1 Chapter Introduction

1.1 Introduction

Storm water is that portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a storm water drainage system into a defined surface water body, or a constructed infiltration facility[1]. Storm water management is the control and use of storm water runoff. It includes planning for runoff, maintaining storm water systems, and regulating the collection, storage, and movement of storm water. Storm water management should also factor in drainage in the design of cities and housing developments. The drainage system should best preserve or mimic the natural hydrologic cycle and fit within the capacity of the existing infrastructure.

1.2 Geography of Bengaluru

Bengaluru is located at 12.59º north latitude and 77.57º east longitude, almost equidistant from the eastern and western coast of the South Indian peninsula, and is situated at an altitude of 920 metres above mean sea level. The mean annual total rainfall as per an Indian Institute of Science (IISc) study[2] (henceforth referred to as 2017 study) is about 880 mm with about 60 rainy days a year over the last ten years. Bengaluru is located over ridges delineating four watersheds, *viz*. Hebbal, Koramangala, Challaghatta and Vrishabhavathi. The catchment area of major valleys of Bengaluru is shown in **Chart 1.1**.

1.3 Storm water drainage network in Bengaluru

Bruhat Bengaluru Mahanagara Palike (BBMP) spread over an area of 741 square kilometre (sq km) is demarcated into eight[3] zones. As per the records of the Chief Engineer, Storm Water Drains (SWD), BBMP has a total drain network (primary and secondary drains only) of 842 kilometre (km). However, as per the master plan of drains also prepared by BBMP, the total length of drains was 856.74 km which includes the length of drains that are outside the jurisdiction of BBMP but are considered for hydraulic analysis purposes only. BBMP did not have on records the length of the tertiary drains under its

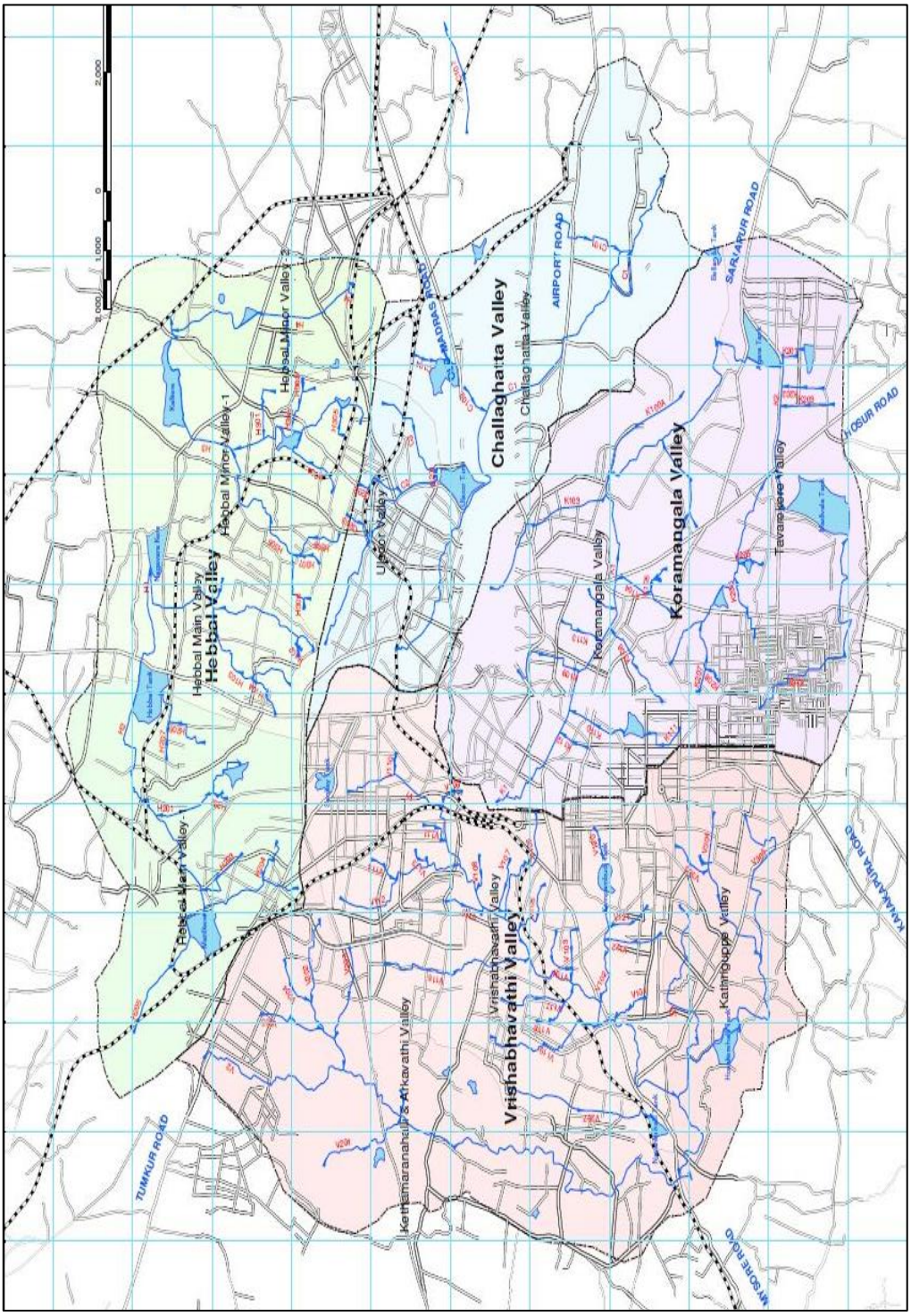
1 National Disaster Management Guidelines: Management of Urban Flooding. A publication of the National Disaster Management Authority, Government of India. ISBN: 978-93-80440-09-5, September 2010, New Delhi.

