app., which is the type of application software designed to run on a mobile device, particularly on smart phones. Presently, the survey data are collected from the field and entered into the database manually that may result in manual errors. In order to control these manual errors, Survey 123 (Figure-9.14) for ArcGIS application has been altered by GIS Team of EMPRI for the usage in BMA to capture the digital data such as GPS location, details of water bodies, geo-tagged photos, etc. in smart forms. Survey 123 for ArcGIS is a data gathering app. in digital format for creating, sharing and analyzing surveys in near real time basis.

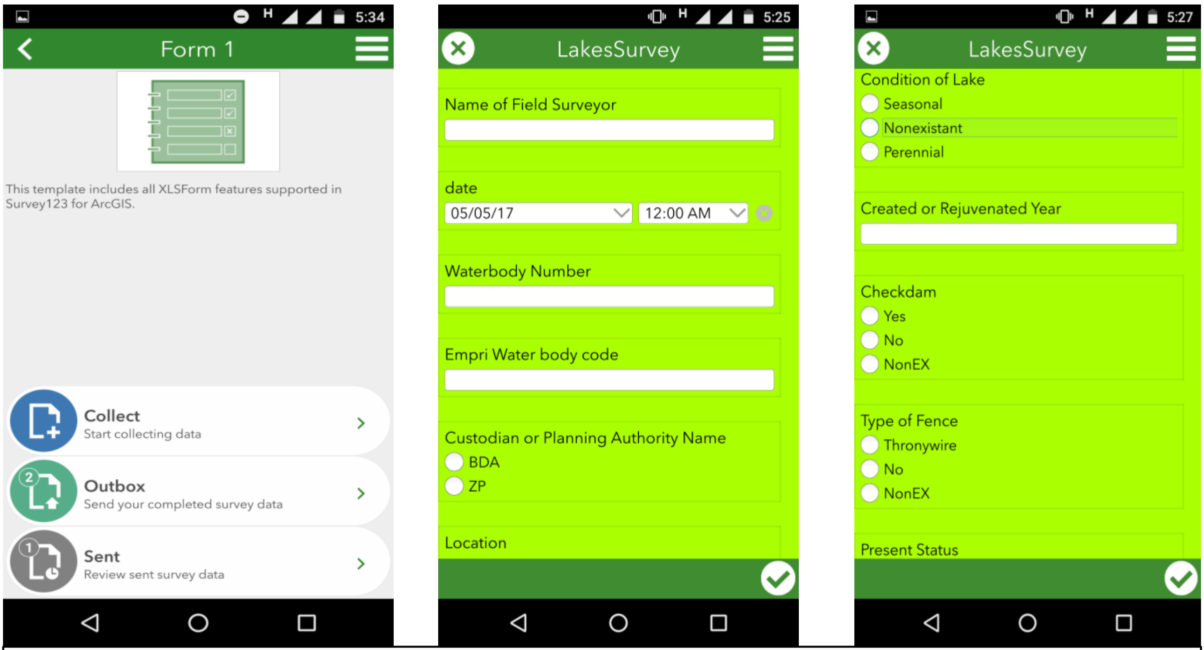

Figure-9.14. Survey 123 for ArcGIS application modified by GIS team of EMPRI for lake survey

9.4.11. Awareness:

Awareness about the importance of lake conservation should be given to public and school children.

9.4.11.1. Climate Change:

Degradation of the water bodies has resulted in the change in the microclimate of the specific region or zone or area. Microclimate has been controlled by the temperature and humidity, which can be monitored by the small weather stations maintained by the KSNDMC. Flash floods and temperature rise in the summer season are common in Bengaluru City due to changes in the climate, which is directly interrelated with the disuse of water bodies. Therefore, the awareness about the climate changes which are interrelated with degradation of the water bodies should be disseminated to the local people, so that they participate in the conservation of existing water bodies. The combination of the micro-climate of the Bengaluru City is reflected as the urban climate of Bengaluru, so the zone or area wise awareness initiative on climate change will help to improve the climate of entire Bengaluru City. Moreover there is fund allotted under the climate change adaptation for water sectors, small part of the fund can be requested by KLCDA to improve the climate of BMA by the bio-conservation of water bodies.

9.4.11.2. *Kere Habba*:

One of the mass awareness programme to deliver the importance of the water bodies is to conduct the festival in the water bodies area. NGO's involved in the maintenance of the Bengaluru lakes have been annually conducting the festival or *Habba* in lakes under their maintenance to generate awareness within the local people and stakeholder. KLCDA may conduct the *Kere Habba* to generate mass awareness on the occasion of Nada Prabhu Kempe Gowda's birthday and the day should also be declared as "Lake Conservation Day" (*Kere Samrakshana Dina*). Kere Habba should be conducted by KLCDA or custodian by involving people to bring awareness. Further, the schools and Pre-university/Degree colleges located near the water bodies should be roped in to involve students for organising lake cleaning camps (*Kere Swatchata Shibira*) to bring awareness on the importance of lakes and its biodiversity, to implement tree planting and cleanliness program in the lake surrounding areas. Further, the ecotourism on BMA water bodies should be promoted to generate awareness about cleanliness of the water bodies and the conservation strength of the local bodies or custodian.

9.4.11.4. Legal Actions:

The legal actions taken on the encroachers and polluters of the BMA water bodies should be showcased or displayed in the crowded area for the public to know that the KLCDA has taken action against violators.

9.4.12. Training:

There is huge knowledge gap within the officials of water body custodian as well as maintenance Agencies such as NGO, RWA and corporates about the conservation of the BMA water bodies. Therefore, the Government officials should be trained on monitoring through bio-indicators, preparation of lake status report, correlating the water analysis results and in improving of the water quality (from Class-E to Class-D or from Class-D to Class-C).

Similarly, the lake warden, NGO, RWA and corporates should also be trained to monitor the lakes using the bio-indicators, to whom to contact during the emergency, preparation of lake status report, identify the harmful weeds, usage of water, prohibited by Acts in lake premises to conserve and maintain the BMA water bodies.

9.5. Strategy Review:

Water bodies are degrading day-by-day due to the different anthropogenic activity in urban scenario. The degrading factors may change over time, and new ones may take their place due to rapid urbanisation or any other factors. Changes in economy, technology, resource availability and norms arising from jurisprudence to set forth an immutable conservation strategy in this dynamic situation would be unwise. A prudent course would be to provide for updating every few years in light of new knowledge and developments, and a comprehensive review in about a decade. The following provisions are made for review, updating and renewal of the conservation strategy:

a. Undertake consultations every five years with groups of diverse stakeholders, i.e. researchers and experts, custodian, community based organizations and voluntary organizations to update the conservation strategy.

b. Undertake a more comprehensive examination of the scientific and policy understanding of degrading issues, redefine the objectives and principles, and recast the strategic themes for action. A new conservation strategy should be the outcome.

9.6. Review of Implementation:

Any strategy or policy is only as good as its implementation. Periodic high level review should be conducted by KLCDA once a year to monitor the implementation of conservation strategies or action plans to protect the water bodies from the pollutant, within three months from the close of the previous fiscal year (NEP, 2006). The findings of the review should be put in public for display.

