3 Chapter

Collection and conservation of storm water

3.1 Policies and regulatory framework

3.1.1 Absence of regulatory framework governing storm water management in Bengaluru

The State formulated (2002) a Water Policy in tune with the National Water Policy, which provides policy guidance for the management of water resources in the State. The Policy stated that the State had experienced a 'serious destabilisation of the water sector with hydrological, economic and ecological impacts'. The State also has the Karnataka Urban Drinking Water and Sanitation Policy, 2002, with the objective of ensuring universal coverage of water and sanitation services. The State enacted the Karnataka Ground water (Regulation and Control of Development and Management) Act, 2011 to regulate and control the development and management of ground water and matters incidental thereto. There was, however, no regulatory framework specifically governing storm water management. The above policies and acts also do not consider the need for management of storm water.

Further, the National Disaster Management Authority (NDMA), Government of India recognised urban flooding as a 'disaster different from riverine floods' and brought out (September 2010) detailed guidelines for Management of Urban Flooding stipulating the institutional framework, designing of urban drainage, mode of disaster risk management *etc*. However, the State Government/BBMP failed to fully comply with the NDM Guidelines, 2010 with regard to urban storm water management as detailed in **Appendix 3.1** and discussed subsequently at appropriate places[7].

The State Government stated (August 2020) that the Water Resources department had brought out the Water Policy which is in force. The reply was, however, silent on the absence of regulatory framework governing management of storm water and the action proposed to be taken to create such a framework.

3.1.2 State Water Policy - Urban surface runoff not recognised as a resource

Government of India brought out the National Water Policy 2012, which laid emphasis on conservation of rivers, river corridors, water bodies and/or associated wetlands, the flood plains, ecological buffer areas to be managed in an integrated manner to balance the environmental and social issues. The State Policy was, however, not updated. The State Policy needs to be revisited, since it does not factor in water sector reforms specially recognising urban water

[7] Paragraphs 4.1.2, 4.1.3, 4.2.1, 4.2.1.1, 4.2.1.5, 5.1.3, and 5.2.3

runoff as a water resource in the wake of growing scarcity and competing demands on the pattern of the National Water Policy.

The State Government stated (August 2020) that surface runoff was not considered as alternate source of water due to the presence of sewage in the drains. It further stated that once the drain and lakes are free of sewage, urban storm water runoff can be an alternate source of water and this issue has since been touched upon in the Master Plan.

The State Government, however, did not furnish the details of action taken/proposed to be taken to free the drains and lakes from sewage despite the fact that huge quantity of sewage continues to flow into the drains.

Recommendation 1: *The State Government/BBMP should formulate a comprehensive policy which clearly recognises urban runoff as a potential resource of water requiring clear plan of action for conservation in consonance with the NDM guidelines.*

3.2 Coordination between different institutions

The amendments to KM / KMC Acts enacted by the State Government in 1994 transferred the functions of "roads and bridges", "water supply" and "public health, sanitation conservancy and solid waste management" to ULBs.

However, the situation on the ground was different and responsibilities were highly fragmented:

(i) BBMP was responsible for construction, maintenance and cleaning of drains and Solid waste management etc.,
(ii) BDA was responsible for preparation of Comprehensive Development Plan for Bengaluru metropolitan region and development of infrastructure, and
(iii) BWSSB was responsible for water supply and sewage disposal within the jurisdiction of BBMP area.

The existence of multiple institutions to carry out various inter-related functions had a negative impact on coordination as indicated in subsequent paragraphs.

3.2.1 Coordination Committee

The State Government had put in place (June 2015) a Coordination Committee which included the Additional Chief Secretary, UDD and all the other stake holders like BBMP, BDA, BWSSB *etc*., for providing basic infrastructure facilities to the citizens of the city under the Chairmanship of the Chief Secretary. Audit observed that meetings were held regularly only from August 2018 onwards *i.e*., three years after the constitution of the Committee.

Review of the proceedings of the meetings showed that encroachments of SWDs and mixing of sewage were regular items in the agenda and the Committee had time and again issued instructions to clear encroachments and prevent mixing of sewage in SWDs. The situation, however, remained the same

as large number of SWDs continue to carry sewage. Audit also observed that there was absence of coordination between various institutions.

Illustration

*The AEE, SWD division of RR Nagar Zone, BBMP registered (22 October 2020) an FIR against the AEE, BWSSB, Banagiri sub-division alleging that BWSSB had dug up the concrete road (Ward no. 160, 1st cross, 2nd main, Gurudatta Layout, Girinagar, Bengaluru-560062 under RR Nagar Zone) laid by BBMP without obtaining the necessary permission from the respective zonal office of BBMP or SWD division to lay underground drainage pipes and construct manholes. The road had a SWD retaining wall on one side and apartments/houses on the other side. He, further alleged that BWSSB had carried out the work unscientifically and without taking necessary precautions; because of which the road was filled with rain water after the rainfall that occurred on 21 October 2020 which resulted in collapse of the retaining wall and damage to the road thereby putting the public to risk (**Exhibit 3.1**).*

Exhibit 3.1: Damage to SWD retention wall and concrete road

Source: Photographs shared by SWD wing of BBMP

3.3 Storm water collection systems

Lakes inter-connected with canals/drains constitute the basic storm water collection systems for Bengaluru city. Various reports/studies have highlighted the fact that rapid urbanisation has given rise to increasing demand on land which led to pressure on water bodies and uncontrolled developmental activities in the neighbourhood of lakes, which led to

- encroachment of lakes and SWDs resulting in decline in ground water table, while increasing the instances of flooding;
- dumping of solid waste, construction debris etc., in SWDs, lake catchment and in lakes;

- sustained inflow of partially or untreated sewage, polluting existing surface and subsurface water resources;
- reduced water holding capacity due to accumulation of silt, debris etc.; and
- loss of interconnectivity between water bodies.