2 Ramachandra T V, Vinay S, Bharath H. Aithal, 2017. Frequent Floods in Bangalore: Causes and Remedial Measures, ENVIS Technical Report 123, Environmental Information System, CES, Indian Institute of Science, Bangalore 560012

3 Bengaluru East, Bengaluru South, Bengaluru West, Bommanahalli, Byatarayanapura, Dasarahalli, Mahadevapura and Rajarajeshwari Nagar.

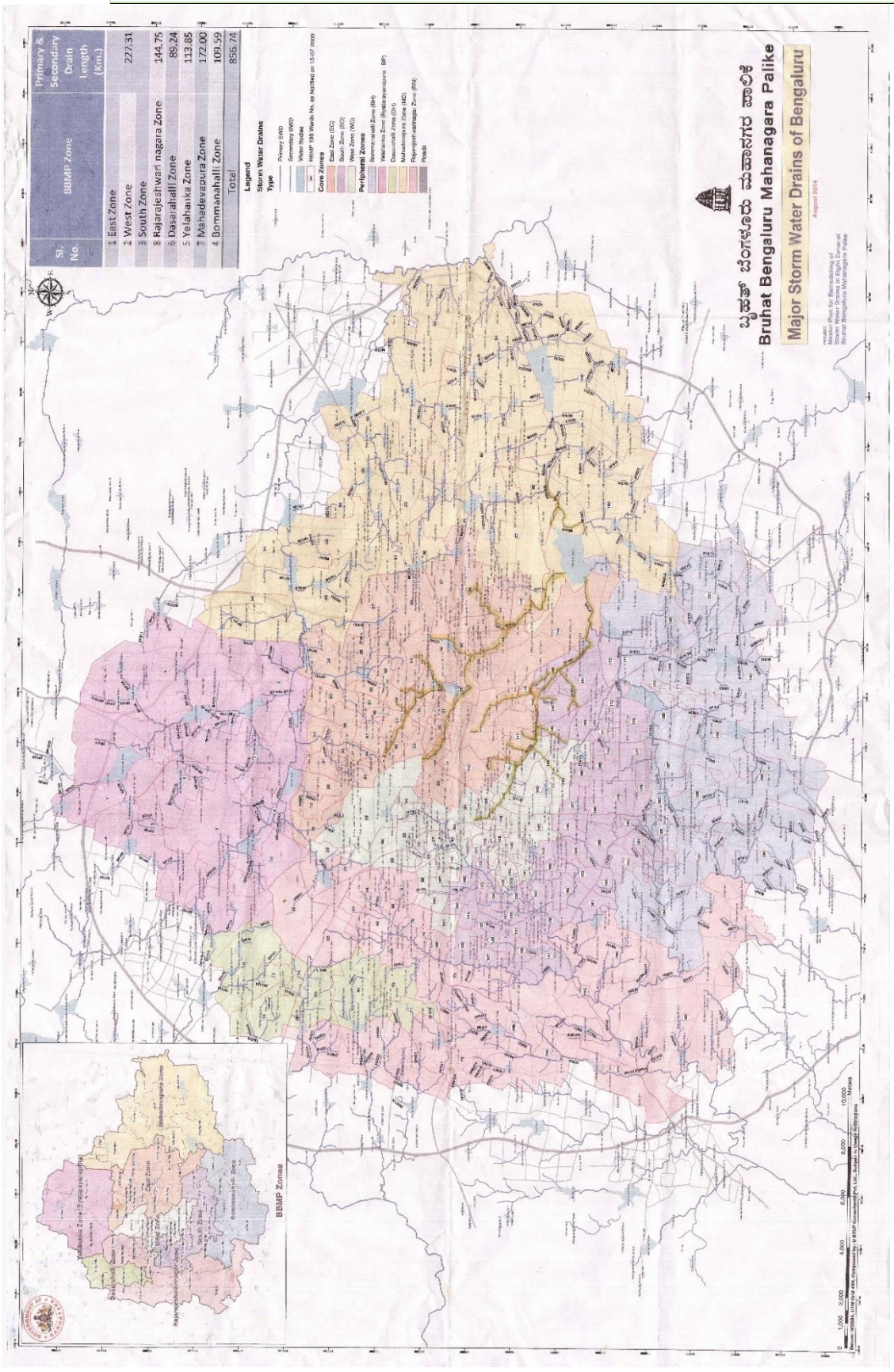
jurisdiction. Even the drainage network map of BBMP has no mention/sketch of the tertiary drains. The storm water drainage network under BBMP is depicted in **Chart 1.2**. Zone-wise maps showing the drains is exhibited in **Appendix 1.1.**