9.7. Conclusion:

During this study, it was found that the 837 water bodies (102 lakes) are disused due to rapid urbanization. Out of the existing 684 water bodies, 332 water bodies are encroached (needs verification from Revenue Department), 89 lakes are dried, 261 lakes are polluted as per the water quality analysis and 303 water bodies have the solid waste dumped in it. The impact of the degradation factors on the water bodies has resulted in foaming, fire on lake, weed infestation, reduction in the density of biota, change in microclimate and even contamination of groundwater. There is an urgent need to conserve and protect the water bodies from degrading factors through the implementation of the conservation strategies. Based on the study experience, stakeholder and community suggestion, and experts opinion the following strategies are formulated to conserve the BMA water bodies.

1. Decision on **inter-jurisdiction lakes** custodian.
2. **Notification of water bodies** (lake as priority) and its stream to preserve it.
3. **Official communication to the Authorities** about custodian of water bodies. In future, segregate three types of custodian based on their work of conservation, gazette the lake custodian and confirm the takeover of the lakes by custodian.
4. **Protection of water bodies land** and its drain through the recovery of water body land by eviction of encroachment and compensation as money or land, and establish two-layer fence.
5. **Protect water bodies from pollution**
   a. *Prevention of wastewater inflow* by diverting (if no other option), commissioning of UGD and STP, reuse the treated wastewater or ensure treated wastewater only flows

into water bodies passing through wetland. Monitor the lakes through the real-time water quality monitoring moor buoy and regulate or ban the use of phosphate in the detergents.

b. *Prevent solid waste dumping* such as domestic garbage through community participation; Construction and Demolition waste (C&D) by pre-allotted dump yard, agriculture waste through awareness and industrial waste include plastic through implementation of institutional frameworks.

6. **Conservation of water bodies** through rejuvenation by Authorities by means of considering the conservation plan, scientific desiltation, installation of aerators to maintain DO, management of constructed wetland, bio-strengthening of bund and declaring Best Management Practice (BMP) for rejuvenation process.
   a. *Consider the lake series rejuvenation* and storm water drains rejuvenation during lake rejuvenation.
   b. *Monitoring of rejuvenation* activities by KLCDA.
   c. *Community participation* for maintenance of rejuvenated lakes and submits annual monitoring report to KLCDA through custodian.
7. **Use the water bodies** for Water Security Plan (WSP), Water Management Plan (WMP), to augment for drinking water supply and pisciculture through aquaponics.
8. **Monitoring and management of water bodies** through lake warden, who should submit pre-formulated quarterly report to KLCDA through custodian.
   a. ***Weed management*** by preventive approach using physical boom barrier, control by mechanical weed control and eradicate by biological control.
   b. ***Regular water quality analysis*** should be initiated for all BMA lakes and rubber boat or drone sampler should be used for better water sampling. Formulate the action plan to improve the water quality of BMA lakes.
9. **Research studies to be undertaken** for baseline study of lake bathymetric maps, water infiltration rates, water balance with the water sustainable plan, socio-economic study on lakes, identify the lake bio-indicators for rapid assessment, Catchment area Action Plan (CAP), annual analysis of lake sediment and develop cost-effective real time monitoring equipment.
10. **Relational Database Management System (RDBMS)** for sharing and upgrading of the BMA water bodies data with stakeholder and public.
   a. *Bridge the gaps* in database such as lake history, rejuvenation activity with budget allocation, custodian of lakes for specific period, meteorological data and flood prone area water bodies.
   b. *Mobile Application* usage to document the pollution in lakes.

11. **Awareness** on importance and conservation of water bodies should be disseminate in schools, celebrate *Kere Habba* (*Kere Samrakshana Dina*) on the occasion of Nada Prabhu Kempe Gowda's birthday, organise lake cleaning camp (*Kere Swatchata Shibira*) perception to microclimate and actions taken on encroachers and polluters should be showcased through banners for public.
12. **Training** of officials, custodians, stakeholder for conserve water bodies and preparation of lake monitoring reports.

Conservation strategy should be reviewed periodically by KLCDA with stakeholder and the same should be replicated in the CDP and implemented on-ground for the conservation of the BMA water bodies. KLCDA should implement the conservation strategies through the custodian such as BBMP, BDA, Karnataka Forest Department; Karnataka Fisheries Department as stakeholder and also through the community participation such as lake maintenance Agencies like corporates, NGO and RWA (Residential Welfare Association). Awareness about the importance of the water bodies within the Bengaluru citizens will pave ways for effortless conservation of water bodies by Authorities.

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Annexure – 1: Water body Inventorisation Datasheet

BMR-LDA Project Ver-0.1

Water body Field Data Sheet

A. General:

Name of District: **Bangalore Urban** Name of the Taluk : **Bangalore North**

Name of the Hobli: ____________________ Name of the Village: _______________

Waterbody Location: Total Extent of Waterbody (A-G): _____

S.No.	Village Name	Survey No.	Hobli Name
1	Same as above		Same as above
2			
3			

Name of the Waterbody: ________________________ Other Name: ____________________

Waterbody custodian: BDA ☐ Minor Irrigation ☐ Zilla Panchayat ☐ Forest Dept. ☐

Taluk Panchayat ☐ Grama Panchayat ☐

If any other, Mention ____

Type of the Waterbody: Perennial ☐ Seasonal ☐ Rejuvenated ☐

Rejuvenated by: BDA ☐ __________ Panchayat ☐ Other _______________________

GPS Position: Lat ________________ Long. ____________________

Elevation (m): ______ Maximum Depth (m): ________ GPS Waterspread Area (ha.): ______

Created Year: ___________ Last Rejuvenated Year: ______________

B. Morphometric Characteristics:

Is Bund is there: Yes ☐ No ☐

If Yes, No. of Bunds: _______; Bund Type: Stone Anchored ☐ Other _________

No. of Island: _______ No. of Sluice Gate: ________ No. of Inlet Drains: __________

If the following things are located in the waterbody, specify the ***Direction***

i. Culvert: __________ iii. Inlet Drains: ____________

ii. Check Dam: _______ iv. Waste-Weirs: ___________

Is the waterbody safeguard with fence: Yes ☐ No ☐

If Yes, mention the type: Wall ☐ Mesh ☐ Thorn Wire ☐ Bio-fence ☐ Nil ☐

Fence Coverage: Fully ☐ Partly ☐, by farmer or ________________________________

1/4

C. Water

Water source for Waterbodies: Rainfall ☐ Runoff ☐ Drain ☐ Wastewater drain ☐
Pumping from well ☐ Other ____________________

Nature of Immediate Catchment (Surrounding): Urban ☐ Agriculture land ☐ Gomala ☐
Settlement ☐ Slope & bare lands ☐ Other ________________

Water Status: Dry ☐ Clean water ☐ Muddy ☐ Polluted ☐ Marshy

Filled with waste ☐ Other ____________________

Water Usage: Drinking water ☐ Irrigation ☐ Fisheries ☐ Cattle feeding/ Grazing ☐
Recreation-Boating ☐ Bathing ☐ Construction activities ☐
Washing – Animal ☐ Vehicle ☐ Cloth ☐ Religious activity ☐

Function of Lake: Groundwater recharges ☐ Flood mitigation ☐ Recreation/ Aesthetic ☐
Supports biodiversity ☐ Rain water Storage Tank ☐