3.3.1 Management of lakes

Bengaluru city was once aptly known as 'city of lakes' due to the presence of large number of lakes. As per the 2016 IISc report, it had around 1,452 water bodies during the early 1800s. These were gradually reduced due to conversions/encroachments as discussed in the subsequent paragraph. The lakes/water bodies in Bengaluru city were under the custody of different authorities such as BBMP, Forest Department, BDA, KLDCA, *etc*. The Government ordered (September 2016 and December 2019) the transfer of all lakes (except Bellandur and Varthur lakes which remained with BDA) to BBMP. The BBMP did not possess comprehensive data on the actual number of lakes, their status and custodians. As per data furnished (December 2020) by the CE, Lakes Division, BBMP, there were 210 lakes under its jurisdiction. Details are furnished in the **Table 3.1** below.

Table 3.1: Status of maintenance of lakes/water bodies in Bengaluru

Status of lakes	Number of lakes
Developed lakes	89
Work in progress	37
To be Developed	66
Disused lakes	18
Total	**210**

Source: CE, Lakes Division, BBMP

It could be observed that while 66 lakes were yet to be developed, 18 lakes with a total area of 254 acres and 17 guntas were reported as disused lakes. The current status of the disused lakes as per the Google Earth images is shown in **Exhibit 3.2** and the list of disused lakes is given in **Appendix 3.2.** There is a significant risk of these lakes being vulnerable to encroachments and future conversions.

Audit observed from media reports that many citizen forums concerned about the degraded condition of lakes and SWDs approached the courts and National Green Tribunal (NGT) seeking directions for proper maintenance. However, CE, SWD did not furnish the details of court cases pending or judgments thereon. The Karnataka High Court expressed dissatisfaction (July 2019) with the attitude of the city's authorities towards its lakes and reprimanded BBMP and other civic agencies for not knowing the number of lakes that existed in the city.

The State Government replied (August 2020) that works were being taken for restoration of lakes in a phased manner. However, the number of active lakes are decreasing over a period of time by way of encroachments and conversion for other purposes as detailed in the subsequent paragraphs. Any delay in taking up the restoration works would lead to further reduction in the number of lakes.

Exhibit 3.2: Current status of disused lakes

(Source: Google Earth images as on 19 January 2021)

Chennammana kere

Chikka Kallasandra kere

Exhibit 3.2: Current status of disused lakes contd….

Doresanipalya kere

Lingarajapuram kere 2000

Lingarajapuram kere 2020

3.3.2 Decrease in water bodies and length of drains

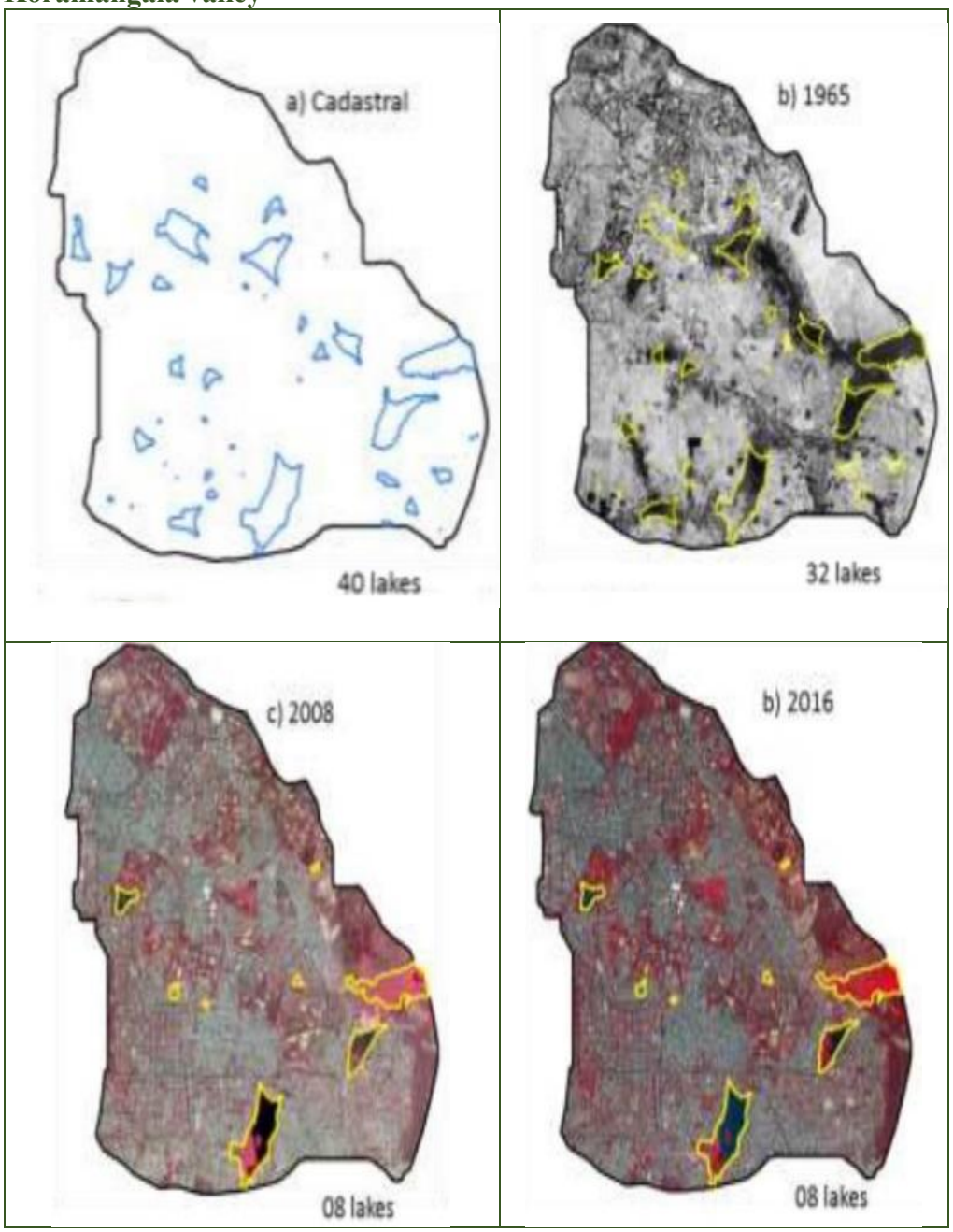
Audit conducted an independent study of long-term changes in land use patterns of Bengaluru city utilising geospatial inputs with technical support from Regional Remote Sensing Centre–South, Indian Space Research Organization, Bengaluru (RRSC). The methodology adopted for the study is already explained in Paragraph 2.4. The study corroborates the fact that urbanisation resulted in decrease in water bodies and length of drains as discussed below.