Chart 1.1: Map showing the catchment of major valleys of Bengaluru



Source: CE, SWD, BBMP

Chart 1.2: Map depicting Storm Drainage Network under BBMP



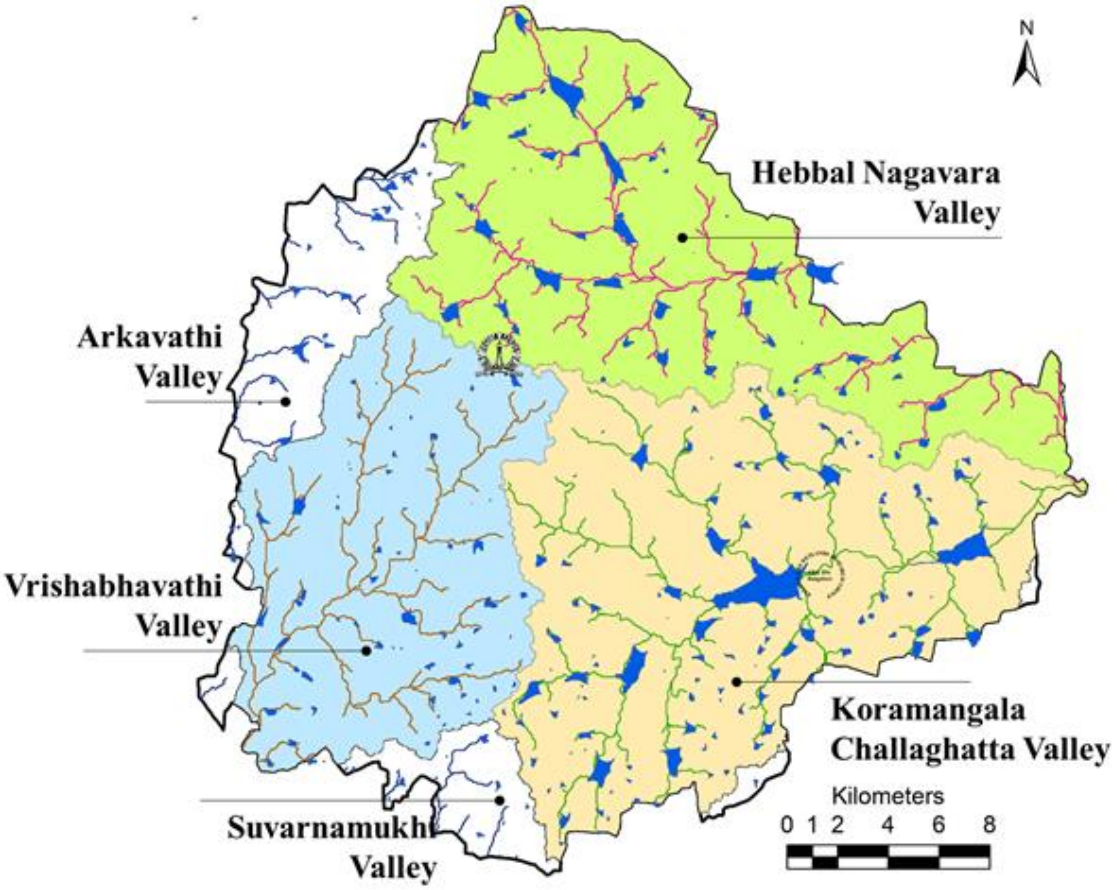
Source: CE, SWD, BBMP

1.4 River and lake network in Bengaluru[4]

The undulating terrain of Bengaluru city (varying from about 700 m to about 962 m above mean sea level) has led to the formation of interconnected lakes. By design, these lakes were all interconnected with canals/drains to enable the transfer of excess water to the next lake. These lakes catered to basic needs such as maintaining and recharging ground water, drinking water, habitat for fish and other aquatic life and agricultural activities.