D. Biodiversity

Vegetation Cover: None ☐ Partially ☐ Complete ☐ Recently cleared ☐

Vegetation Type: Growing on bank ☐ Submerged in water ☐ Emergent ☐ Algae ☐

Free floating ☐

Aquatic Plants: Submerged ☐ Emergent ☐ Free floating ☐ Algae ☐

Aquatic Animals: Mollusca ☐ Fish ☐ Amphibia ☐ Reptiles ☐ Birds ☐ Mammals ☐

S.No.	Common Name of Aquatic Animals				
	Fish	Amphibian	Reptiles	Birds	Mammals
1					
2					
3					
4					
5					

Eco-Indicators: Butterfly ☐ Dragonfly ☐ Snail ☐ Lotus ☐ Typha ☐
Parthenium ☐ Ipomea ☐ Water hyacinth ☐ Algae Bloom ☐

E. Issues

Pollutant: Domestic sewage ☐ Industrial Effluents ☐ Storm-water Mix ☐

Agricultural Runoff ☐ Human Defecation ☐ Cattle wading ☐

Dumping Type: Domestic garbage ☐ Agriculture wastes ☐ Construction debris ☐

Industrial wastes ☐ Plastic wastes ☐ Poultry wastes ☐

Biomedical wastes ☐ Other: ____________________________________

Religious wastes: Religious offerings ☐ Idol immersion (Clay ☐ /Straw ☐)

If Industrial waste, Synthetic Fibre ☐ Plastics ☐ Electrical wastes ☐ e-wastes ☐

Packing materials ☐ Ash ☐ Granite & Polish wastes ☐ Tyre&Garment waste ☐

Pollution Status: Very high ☐ Moderately ☐ High ☐ Medium ☐ Low ☐ Negligible ☐

Encroachment Detail:

Encroachment on	Encroached for	Type	Encroached by	Encroached Direction (as per cart)	Approx. Encroached Area (A-G)
Lake/ Waterbody	Agriculture	Permanent	Local farmers		
		Seasonal			
	Residential/ Layout	Private	Local residents		
			Developers		
		Public			
	Development	Road			
		Park			
		Temple			
		Industries			
		Graveyard			
Nallah/Drain					

BMR-LDA Project Ver-0.1

Is any other Issues in the waterbody: Yes ☐ No ☐

If Yes. Mention it - Soil Excavation ☐ Sand mining ☐ Grass patch removal ☐

Decline of fisheries ☐

F. Water Sampling:

Is water is in waterbody for WQ analysis: Yes ☐ No ☐

If Yes. Volume of water for sampling: Small ☐ Medium ☐ Huge ☐

Water type: Clean water ☐ Shallow water ☐ Sewage water ☐

Is Sewage is flowing to waterbodies: Yes ☐ No ☐

If Yes. through Nallah ☐ Storm-water Drain ☐ Other________________________

Direct Connection of Domestic House / Industry ☐

Date of Survey: Approx. Time of Survey:

Members involved in survey:

1.

2.

3.

4.

4/4

Annexure – 2: Datasheet for Disused Water bodies

BMR-LDA Project Ver-0.1

Details of Non-Existing Waterbodies

A. General:

Name of District: ____________________ Name of the Taluk : ______________

Name of the Hobli: __________________ Name of the Village: ______________

Waterbody Location: Total Extent of Waterbody (A-G): _____

S.No.	Village Name	Survey No.	Hobli Name
1	Same as above		Same as above
2			
3			

Name of the Waterbody: ______________________ Other Name: ___________________

Waterbody custodian: BDA ☐ Minor Irrigation ☐ Zilla Panchayat ☐ Forest Dept. ☐

Taluk Panchayat ☐ Grama Panchayat ☐

If any other, Mention ____

Converted to	Converted by	Converted Year

Date of Visit: Approx. Time of Visit:

Members involved in Visit:

1.

2.

3.

4.

Annexure – 3: Major Lakes

Byrasandra Kelaginakere

Gattihalli *Kere*

Yellamallappa Shetty *Kere*

Nagadasarahalli *Kere*

Bellandur Lake

Varthur Lake

Annexure – 4: Disused Lakes

Audugodi lake Converted as Bus Stand


Kodihalli lake Converted as ISRO


Makali lake Converted as Warehouse


Chellaghatta lake Converted as Golf Park


Vijinapura lake converted as Dooravani Nagar


Chikka Nagamangala lake converted as layout

Annexure – 5: Rejuvenated Lakes

Kudlu Doddakere

Yediyuru *Kere*-2

Dorekere

Allasandra *Kere*

Kasavanahalli *Kere*

Nagawara *Kere*

Annexure – 6: Water Sampling Datasheet

EMPRI/IMS/WL/FORM/01/00
Page 1 of 2

LAKE WATER QUALITY SAMPLING FIELD DATA SHEET
Centre for Lake Conservation (CLC), EMPRI

(Forms must be submitted with samples to Lab Chemist)

Sample Date: ________ **Time (A.M.):** ______

1. Basic Information:

Information	Office Note	Information	Office Note
Name of Lake		Lake GPS	Lat.
KLCDA No.			Long.
Village Name		Type	Revival / Not
Hobli Name		Sample Code	
Taluk Name			

2. Lake Inlet (Nearby) Sample: (GPS Location ____)

Sl.No	Parameter	Unit	Single	Duplicate	Triplicate	Average/ Remarks
1	Air Temperature	°C				
2	Water Temperature	°C				
3	pH	-				
4	Conductivity	µS/cm				
5	TDS	mg/l				
6	Light Transparency	m				

3. Sewage Inflow Quantity (________________________________)

(Based on BIS-1194:1960 Forms- 4 & 5 for recording water flow in open channel)

Sl.No	Parameter	GPS Location	Width of drain (m)	Depth of Drain (m)						15m Passage Time (Sec.)
				1	2	3	4	5	Avg.	
1	Inlet-1									
2	Inlet-2									
3										
4										

EMPRI/IMS/WL/FORM/01/00
Page 2 of 2

4. Lake (Major) Outlet Sample: (GPS Location ______________________________)

Sl.No	Parameter	Unit	Single	Duplicate	Triplicate	Average/ Remarks
1	Air Temperature	°C				
2	Water Temperature	°C				
3	pH	-				
4	Conductivity	µS/cm				
5	TDS	mg/l				
6	Light Transparency	m				

5. Check List

Sl.No	Parameter	Put ✔
1	Collected water sample for Bacteriology analysis	
2	DO sample collected & fixed	
3	1L water sample collected	

Note: Collect and analyse water sample in the following order

a. Water sample for bacteriology analysis
b. Measure temperature, pH, EC & TDS
c. Collect water sample & fix it for DO
d. Collect 1L water sample &
e. Measure light transparency

Comments (unusual results, surrounding conditions, anything worth noting):
Please use the back of the sheet if necessary.

Sampling Persons:

1. Mr. Shashi
2. Mr. Siddaraju
3. Mr. Mallesh
4. Mr. Nagendra
5. Mr. Sanna Gundappa

Signature of Sampling Supervisor with Date:

1. Mr. Sreenivas
2. Dr. Jeya Prakash

------------------------------------*-----------------------------*-------------------------------------*

EMPRI Lab Use

The following samples have been received with the field data sheet

1. Water sample for Bacteriology analysis
2. Fixed DO samples
3. One Liter water sample in plastic can

Sample Received on Date: _________ Time: _______(A.M./ P.M.)