◈ Decrease in water bodies

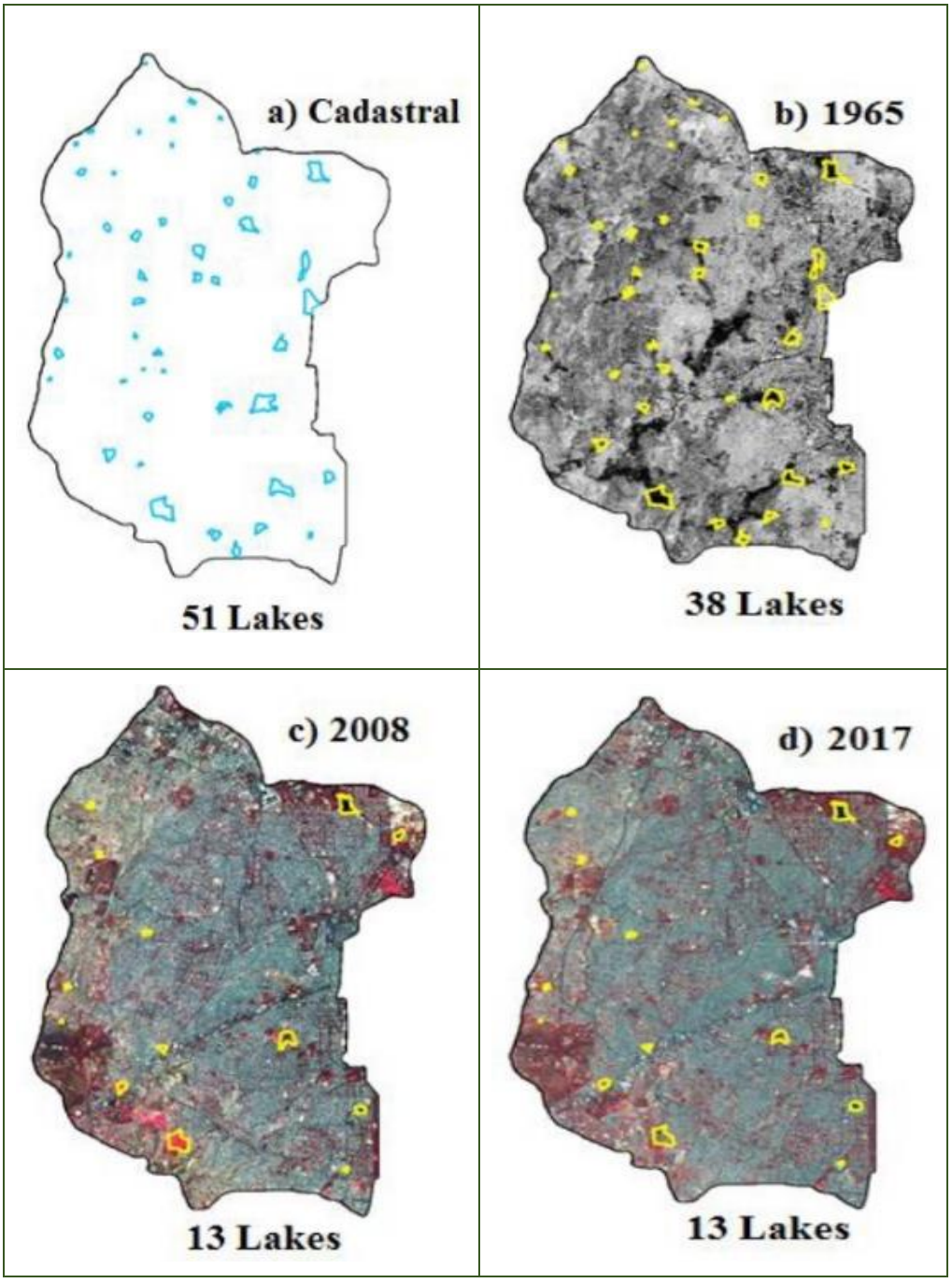
The study revealed that about 41 and 51 water bodies, which existed in Koramangala and Vrishabhavathi valleys respectively as per the cadastral map (prepared through field survey during early 1900s) were reduced to 8 and 13 by the year 2008 indicating the severity of lake conversion. Further, the wetland system (lakes, tanks, *kere* and *katte*), which contributed about 479.48 ha (0.75 *per cent*) and 215.46 ha (2.24 *per cent*) to the geographical area of the valleys as per the cadastral map decreased to 262.37 ha and 62.05 ha during 2016/2017 indicating erosion due to land use changes. The time series map showing the changes in lakes/tanks is indicated in **Chart 3.1**.