Bengaluru being located on the ridge, forms three watersheds as precipitation flows as runoff in three directions along the valleys (**Chart 1.3**) – Koramangala-Challaghatta valley (K&C valley), Hebbal valley and Vrishabhavathi valley. Both K&C valley and Hebbal valley join at Nagondanahalli village (BBMP Ward 94 – Hagadur) which further flows to Dakshina Pinakini river while Vrishabhavathi valley joins Arkavathi river which is a tributary of river Cauvery.

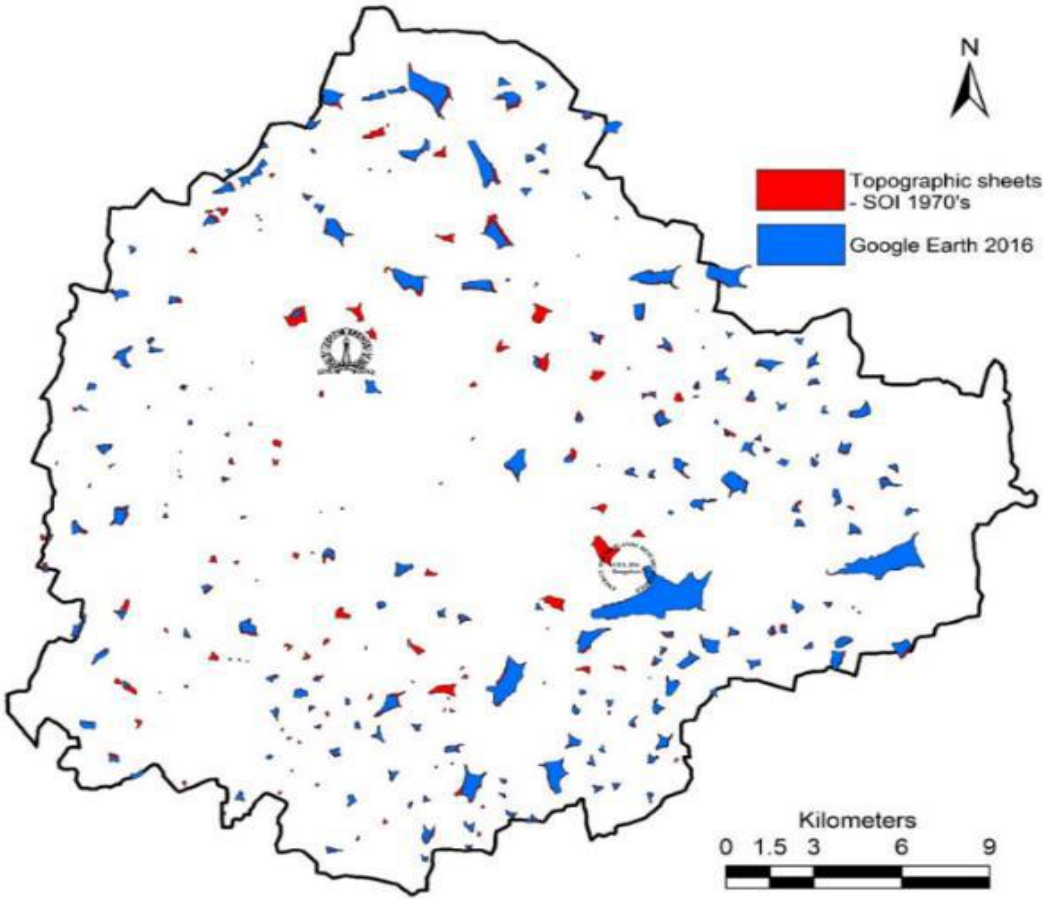
Chart 1.3: River and lake network along major valleys