Lab-Chemist Signature: ____________________

Annexure – 7: Water Sampling

Preparing to collect water samples from lake

Collecting water sample from lake

Measure the water temperature and fixing DO

Measure the light transparency

Collected and labelled water samples

Measure the inflow of water in lake

Annexure – 8: Project Advisory Committee Proceedings

PROCEEDINGS OF THE 1st ADVISORY COMMITTEE MEETING ON **"INVENTORIZATION OF WATER BODIES IN BANGALORE METROPOLITAN REGION"** HELD AT 11:00 on 30.09.2014 IN THE CONFERENCE HALL, EMPRI, BANGALORE

List of participants:

1. **Smt. Ritu Kakkar, *IFS*,**
   Director General, EMPRI

2. **Sri. Vipin Singh, *IFS*,**
   Director, EMPRI

3. **Sri K. H. Vinaya Kumar, *IFS*,**
   Director (Research), EMPRI

4. **Sri. S R Nagaraj**
   Executive Engineer, LDA

5. **Sri. T Mahesh**
   Environmental Officer, KSPCB

6. **Sri. Thippe Swamy**
   Joint Director, BMRDA (Rep)

7. **Prof. Ravichandra Reddy**
   Retd. Professor from Bangalore University

8. **Dr. Mamtha Rao**
   Associate Professor, Dept. of Botany,BU

9. **Sri. Harish Kumar**
   Executive Engineer, PRE Division

CLC Team Members:

1. **Mr. V. Sreenivas,**
   Research Scientist, CLC, EMPRI

2. **Dr. Jeya Prakash,**
   Research Scientist, CLC, EMPRI

3. **Ms. B.S. Chandrakala,**
   Research Associate, CLC, EMPRI

4. **Ms. Reethu Singh**
   Research Associate, CLC, EMPRI

5. **Ms. Nayana Prakash,**
   Research Associate, CLC, EMPRI

6. **Mr. Kumar. K**
   Research Associate, CLC, EMPRI

7. **Mr. Shashi kumar S**
   Technical Assistant, CLC, EMPRI

At the outset, **Sri. Vipin Singh *IFS,*** Director EMPRI, welcomed the participants

Dr. Jeya Prakash gave a presentation on the project, **"Inventorization of water bodies in Bangalore Metropolitan Region"** explaining the objectives i.e. inventorization and coding of water bodies and methodology adopted. He further explained about the unique features of the this project, need of the project in BMR region, the project team members i.e. their designation and responsibilities, the progress of the project till date, water quality parameters to be analyzed, BMR revised structure plan-2013, taluk and hobli maps and lastly the details of database and lake atlas.

Ms. Reethu Singh, Project Research Associate gave a detailed presentation of the work done on Yelahanka Hobli and then Mr. Kumar k, Project Research Associate detailed Jala Hobli of the project.

A) Thereafter the meeting discussed the issues of the project, Prof. Ravichandra Reddy, Retd. Professor, Bangalore University suggested the following -
   1. A separate column should be included in the database w.r.t encroachment of lakes by OTHERS, as only encroachment for agriculture was mentioned in the presentation.
   2. Dead storage for each lake should be documented, Dr. Jeya Prakash, Research Scientist, responded that as the project is for two years, there is time constraint and also it i8s difficult to accommodate this aspect.
   3. If the lakes from the previous project "Assessment Derived Conservation Strategies for the Major Lakes of Bangalore" ,are included in this study it might appear that there's a repetition in the present project. Dr. V Srinivas, Research Scientist, responded by telling that there is no repetition of the lakes in the study and only five villages out of 36 villages from the previous project comes under the BMR region. The status of the lakes in these five villages as of 2014-2015will be updated in the current study.
   4. Identify the depth of each lake during the lake visit for better understanding of the research work for the study, only perennial lakes can be included for depth.
   5. Lake Visit should be done twice for each lake i.e. both in summer as well as rainy season as there will be variation in water levels, to this Dr. Jeya Prakash said that it is not possible to undertake multiple visits to the lake due to time

constraint and only one visit to the lake is envisaged in the design of the study..

6. Water samples collected should be tested for identification of zooplankton especially rotifers as they are indicator species. Dr. Jeya Prakash clarified that the identification of zooplankton was not mentioned in the proposal and it is very difficult to identify an expert for this identification. He also said the objective of the study is to create database depending on the water pollution in the lake hence the identification of zooplankton is deemed unimportant.
7. Cows and sheep should be identified under the visitors to the lake rather than mentioning it under biodiversity.
8. The drainage pattern map should be labeled with all the lake names.
9. The details of the lakes that were encroached should be included in terms percentage of area encroached.

The committee deliberated the above mentioned aspects and directed the CLC team to act on the suggestions that were agreed upon.

B) Sri. Mahesh T, EO, KSPCB Suggested the following -

1. Different aspects of lake like: history, rejuvenation, restoration, approximate cost for these developments and other activities of each lake should be collected from concerned departments like Zilla Panchayat etc. for better understanding of the lakes.
2. Water spread area in the map needs to be demarcated properly i.e. the actual extent of water body and water spread area during the field visit.
3. Construction and demolition (C&D) waste should be termed properly instead of demolition waste as mentioned in the ppt.
4. The bund need to be shaded in cartography for better visualization.
5. The study area i.e. the BBMP and BMR regions should be demarked more accurately.

C) Sri. Thippe Swamy, Joint Director, BMRDA (Rep) and Sri. Harish Kumar, Executive Engineer, PRE Division gave assurance to extend all their support w.r.t providing secondary data for the study.

D) Sri. S R Nagaraj, Executive Engineer, LDA suggested

1. A responsibility of each hobli should be designated to each of the team members in the project, which will enhance the work.
2. Opined that with the present staff strength of the project team, it may be difficult to complete the study within the allotted timeframe of two years, hence he suggested recruiting the field and technical assistants at the earliest.

E) Prof. Ravichandra Reddy, Retd. Professor, Bangalore University mentioned that he has been mentioning for last three years that EMPRI needs its own laboratory to function more efficiently. Shri. Mahesh T, EO, KSPCB mentioned that EMPRI can establish its own laboratory under the project study, without involving accreditation from MoEF. Sri. S R Nagaraj, Executive Engineer, LDA extended his support by saying that LDA will fund EMPRI for Laboratory establishment

After detailed discussions, the committee member's opined that EMPRI should have its own laboratory as the question of authenticity and validation of the water quality report/results submitted by the outsourced laboratory may arise between the water quality results and the pollution documented by the EMPRI researchers. The committee discussed funds registered for the establishment of water quality analysis laboratory and agreed that establishment of laboratory in EMPRI will be more economical compared to the outsourced laboratory. The committee further pointed out that budget provided in the project (Rs. 68 Lakhs) is sufficient for the initial establishment of a laboratory in EMPRI

The Advisory committee meeting was concluded with vote of thanks to the chair

DG, EMPRI

Annexure – 9: Committee for Water Quality Analysis Laboratory Establishment

Environmental Management & Policy Research Institute
Department of Forest, Ecology and Environment, Government of Karnataka

Ritu Kakkar, *IFS.,*
Director General

No. CLC/EWQAL-BMR/CR-10/2014-15/ 128 **Date: 28.05.2015**

OFFICIAL MEMORANDUM

Sub : Constitution of Expert Committee to advise on Establishment of Water Analysis Laboratory in EMPRI – reg.