Chart 3.1: Time series maps showing changes in lakes / tanks

Koramangala valley



Vrishabhavathi valley



The change in size and shape of a few lakes in both the valleys which is indicative of significant reduction of lake foot print is indicated in **Appendix 3.3**. The reduction in the number of lakes can be linked to conversion of lakes for other purposes **(Exhibit 3.3)** such as bus stands, stadiums/sports grounds, National Games village housing complex, residential layouts etc., as indicated in **Appendix 3.4**.

Exhibit 3.3: Conversion of lakes for other purposes

(Source: Photographs taken during field visits)

Kamakshipalya lake converted as sports ground

Dasarahalli tank converted as Dr. B.R. Ambedkar Stadium

Evidently, these conversions were authorised by the State Government, BBMP, BDA *etc*., over a period of time. Reference is invited to Paragraph 4.4 of the Report on Lakes which refers to instances of irregular grant of lake land to various Government bodies, private parties and others in violation of the codal provisions which resulted in reduction of lake area. These conversions also resulted in the change in land use from being pervious to impervious thereby leading to higher runoff of rain water and consequent flooding.

Further, a Legislative Committee[8] constituted to study the status of encroachments on lakes/water bodies in Bengaluru and its surroundings covering the period 2014-2017, in its report revealed unabated encroachments of most of the water bodies, both by government departments/agencies and private parties, leading to diminishing boundaries of wetlands besides pollution of the ecosystem. The major encroachers among government agencies were Education department, Forest department, BDA, BWSSB, BBMP, Bengaluru Electric Supply Company, Bengaluru Metropolitan Transport Corporation, Karnataka Housing Board, Railways, Defence authorities, National Highways, *etc.*

The Committee expressed dissatisfaction particularly with the BDA, forming residential layouts over as many as 23 water bodies without obtaining the permission from the Revenue Department. The Committee attributed degeneration of water bodies to the negligence and irresponsibility of officials and recommended action against the offenders through a judicial investigation.