[4] Study on Water situation in Bengaluru - Ramachandra T V, Vinay S, Durga Madhab Mahapatra, Sincy Varghese, Bharath H. Aithal, 2016. Water situation in Bengaluru, ENVIS Technical Report 114, Environmental Information System, CES, Indian Institute of Science, Bengaluru 560012

As per the study on Water situation in Bengaluru (henceforth referred to as 2016 study), the city had 1,452 water bodies with a total storage capacity of 35 TMC (thousand million cubic feet) (in the current spatial extent of 741 sq km) during early 1800s. By 2016, the number of water bodies in the same area reduced to 194 with a storage capacity of 5 TMC. Due to siltation, the current storage capacity further decreased to 1.2 TMC (2016). The status of lakes in Bengaluru is given in **Chart 1.4.**

Chart 1.4: Status of lakes in Bengaluru

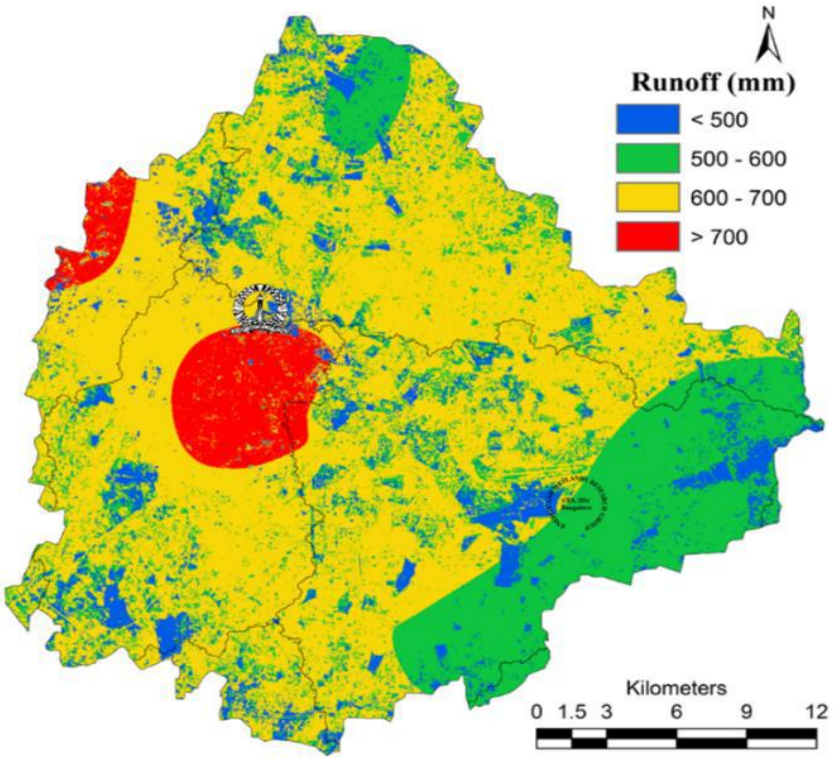


(Red colour indicates lost lakes between 1970's and 2016)