Ref : 1. I[st] Advisory Committee Meeting of BMR Project dt. 30.09.2014.

2. Agenda No. 4 of the proceedings of the 42[nd] G.B. Meeting, held on 10.03.2015.

Preamble :

In the 1[st] Advisory Committee Meeting of EMPRI dt. 30.09.2014, for the Project **Inventorisation of Waterbodies in Bangalore Metropolitan Region** has recommended that EMPRI should establish a Water Quality Analysis to carry out the project efficiently and opined that EMPRI should have its own Laboratory. As per the recommendations of the Advisory Committee, the subject regarding Establishment of Water Analysis Laboratory in EMPRI was placed before the 42[nd] GB meeting held on 10.03.2015. During the course of deliberations, it was informed by DG EMPRI, that an Expert Committee will be constituted comprising of members from KSPCB, CPCB/NABL to advise on the subject, for which the GB has consented and approved the same. In view of this, an Expert Committee is constituted. Hence this order.

O R D E R

Under the circumstances, a 7 member Expert Committee to advise on Establishment of Water Analysis Laboratory in EMPRI is hereby constituted comprising of the following:

1. Director General, EMPRI : Chairperson
2. CCF & Director, EMPRI : Member
3. CF & Director (Research), EMPRI : Member
4. Sri. Suresh : Member
   Scientist 'D' & I/c.
   Zonal Office
   Central Pollution Control Board
   Bengaluru

P. T.O.

"HASIRU BHAVANA", DORESANIPALYA FOREST CAMPUS, VINAYAKANAGAR CIRCLE, J. P. NAGAR 5[TH] PHASE, BANGALORE 560 078
TEL 080-2649 0747 /46 • FAX 080-2649 0745 • EMAIL EMPRI.BLR@GMAIL.COM • WEBSITE HTTP://EMPRI.KAR.NIC.IN

5. Sri. Kumara Swamy : Member
   Chief Environmental Officer
   KSPCB, Bangalore
6. Sri. Nanjundaiah : Member
   Chief Chemist
   Water Analysis Laboratory
   Public Health Institute
   Dept. of Health & Family Welfare
   Seshadri Road
   Bengaluru – 1
7. Smt. Sumathi : Member
   Chief Chemist (Govt. Analyst)
   Water Analysis Lab.
   Dept. of Mines & Geology
   No. 49, Khanija Bhavan,
   Race Course Road, Bengaluru – 1.

Director General
E M P R I

Copies to:

1. The Director, Dept. of Mines & Geology No. 49, Khanija Bhavan, Race Course Road, Bengaluru – 1.
2. The Joint Director, Public Health Institute, Dept. of Health & Family Welfare, Seshadri Road, Bengaluru – 1
3. Communicated to all the Members
4. Copy to : Dr. Jeya Prakash, Research Scientist, EMPRI

Annexure – 10: Committee for Water Quality Analysis Laboratory Establishment

Proceedings of the 2nd Advisory Committee Meeting held on 22.09.2015 in EMPRI, to finalize the specification of instruments for the Establishment of Water Analysis Laboratory.

<u>List of members attended</u>

1. **Smt. Ritu Kakkar, *IFS*** — Chairman
   Director General, EMPRI

2. **Sri. K. H. Vinaya Kumar, *IFS*** — Member
   Director (Research), EMPRI

3. **Sri. Niranjan Bagchi, Consultant** — Consultant
   Former Joint Secretary (IA) MoEF, New Delhi

4. **Dr. S. Kumaraswamy** — Member
   CEO, KSPCB

5. **Smt. K.N Sumathi** — Member
   Chief Chemist, DMG

6. **Sri. S. Jagadeesh,** — Invitee
   AEE, KRIDL

7. **Dr. Jeya Prakash** — Coordinator
   Research Scientist, EMPRI

8. **Dr. G.S Yashwanth Kumar** (Representing Smt. Sharadha, Chief Food Analyst, PHI) Member
   Food Analyst, PHI

9. **Miss. Nayana Prakash,**
   Research Associate, EMPRI

At the outset, **Smt. Ritu Kakkar, *IFS,*** Director General, EMPRI, welcomed the members to finalize the specification of instruments for the Establishment of Water Analysis Laboratory in EMPRI.

Dr. Jeya Prakash, Research Scientist, EMPRI started the discussion by going through the specifications of each instrument, for receiving comments and suggestions from the members. He distributed the list of instruments along with the draft specification.

The comments received are given alongside the instrument given below-

S.No.	Name of the instrument	Quantity	Specification
Physico-Chemical Lab			
1.	Mercury Thermometer	2	Technically Approved
2.	Digital Thermometer	2	Technically Approved
3.	Sechhi Disk	2	Technically Approved
4.	Wastewater Flow Meter	1	Technically Approved
5.	Deep/ Quick Freezer	1	Vertical model with at least LCD display for dual display of microprocessor based PID temperature controller minimum of -20°C ±1°C was proposed, but Mr. kumarswamy felt -20°C wasn't required as it is not necessary at the initial stage of the laboratory and also its more expensive. However, Mr. kumarswamy later confirmed that the minimum temperature of -20 C was correct and no change was therefore recommended. Technically Approved
6.	SS Vertical Water Distillation Unit	1	Technically Approved
7.	Precious Analytical Balance	1	Technically Approved
8.	Benchtop pH Meter	1	Technically Approved, suggested to purchase buffer tablets, from the manufacturer, for calibration.
9.	Benchtop EC/TDS Meter	1	Technically Approved, but need to purchase a built in electrode arm with vertical movement.
10.	Benchtop Turbidity Meter	1	Technically Approved
11.	BOD Incubator	1	Technically Approved
12.	Kjeldahl Apparatus	1	Technically Approved. Check to ensure that the visibility (transparent) of the Digestion Unit is present as it is important to see what is happening inside the unit.
13.	Digital Water Bath	1	Technically Approved
14.	Uv-Vis Double Beam Spectrophotometer	1	Technically Approved. Suggested to purchase with a Multi Cuvette holder (8 cuvettes) and the range from 190-1100nm.
15.	Analytical Balance	1	Technically Approved
16.	Hot plate with Magnetic Stirrer	1	Technically Approved. Check to see if the temperature range of 30°C to 200°C is adequate and available.
17.	Millipore Membrane Laboratory Filtration Apparatus	1	Technically Approved
18.	Automatic Autoclave	1	Technically Approved
19.	Digital Autoclave	1	Technically Approved
20.	Hot Air Oven	1	Technically Approved
21.	Laminar Air Flow	1	Technically Approved
22.	Bacteriological Incubator	1	Technically Approved. Check for the availability of the instrument with tray adjustment.

23.	Digital Colony Counter	1	Technically Approved. But check for the MPN method as an alternative.
24.	Stabilizer	3	Technically Approved

At the end of the meeting the following comments were made-

1. It was observed by the Committee Members that the Laboratory should have an independent UPS for transition of turning out the equipment in case of load shedding.
2. The microbiology section should test for E coli in addition to Total Coliform since there is contamination of lakes with sewage in Bangalore.