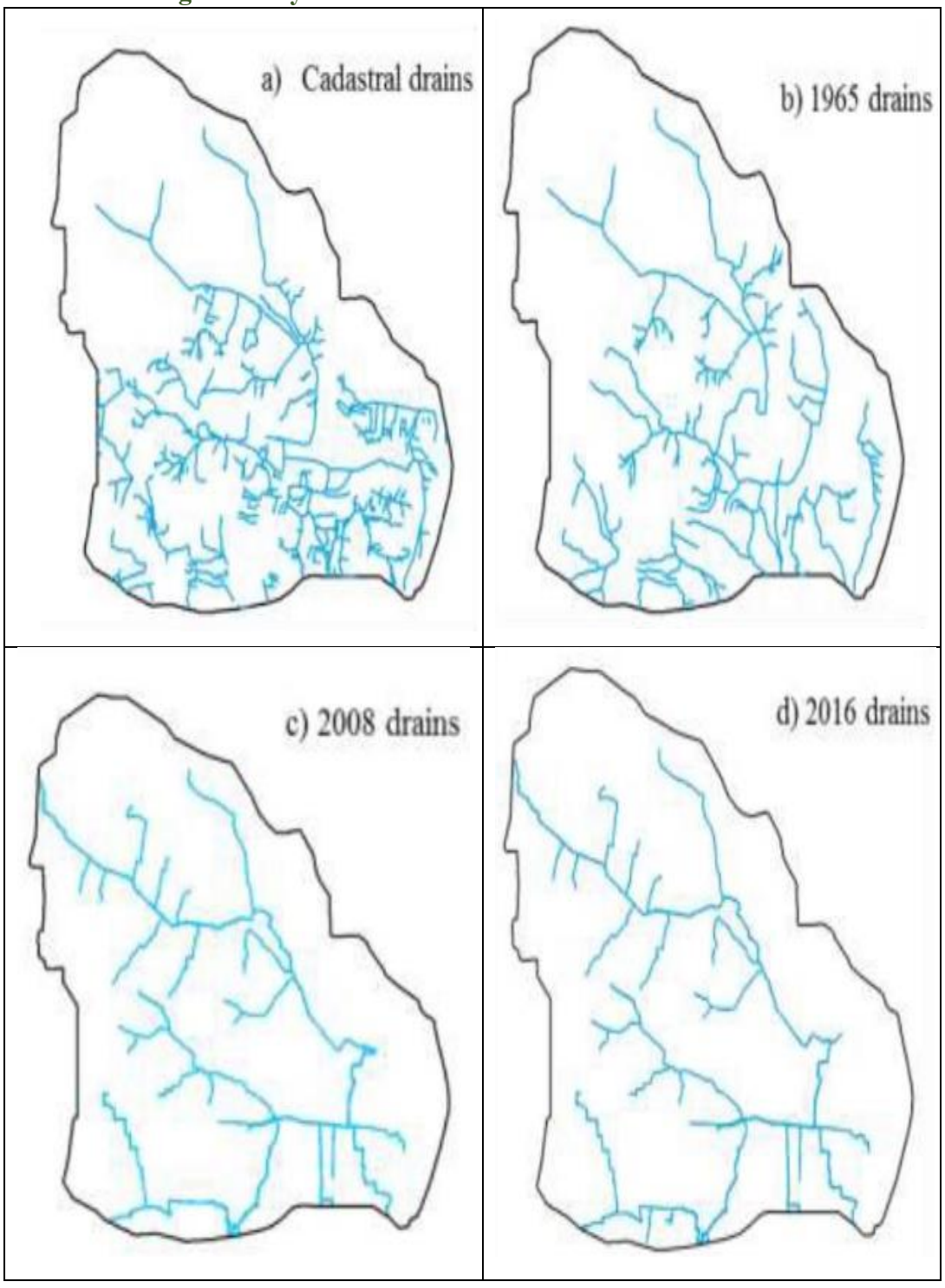
◈ Reduction in length of drains

Natural drainage/stream systems were concretised into storm water drains with increase in urbanisation. As per the study, total length of drains (primary and secondary) as per cadastral maps (early 1900s) was 113.24 km and 226.29 km in Koramangala and Vrishabhavathi valleys respectively, which was reduced to 62.84 km and 111.72 km by 2016/2017. The time series drainage maps showing the changes is indicated in **Chart 3.2**.

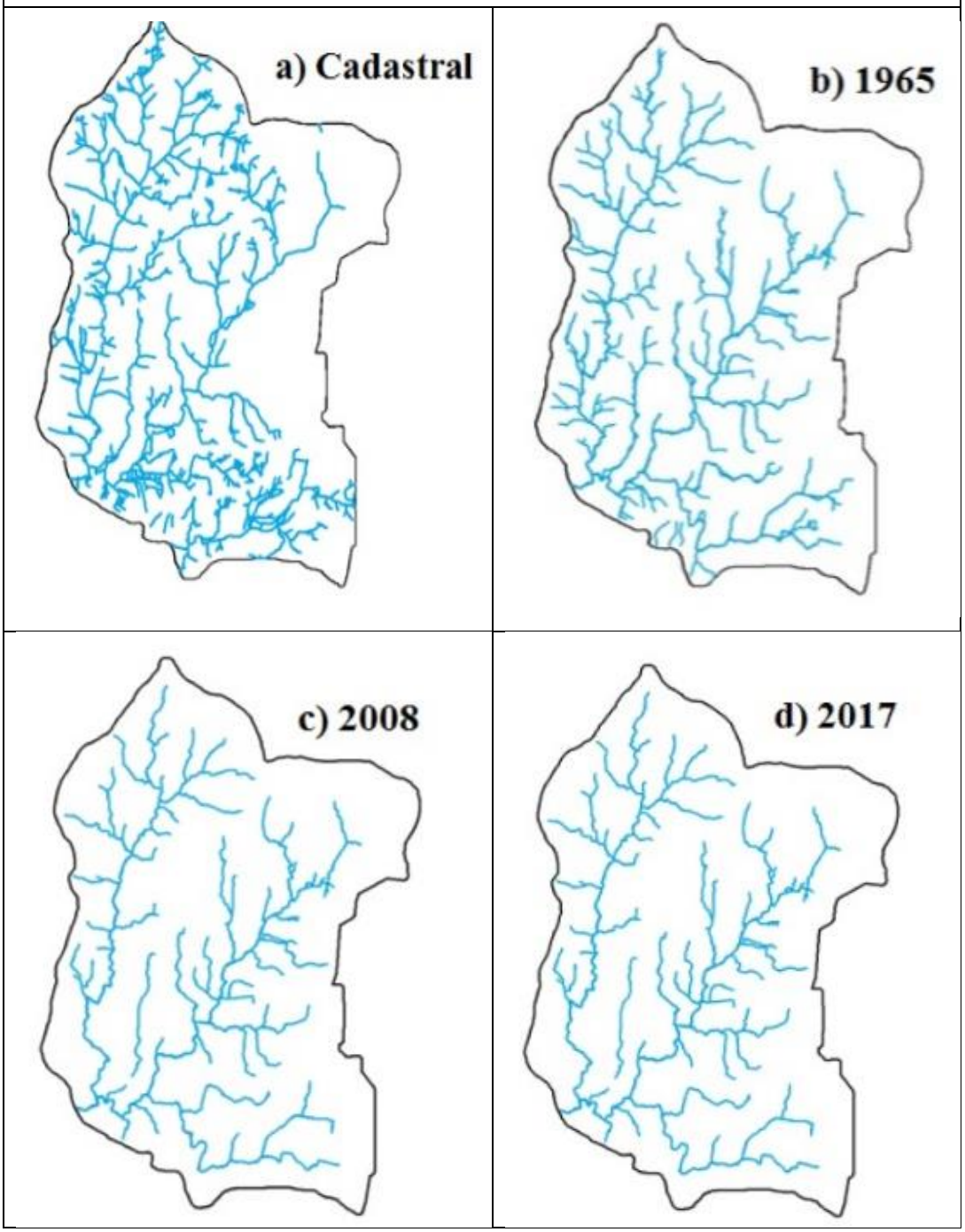
[8] Headed by Sri..K.B Koliwad, the then Hon'ble Speaker of Karnataka Legislative Assembly.