1.5 Rainfall and runoff yield in Bengaluru

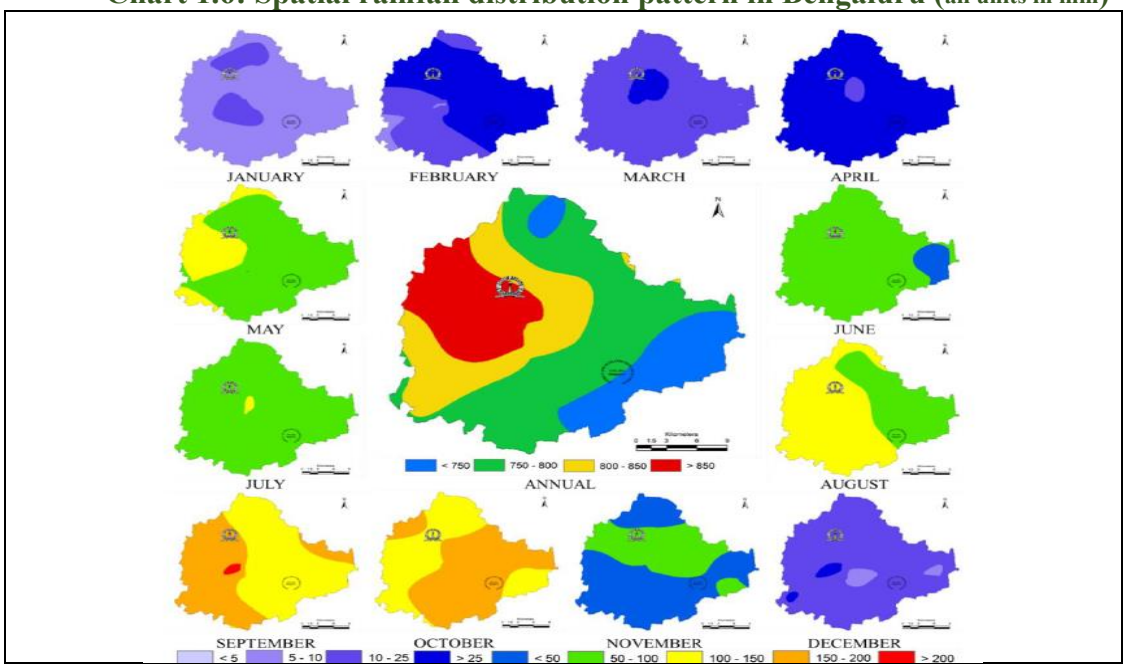
The average annual rainfall in Bengaluru is about 787 mm with 75 *per cent* dependability and return period of five years. The runoff yield is in the range of 600-700 mm in most of Bengaluru as indicated in **Chart 1.5**. Catchment wise water yield analysis indicates about 49.5 *per cent* of water yield in the Vrishabhavathi valley, followed by 35.2 *per cent* in K&C valley and 15.3 *per cent* in Hebbal valley. The total annual water yield in Bengaluru is about 14.80 TMC.

Chart 1.5: Runoff yield in Bengaluru (mm/year)



Considering the rainfall data for 115 years between 1901 to 2015, the 2016 study reports that the rainfall in Bengaluru was spread across seven months (i.e., 87 *per cent* of rainfall occurs between the months of May and November, September being the highest with average rainfall of 156 mm). The spatial monthly rainfall distribution pattern is depicted in **Chart 1.6**.