The Committee Members were taken around the proposed Laboratory. Mr. Jagadeesh from KRIDL, gave a layout of the laboratory furniture that has been finalized in consultation with Dr. Jeya Prakash and Mr. Bagchi. He had brought up an issue of a requirement of an air-lock room in the laboratory. The matter was clarified to him at 3:30 p.m., after the meeting, that this was not necessary. Mr. Jagadeesh stated that he will submit the estimate within this week.

All the specifications of the Laboratory instruments as mentioned above in the Table, has been finalized in this meeting.

The Meeting ended with thanks to the Members.

Rit kakk.
Ritu Kakkar, *IFS*
(Director General)

Encl. The list of instruments with the draft specifications as circulated in the meeting.

Annexure – 11: Trees

Phoenix sylvestris at Gollahalli lake

Tabebuia argentea & *Polyalthia longifolia* at Chellakere

Tectona grandis at Chikkabellandur lake

Cocos nucifera at Chikkabellandur lake

Spathodea campanulata at Kalkere

Pongamia pinnata and *Eucalyptus* sp. at Panathur lake

Ficus religiosa at Sulikunte Devarakere

Tabebuia rosea at Attur lake

Grevillea robusta at Attur lake

Bauhinia purpurea at Lalbagh lake

Terminalia arjuna at Bellihalli lake

Syzygium cumini at Nyappanahalli lake

Elaeis guineensis at Anekal lake

Caryota urens at Anekal lake

Thespesia populnea at Puttenahalli lake

Terminalia catappa at Halagevaderahalli lake

Calliandra tweedii at Puttenahalli lake

Ricinus communis at Hongasandra lake

Annexure – 12: Herbs

Ipomoea cairica at Bellandur lake

Ipomoea cairica at Puttenahalli lake

Asclepias curassavica at Doddatogur lake

Crotalaria sp. at Elenahalli lake

Annexure – 13: Shrubs

Bougainvillea spectabilis at Hullahalli lake

Lantana camara at Hullahalli lake

Eupatorium odoratum at Ullalu lake

Dracaena sp. at Mattikere lake

Annexure – 14: Emergent Macrophytes

Alocasia sp. in Bellandur lake

Cyperus sp. in Arakere lake

Hygrophila schulli in Puttenahalli lake

Polygonum glabrum in Kogilu lake

Typha angustifolia in Begur lake

Ipomoea fistulosa in Hulimavu lake

Sacciolepis myosuroides in Byrasandra lake

Cyperus alternifolius in Kadirenahalli lake

Alternanthera philoxeroides in Chokkanahalli lake

Annexure – 15: Submerged Macrophytes

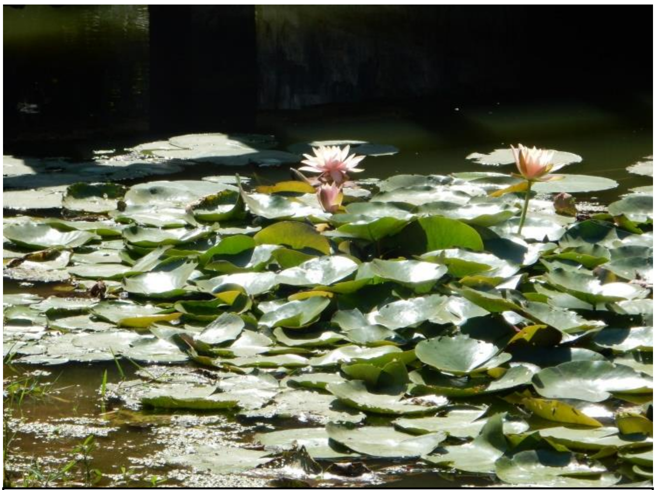
Aponogeton natans in Vasanthapura lake

Nymphoides indica in Hullahalli lake

Hydrilla sp. in Betta Halsur lake

Annexure – 16: Rooted-floating Macrophytes

Nelumbo sp. in K. Uttarahalli lake



Nymphaea sp. in Mattikere lake

Lilly in Kannaminiki lake-1

Annexure – 17: Free floating Macrophytes

Spirodela polyrrhiza in Kattigenahalli lake

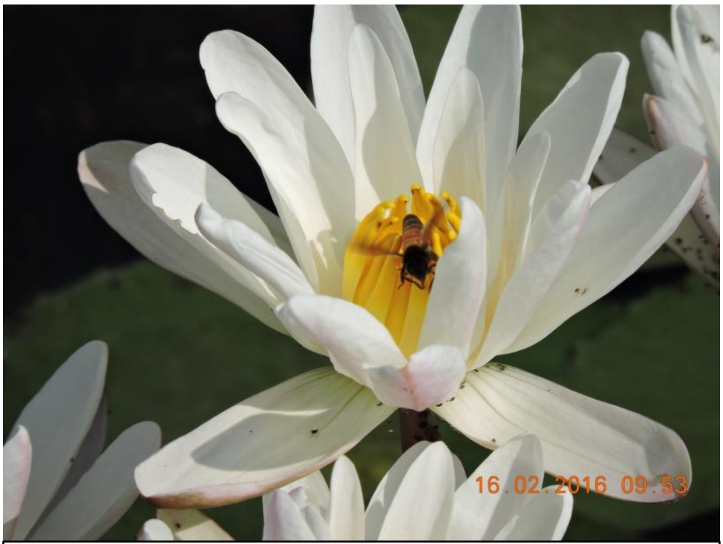
Eichhornia crassipes in Chikkabegur lake