Chart 3.2: Time series drainage maps

Koramangala valley



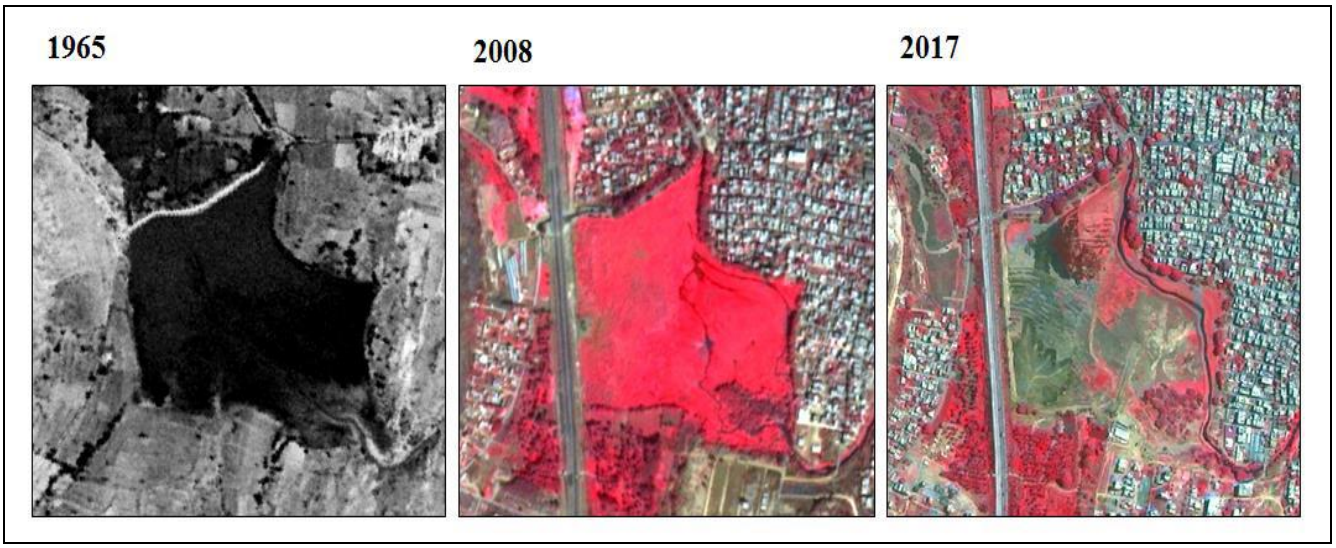
Vrishabhavathi valley



The spatial analysis also showed significant changes in the alignment of drains mainly due to remodelling. For example, in Koramangala valley, the length of two drains which merge before entering into Bellandur Lake was reduced from 338 m to 136 m (**Exhibit 3.4**) between the years 2008 and 2016 which allowed constructions thereby affecting the free flow of storm water. In Vrishabhavathi valley, the drain passing along the border of Hosakerehalli lake was remodeled and diverted to flow through the lake thereby reducing the area of the lake (**Exhibit 3.5**).

Exhibit 3.4: Realignment and remodelling of drainage network near Bellandur Lake

Exhibit 3.5: Realignment of drainage network near Hosakerehalli Lake



Physical verification of few storm water drains revealed that the drains were covered and encroached upon as indicated in **Appendix 3.5**.

The State Government stated (August 2020) that some of the drains were remodeled based on the geographical conditions of the site and for allowing smoother flow.

The reply cannot be accepted as in the instant case of Bellandur lake, the realignment was done in such a manner that it facilitated unauthorised developments in and around the lake area as can be seen from the Google Earth images taken over a period of time as exhibited **(Exhibit 3.6)**.

Exhibit 3.6: Google earth images showing the realignment of drains

As at April 2012

As at October 2012

As at March 2014

As at February 2020

Further, large number of SWD work files relating to JNNURM were not on the records of CE, SWD, BBMP and were not furnished to audit; in the absence of which the exact reasons for modifications could not be ascertained.

The State Government further stated (August 2020) that a number of measures were yet to be taken to counter increased runoff.

3.4 Storm water conservation systems

Storm water is best managed through ground water recharge and rainwater harvesting techniques.