Chart 1.6: Spatial rainfall distribution pattern in Bengaluru (all units in mm)

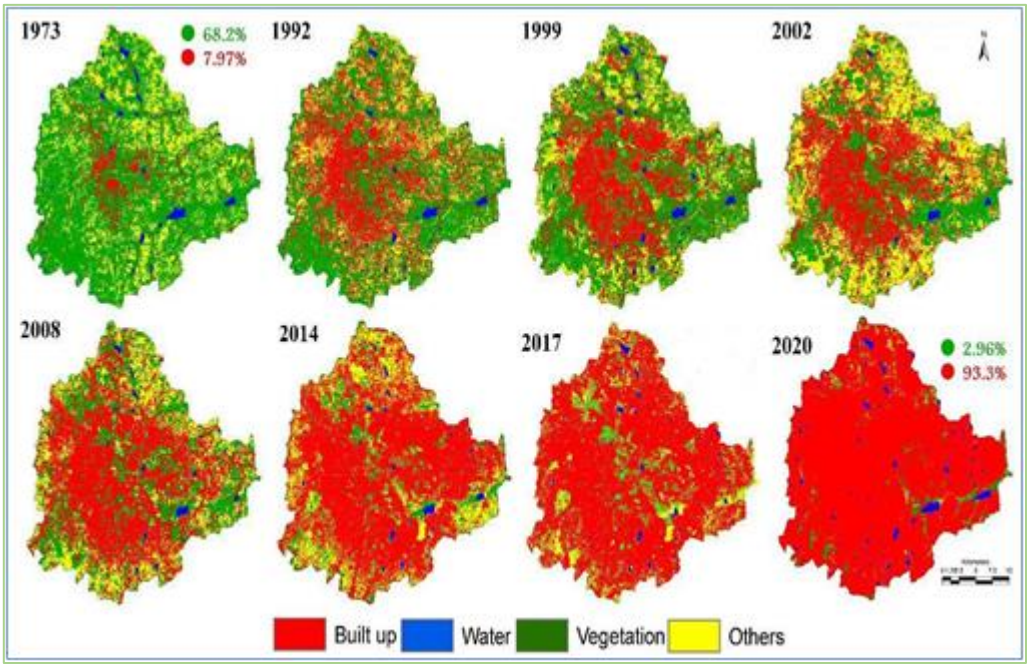


The 2016 study also estimates the requirement of water for domestic consumption at 20.08 TMC. Ideally, about 73 per cent of Bengaluru's water demand can be met out of rain water. Steps towards achieving this would include rejuvenating of lakes and re-establishing inter connectivity, treatment of sewage generated in households, rainwater harvesting, etc.

1.6 Need for storm water management

Bengaluru is experiencing rapid urbanisation. Accelerated growth has resulted in population increase and consequent pressure on infrastructure and natural resources leading to encroachment of water bodies/drains and depletion of natural drainage systems. Increase in concretisation and impervious layer results in increase of storm water runoff. The higher the runoff, the more the flooding. A 2017 IISc study estimated an increase of more than 1,000 *per cent* urbanisation since 1970s and an alarming decrease in vegetation cover (88 *per cent*) and water bodies (79 *per cent*) during the same period. The change in land use in Bengaluru as per the above study is depicted in **Chart 1.7**.

Chart 1.7: Land use dynamics in Bengaluru



The frequency of floods has increased over the years and has become a regular phenomenon resulting in submergence of low areas causing water stagnation at several locations, restricting pedestrian movements, traffic holdups for several hours, and extensive damage to public property. The need for effective storm water management is thus paramount.

Effective storm water management provides environmental, social and economic benefits to local communities. When storm water is managed well, streams, rivers and lakes are cleaner; flood risks are reduced; costs due to flood damage decrease and quality of community life increases.

1.7 Organisational structure for management of storm water drains in Bengaluru

The Urban Development Department (UDD) headed by Additional Chief Secretary (ACS) to Government of Karnataka is the controlling department for all Urban Local Bodies in the State, including BBMP. The Commissioner, BBMP is responsible for enforcing and overseeing the implementation of storm water management under the BBMP area. The Commissioner is assisted by Special Commissioner (Projects), Engineer-in-Chief and Chief Engineer (SWD). For the management of SWDs, the BBMP is divided into nine zones[5] each headed by an Executive Engineer (EE).

[5] Bengaluru East, Bengaluru South, Bengaluru West, Bommanahalli, Byatarayanapura, Dasarahalli, Koramangala, Mahadevapura and Rajarajeshwari Nagar.