Pistia stratiotes in K.Uttarahalli lake

Lemna sp. in Rachenahalli lake

Wolffia in Bennerughatta *Kunte*-1

Annexure – 18: Terrestrial Insects



Honey bee in Kannaminiki lake


Spider in K. Gollahalli lake


Grapevine moth in Mylasandra lake


Termite mounds in Ramsandra lake


Stink bug in Lake Gubbalala lake


Blister beetle in Ullalu lake


Short horned grasshopper in Hommadevanahalli Lake

Annexure – 19: Odanates

Trithemis sp. in Chinnakurchi lake

Diplacodes sp. in Maragondanahalli lake

Orthetrum sp. in Bhimanakuppe lake

Tramea sp.in Kumalagudu lake

Brachythemis sp in Vaderahalli lake

Trithemis sp in Kumbalagudu lake

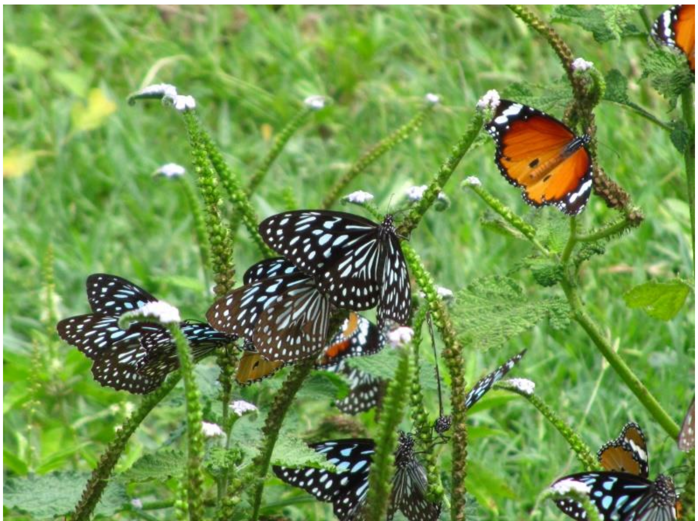
Annexure – 20: Butterflies

Belenois sp. in Amruthahalli lake

Euploea sp. in Chinnakurchi lake

Danaus sp. in Kambipura lake

Junonia sp. in Devagere lake



Tirumala sp. in Kalenhalli lake

Annexure – 21: Fish

Jalebi fish caught in Madiwala lake

Jalebi fish caught in Hulimavu lake

Catfish fish caught in Madiwala lake

Fish caught in Chokkasandra lake

Catla fish caught in Kattiganahalli lake

Fish caught in Jakkru lake

Annexure – 22: Herpetofauna

Southern rock agama in Vodderahalli lake

Common garden lizard in Raysandra lake

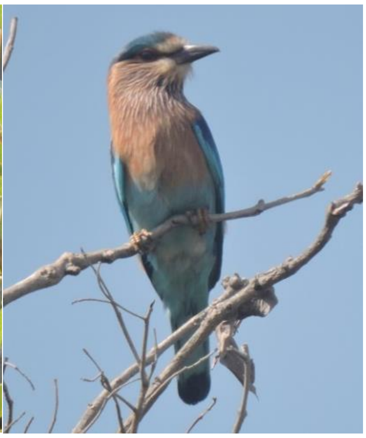
Tortoise in Lalbagh tank

Checkered keel back in Jarakabandikaval lake

Indian Cobra in Valagerehalli lake

Skittering Frog in Chinnakurchi lake

Annexure – 23: Birds

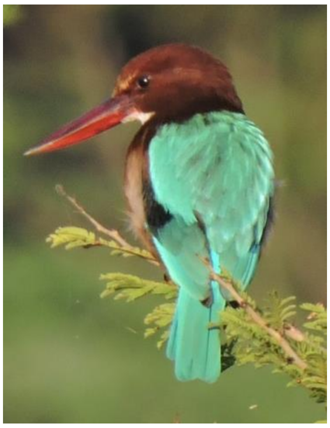











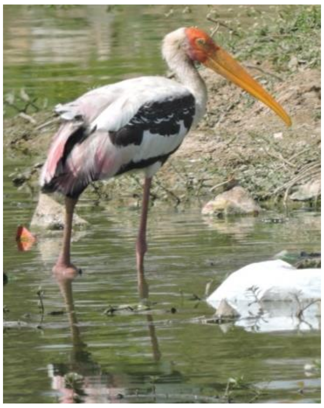




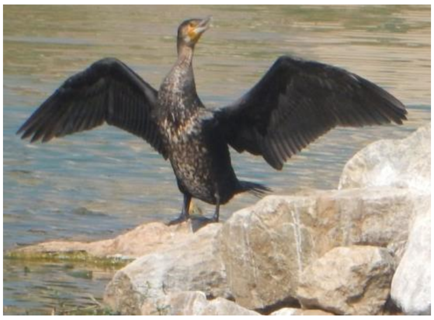


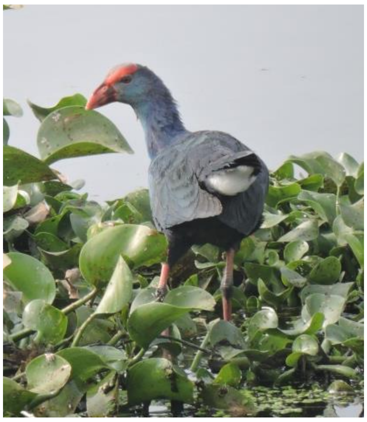






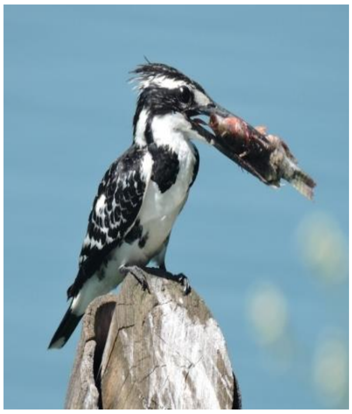






















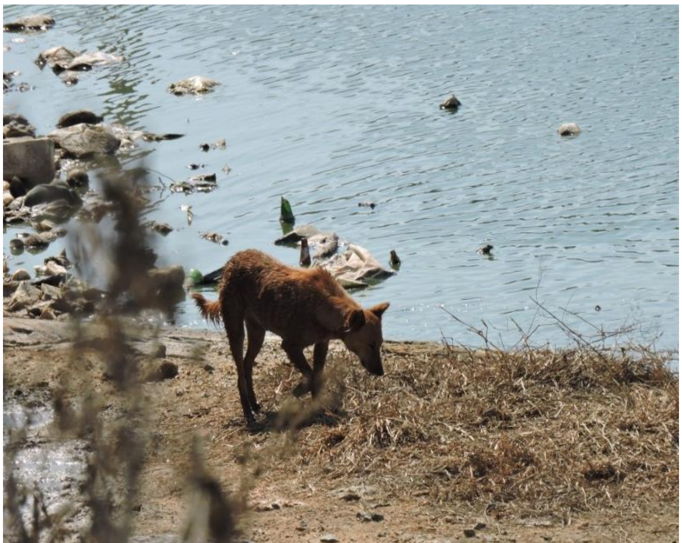

Annexure – 24: Visiting Mammals

Bat in Sankey Tank

Indian Palm Squirrel in Lalbagh Tank

Pig in Avalahalli lake

Horse in Sankey Tank



Dog in Sankey Tank

Cow in Sankey Tank

Annexure – 25: Peer-Review Report

JSS Mahavidyapeetha

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING

JSS Technical Institutions Campus, Mysore - 570 006, Karnataka, India

* Autonomous Institute Under Visvesvaraya Technological University, Belgaum
* Approved by A.I.C.T.E. and Accredited by National Board of Accreditation
* Governed by the Grant-in-Aid Rules of Government of Karnataka
* Identified as Lead-Institution for World Bank Assistance under TEQIP Scheme

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DEPARTMENT OF ENVIRONMENTAL ENGINEERING

04.10.2017

To,
Mrs. Ritu Kakkar, *IFS*
Director General,
Environmental Management & Policy Research Institute,
Department of Forest, Ecology and Environment,
Government of Karnataka,
"Hasiru Bhavana", Doresanipalya Forest Campus,
Vinayakanagar Circle,
J. P. Nagar, 5th Phase,
Bangalore – 560 078

Dear Madam,

Sub.: Peer Review of the project report entitled "***Inventorisation of Waterbodies in the Bruhat Bengaluru Mahanagara Palike and Bangalore Development Authority (BDA) Area***"– Reg.

I once again thank you for offering me to peer review the research project report entitled "***Inventorisation of Water bodies in the Bruhat Bengaluru Mahanagara Palike and Bangalore Development Authority (BDA) Area***", prepared by your office. I am herewith enclosing the review report for your kind perusal. Kindly let me know for any clarifications in the review report.