3.4.1 Ground water recharge

Groundwater recharge is both natural and artificial. Groundwater is recharged naturally by rain and snow melt and to a smaller extent by surface water (rivers and lakes). This helps in aquifer recharge as well. Natural replenishment of ground water reservoir is a slow process and is often unable to keep pace with

the excessive and continued exploitation of ground water resources resulting in declining ground water levels and depletion of ground water resources. Artificial recharge efforts are basically aimed at augmentation of the natural movement of surface water into ground water reservoir through suitable civil construction techniques. Rainfall and runoff available constitute major sources of water for artificial recharge of ground water. The common recharge structures comprise of percolation ponds/tanks, check dams, recharge pits, injection wells etc.

While the above recharge structures help in replenishing the ground water to a certain extent, a large quantity of storm water runs off the impermeable, non-porous and concrete surfaces in urban areas. This surface runoff is to be conveyed/channeled either to the lakes/rivers or to inlets and recharge structures through SWDs to prevent flooding and aid in ground water recharge. An efficient, well designed/maintained SWD system would minimise the level of water logging and damage, and therefore play an important role in storm water management. In the backdrop of depleted ground water in urban conglomerates, the IRC guidelines stipulated that all SWDs should be efficiently utilised for the benefit of raising the existing ground water table.

BBMP neither had a policy in this regard nor had taken up works relating to recharge structures for replenishment of groundwater.

The State Government stated (August 2020) that implementation of recharge structures was deferred due to sewage flow in the drains.

3.4.2 Rainwater harvesting

The State Government made rainwater harvesting (RWH) mandatory in Bengaluru Urban Area by inserting Section 72A through an amendment to the Bangalore Water Supply and Sewerage Board Act, 1964 (August 2009). After a delay of nearly two years, the State Government notified (May 2011) that the owners and occupiers of residential and non-residential buildings as specified shall comply with providing rain water harvesting structures by 31 December 2011.

As per the information furnished (February 2020) by BWSSB, about 2.12 lakh properties were required to adopt RWH structures out of the total 9.85 lakh properties under the purview of BWSSB. However, only 1.27 lakh properties had adopted RWH structures. The compliance thereof was 60 *per cent*. Non-adoption of RWH structures resulted in failure to tap a potential source of water for storage and adequate ground water recharge. This, in turn, contributed to excess runoff in SWD systems. Further, adoption of RWH structures was not made mandatory for areas/properties not covered by BWSSB.

The State Government stated (August 2020) that measures required for ground water recharging has been indicated in the master plan of drains and the same is being implemented by BWSSB. The reply cannot be accepted as BWSSB is catering to less properties when compared to the properties under the overall jurisdiction of BBMP.

3.4.3 Loss of interconnectivity between water bodies/drains

The reduction in water bodies and drains led to loss of connectivity between water bodies and between water bodies and drains. Joint inspection of drains showed that the SWDs were not directly connected to water body/lake in few cases and the runoff was flowing in constructed deviation canals adjacent to the water body due to the fact that SWDs were carrying large quantity of sewerage. This facilitated overflows in SWDs channels and flash floods thereon.

Failure of BBMP to ensure linkage of drains with water bodies facilitated drying up of a number of lakes in Bengaluru city which in turn facilitated conversion of lakes for other purposes as discussed in Paragraph 3.3.2.

The State Government stated (August 2020) that many of the lakes were disconnected from the drains due to presence of sewage in the SWDs. It also stated that as BWSSB was in the process of segregation of sewage from SWD and implementing sewerage system in the new BBMP zones, the sewage flow in the drain may get minimised.

Though BWSSB was undertaking the segregation of sewage from SWDs as stated in the reply, the flow of sewage into the SWDs continues to be substantial.

Recommendation 2: *BBMP should prevent further reduction in water bodies and length of the natural drains and ensure inter-connectivity of water bodies for proper conservation of the ecosystem as well as ground water.*

Recommendation 3: *BBMP and BWSSB should jointly prepare a plan of action to prevent sewage flow into SWDs within a definite time schedule and the implementation thereof should be monitored by the State Government.*

3.4.4 Recharge of water bodies

Recharging the existing water bodies not only helps in ground water recharge but also caters to needs such as drinking water, agricultural activities and habitat for fish and other aquatic life. Hence it is imperative that the existing water bodies be protected for which a definitive plan of action is to be drawn. Out of the 210 lakes under the jurisdiction of BBMP, only 89 lakes were developed, and works were in progress for 37 lakes.

Analysis of the works in progress showed that rejuvenation activities such as desilting, formation/improvements of main and ring bunds, inlet improvements, creation of sewage diversion drains, walkway formations, security rooms *etc*., were taken up. While these activities help in restoration of the lakes, activities relating to actual recharging of the water bodies were not taken up. The Government of Karnataka had adopted a method of recharging dry water bodies by letting the treated water into the water bodies[9]. This would ensure that all

[9] In 2010, in respect of Jakkur lake, rejuvenation work was done by the Government where treated water was let into the lake for the purpose of groundwater recharge, agricultural activities *etc*. Since it was successful in respect of Jakkur lake, the filling up of water bodies in Kolar and Chikkaballapura districts were also taken up with treated water.

the inter-connected water bodies would be filled up which in turn would prevent disuse of lakes and their possible encroachments and conversions. This treated water combined with rain water would percolate into the ground and increase the ground water level. It was observed that an average of 170 and 73 MLD of treated sewage water were being pumped to water bodies in Kolar and Chikkaballapura districts respectively.

Recommendation 4: *The State Government/BBMP should explore the possibility of letting the treated water to the water bodies in the city to prevent drying up of water bodies and to aid in enhancing ground water recharge.*

3.4.5 Impact of concretisation of storm water drains on ground water recharge

Natural soil bed inside SWDs would help reducing velocity of flow as well as infiltration leading to ground water recharge.

Joint physical verification and verification of records relating to execution of works for improvements to SWDs revealed that the flow path/bed of drains were invariably concretised which not only affected hydrological functional ability of SWDs but also impacted ground water recharge. Besides, concretisation of SWDs also aggravated vulnerability to frequent floods.

The State Government replied (August 2020) that SWDs were carrying high volume of sewage increasing the pressure on SWDs meant for carrying rainwater and large quantity of debris/wastes were also being dumped into SWDs which was affecting the flow in the drains. Hence, the drain beds were concretised to allow smooth flow and avoid flooding/overflowing due to obstructions from wastes/debris.

The reply is not acceptable as concretising of drain beds allowed drain water to flow with higher velocity and increased runoff. Further, since the floor of the drain was concretised, water could not be absorbed naturally.

3.5 Other factors affecting the conservation of storm water

Besides the reduction in number of water bodies and decrease in length of the drains, the joint study with RRSC also showed significant findings, as indicated in **Table 3.2.**

Table 3.2: Other significant findings of the joint study

Parameter	Koramangala valley	Vrishabhavathi valley
Changes observed from 2008 to 2016/2017		
Pervious layer	Decreased by 11 *per cent*	Decreased by 14 *per cent*
Impervious layer	Increased by 15 *per cent*	Increased by 13 *per cent*
Built up area	Increased from 19.98 sq km to 23.88 sq km (20 *per cent)*	Increased from 39.14 sq km to 44.69 sq km (14 *per cent*)

Parameter	Koramangala valley	Vrishabhavathi valley
Vegetation cover	Decreased from 20.33 sq km to 19.34 sq km (5 *per cent*)	Increased from 26.82 sq km to 28.38 sq km (6 *per cent*)
Open land[10]	Decreased from 13.88 sq km to 10.94 sq km (21 *per cent*)	Decreased from 17.67 sq km to 9.74 sq km (45 *per cent*)

The above factors have a direct bearing on the collection and conservation of storm water. The decrease in vegetation cover and open land affects natural recharge of ground water. The increase in impervious layer and built up area results in increased runoff of storm water leading to frequent flooding.

Conclusion

The decrease in natural storm water collection systems and increase in runoff necessitate the need for formulation of a robust policy for storm water management. The depletion in length of natural drains coupled with the failure to construct and adopt storm water conservation structures affected efficient and effective recharge of ground water besides impacting the ecosystem adversely with the increase in runoff. Absence of coordination between various institutions responsible for preventing mixing of sewage with storm water, also highlights the inadequacy of the existing mechanism for efficient management of water.

Summary of important audit findings

Para number	Audit findings
3.1.1	There was no regulatory framework governing storm water management.
3.1.2	Urban surface runoff was not recognised as water resource despite the growing scarcity and competing demands on the existing water situation.
3.2.1	There was absence of coordination between various institutions responsible for providing basic urban infrastructure facilities.
3.3.1	Out of existing 210 lakes under the jurisdiction of BBMP, 66 were yet to be developed and 18 lakes were reported as disused lakes. These disused lakes were vulnerable to encroachments and future conversions.
3.3.2	An independent study conducted with technical support from RRSC, ISRO showed reduction in water bodies and length of drains in the test-checked Koramangala and Vrishabhavathi valleys. The study revealed that (i) about 41 and 51 water bodies, which existed in Koramangala and Vrishabhavathi valleys respectively as per the cadastral map were reduced to 8 and 13 by the year 2008 indicating the severity of lake conversion.

[10] The open land means areas not occupied by any structures like buildings or vegetation typically includes ground, fallow/wasteland.

Para number	Audit findings
	(ii) total length of drains (primary and secondary) as per cadastral maps which was 113.24 km and 226.29 km in Koramangala and Vrishabhavathi valleys respectively was reduced to 62.84 km and 111.72 km by 2016/2017.
3.4.1	BBMP had not taken up any works relating to recharge structures for replenishment of groundwater.
3.4.2	Of the 2.12 lakh properties under the purview of BWSSB that were required to adopt RWH structures, only 1.27 lakh properties (60 *per cent*) had adopted RWH structures. Adoption of RWH structures was not made mandatory for areas/properties not covered by BWSSB.
3.4.3	BBMP failed to ensure linkage of drains with water bodies which resulted in drying up of a number of lakes in Bengaluru city and in turn facilitated conversion of lakes for other purposes.
3.4.4	Activities relating to recharging of the water bodies were not taken up.
3.4.5	The flow path/bed of drains were concretised which not only affected hydrological functional ability of SWDs but also impacted ground water recharge. Besides, concretisation of SWDs also aggravated vulnerability to frequent floods.