Thanking you,

Yours Sincerely

B. Manoj

Dr. B. Manoj Kumar BE, M.Tech, PhD (IIT, Bombay)
Professor,
Department of Environmental Engineering,
Sri Jayachamarajendra College of Engineering,
Mysore – 570 006, Karnataka
Cell: 09886544263

Encl.: Review report

INVENTORIZATION OF WATER BODIES IN BENGALURU METROPOLITAN AREA (BMA)

Review Report

The efforts of Environmental Management and Policy Research Institute, Bengaluru in preparing the research report on "inventorization of water bodies in Bengaluru Metropolitan Area" are greatly appreciated. In general there are minor corrections required in report (technical) that need to be addressed with suggested corrections/ clarifications. In general the following could have been addressed:

a. Previous lake water quality data from KSPCB, if available can be recorded to know the changes in water quality.
b. A chapter on methodology is to be provided explaining the details of sampling methods, sample preservation etc. A detailed methodology adopted for characterization of water quality of water bodies can be mentioned.
c. Few references quoted in the text are not found in the references list page 353 onwards. Several references listed is not quoted in the text.

<u>Following needs to be addressed in the report:</u>

ABBREVIATIONS

Include the following:

BMICAPA – Bangalore-Mysuru Infrastructure Corridor Area Planning Authority
BIAAPA - Bangalore International Airport Authority Planning Area
SSLR – Survey, Settlement and Land Records

Chapter – 1: General Introduction

Page 2, Paragraph 1, Line 3 – domestic sewage can be replaced by
Sewage or domestic wastewater or municipal wastewater.

Page 3, Paragraph 2, Line 3 – and readjust: meaning?

Page 3, Table 1.1 – for serial nos. 3, 5 and 6 event date is missing, for serial no. 8 source should be written as Bharadvaj (2016) and the same can be incorporated in reference list.

Page 3, Paragraph 3 - more information on warm water fish and cold water fish referring to dissolved oxygen can be provided (refer Thomann and

Mueller,1987.Principles of Surface Water Quality Modeling and Control, Pearson Publisher)

Page 4, Paragraph 2 - mention of holomictic lakes is required before mentioning different types (four types of holomictic lakes are: oligomictic lakes, polymictic lakes, monomictic lakes and dimictic lakes).

Chapter – 2: Objectives and Scope of the Study

Page 17, Paragraph 1, last three lines – Rephrase required, use of "understand the implementation issues during planning and execution stages"?.

Page 17, Paragraph 3, 4^{th} line and 9^{th} line – mentioned as 14 water quality parameters and 11 parameters, if water temperature and light transparency is included it will be 13 parameters (Refer Page 113).

Chapter – 3: Description of Study Area

Page 19, Paragraphs 1 and 2 - Requires source of information since data has been mentioned (Bangalore is situated in the South East of the South Indian state of Karnataka. It is positioned at 12.97° N 77.56° E and covers an area of 2,190 square kilometres (850 sq mi); GPS coordinates of 12° 58' 20.7912" N and 77° 34' 50.3148" E).

Page 19, Paragraph 2, line 2 – Tamil Nadu state on the south should be written as Tamil Nadu state on the South-East.

Chapter – 4: Status of Water Bodies

Page 65, Figure 4.17 – does not provide the index showing blue and red dots.

Page 86, Section 4.7, line 16 – mentioned as 37 lakes but page 111 table 4.1 shows 39 lakes.

Page 86, Section 4.7, line 16 - figure 4.73 not shown.

Chapter – 5: Water Quality of Lakes

Page 112, Paragraph 3, lines 5 and 6 – In addition to BIS, APHA 1998 could have been referred for standard methods for the examination of water and wastewater.

Page 112, Paragraph 3, line 8 – 4^0C or $+4^0$C since sample preservators (refrigerators will work from 5^0C onwards except for deep freezers)

Page 113 - table caption and check parameters

Page 113, Section 5.3.1, line 3 – Replace maximum temperatures with higher temperature.

Page 114, Paragraph 1, line 2 – 28.5^0C needs to be replaced with 28.3^0C (Highest temp in line 3) while mentioning the temperature of lakes it is preferable to mention the time of the day since the dissolved oxygen has reached super saturation (Page 117 and 118)

Page 114, Section 5.3.2, Paragraph 4, lines 1 – pH in the lakes is ranging from 4.5 to 10.8, 10.8 to be replaced by 10.75 (line 2). Similar correction is required in paragraph 1 of page 115.

Page 116, Paragraph 2 and 3 – how electrical conductivity of lakes water in the monsoon season is higher than summer season? Needs to be explained.

Page 116, Section 5.3.6, line 1 – suspended solids should be replaced by "Total Suspended Solids (TSS)"

Page 117, Paragraph 2, line 3 – Mavallipura Kere 4, what does 4 represent?

Page 117, Paragraph 2, line 5 – for which tolerance limit is it referred for? Mention IS code reference.

Page 117, section 5.3.9 – Reasoning for very low and high DO values needs to be elaborated.

Page 118, Figure – In one of the lake, the monsoon season temperature is higher than summer season temperature? Thus it is preferable to mention the time of monitoring.

Page 121, figure – figure caption/title is to be provided. Y-axis mentions 43 lakes number, below the figure the name of corresponding lake is to be provided.

Page 121 - explanation for very high phosphate concentration in monsoon season for 5 lakes (refer figure) needs to be provided.

Page 121, Paragraph 2, line 1 – the higher value of 70mg/l is to be replaced by 68mg/l (line 2)

Page 122, Section 5.3.14, Paragraph 1, line 5 and Paragraph 2, line 1 - Measurement of total coliform in concentrations <2MPN/100ml?. It should be 2 MPN/100ml

Pages 124 and 125 – the temperature during summer season is shown to vary between 20-29.5^{0}C while in page 114, paragraph 2 It is mentioned as 18-29.5^{0}C. Similarly the monsoon temperature is shown to vary between 17.4 to 24.5^{0}C in table 5.1 while in page number 114, the range is mentioned as 15 to 28.5^{0}C: needs to be corrected.

Chapter 6 – Biota of Water Bodies

Page 128, Section 6.1, Paragraph 2 - last three lines needs rephrasing

Page 128, Paragraph 2, line 2 – Avifaua should be corrected as **avifauna**

Page 131 – plates shown in figure 6.1 and 6.2 plantations are shown. Details need to be provided whether it is private or government plantation.

Page 131, Section 6.3.2, line 2 – 26 types of herbs belonging 18 families are recorded. But table 6.2 shows 17 families?

Page 140, Paragraph 2, line 16 to line 18 – is it primary data or secondary data? If secondary, the source has to be provided

Chapter 7 – Pollution and Issues

Page 161, Paragraph 3 – reported as 44.5% water bodies was found with solid waste dumping. The details of solid waste and any leachate entering to solid waste needs to be detailed (only 2 lakes name has been provided in page 162)

Chapter 8 – Manual for Inventorisation of Urban Water bodies

The manual for inventorisation of water bodies and the lessons learnt during the inventorisation of water bodies will be helpful to the KLCDA for prepare the water body database for other municipalities in Karnataka.

Chapter 9 – Conservation Strategies

Advanced technology shall be look over for the conservation of water bodies.