AN ANALYSIS OF UNDEPENDABLE WATER SUPPLY IN BENGALURU CITY

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Abstract
The demand for urban water supply service is increasing rapidly as globalisation accelerates economic expansion and brings improvements in living standards in India with the interactive effects of demographic growth and influx of migrants into cities due to push and pull factors. Provision of reliable and safe water supply to urban habitat is an essential input for overall economic and social advancement.Urban water supply sector in India and particularly the study area Bengaluru is facing a number of challenges and constraints in meeting sustainable, safe drinking water. Bengaluru have augmented by an enormous 1005%, 100 times, in the past 40 yearsthis came at the detriment of the green cover, reducing from 68% in 1973 to merely 25% in 2012. The area of ponds and lagoons condensed to less than one third from 3.4% to just 1%. If the trend endures, Bengaluru would be left with merely 3% of green cover in the next couple of years.This paper has dealt primarily with the water supply sector of Bangalore city, the experiences and illustrations presented in this paper represent the prevailing water supply issues and this study primarily relies on secondary sources of data from Bengaluru Water Supply and Sewerage Board (BWSSB) and also various reports of World Bank and Asian Development Bank. The methodology adopted for the study includes the use of reference databases to create an overview of the water supply and demand situation in Bangalore city. The review evaluates the economic performance of water supply to illustrate the severe problems involved in pricing water, unaccounted for water and non-revenue supply of water and lists out the myriad political-economy and governance challenges in reforming the urban water supply sector.

Keywords: *Urban Water Supply, Water demand and Supply, Change detection, Demographic growth.*

Introduction

Bengaluru city has expanded rapidly with establishment of job generating industries. Recently, there has been a drastic change in the city growth trend in various sectors. This is mainly caused by migration of people from neighboring states. The changes in land use to meet the increasing housing demand, industrial infrastructures and commercial establishments have resulted in the increase of water scarcity and demand.

The World Urban population is projected to increase by 2.9 billion, from 3.4 billion in 2009 to 6.3 billion total in 2050 and 75% people will be living in urban areas (Comprehensive Assessment of Water Management in Agriculture, 2007, UN-HABITAT: 2013).

Between 2001 and 2011, the population of Bangalore grew by nearly 30 percent from 5.9 million to reach 8 million (Gindele et al, 2012; p. 1). It has a total land size of 1,279 square kilometers and now considered as the second largest city after Delhi.

Bengaluru of the yesteryears was a city of gardens; cool, pleasant and green. In addition to the 2000+ species of trees some natural and some specifically planted individual gardens in small households contributed to the large biodiversity here. The undulating terrain of the city allowed formation of lakes natural and manmade that were interconnected. As the ‘Garden City’ transformed into the ‘Silicon Valley of India’, the city’s rapid, uncontrolled growth turned this biodiversity haven to a concrete jungle.

The city does not have any surface water sources within 50 kilometer radius. The city therefore relies on water pumped from two distant rivers. These are the Arkavathy and the Cauvery rivers; with the latter being the predominant source. Apart from the long distance, river Cauvery is about 500 meters below the city of Bengaluru, necessitating huge pumping and energy costs. Notwithstanding these efforts, a significant proportion of the city's populations are not connected to the centralized water system.

Study Area

ThestudyareaBengaluru city lies in the southeast of the South Indian state of Karnataka. It is in the heart of the Mysore Plateau (a region of the larger Precambrian Deccan Plateau) at an average elevation of 920 m (3,020 ft). It is positioned at12.97°N 77.56°E and covers an area of 800 km². The City Government was called Bangalore MahanagaraPalike (BMP), with 100 wards in 1986. It was renamed as Bruhath Bangalore MahanagaraPalike (BBMP) in 2007 (147 wards). Presently there are 198 wards in BBMP according to 2011 Census. The population has 9.588910. With sex-ratio of 908 female/1000 males and its density were 4,378 people per square km in 2011 census. There are seven City Municipality Councils and one Town ship (Kengeri), 110 villages, four taluks (Bangalore North, Bangalore South, Bangalore East, Anekal), all together can be called BBMP or Bangalore Urban District. The study is limited to BBMP.

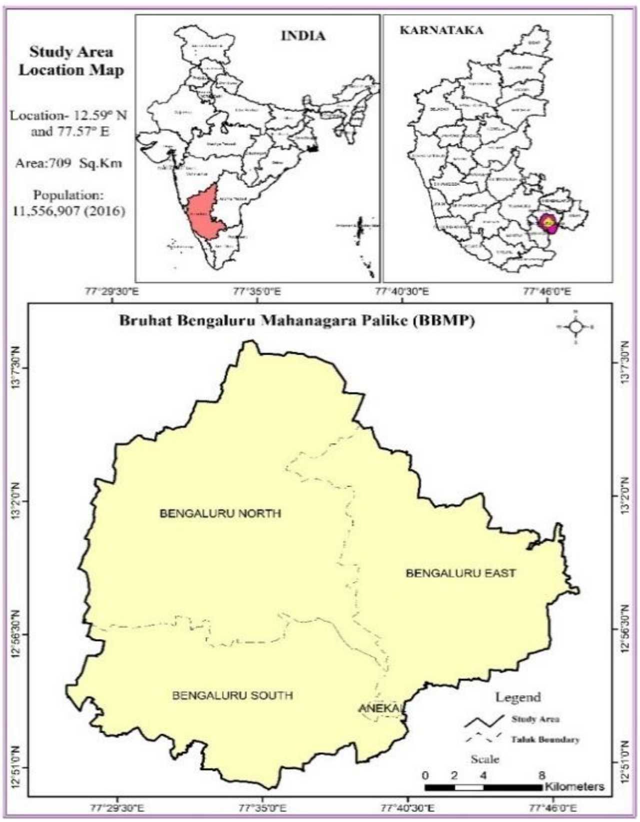

Figure 1. Location Map of the Study Area

The annual mean air temperature is around 22°C with May is the hottest month having maximum temperature of 38°C and December is the coldest month having minimum temperature of 13°C. The study area has a semi-arid subtropical climate with mild summers and cold winters. The average annual rainfall in the study area is about 950 mm. The major portion (i.e., around 55%) of the rainfall is received during the south-western monsoon period (June to September); and, the pattern of rainfall in the city shows an increasing trend with wide variation.

Data and Methodology

In the present study we have used mainly two types of data. These are topographic maps and Primary data.The Topographic map of the study area is digitized with the help of toposheet number 57H/9 and 57H/9/1 with the scale of 1:25,000 obtained from Survey of India.First of all, the topographic maps of 1973 were scanned and rectified using a geometrically corrected image with the ArcGIS10.1 software. Primary data collected during the period of fieldwork, various strategic locations were visited and were geo-tagged using the GPS machine. This has been mainly for the purpose of identifying landmarks and to provide inputs for Urban water supply maps.

Transect walks were conducted all over the study area. For the purpose of transect walk, the study area was divided into Nine zones. The researcher’s objective was to cover as much of the area as possible, so that proper inputs could be generated for Urban water mapping. This was also to create a realistic understanding of the water supply scenario.

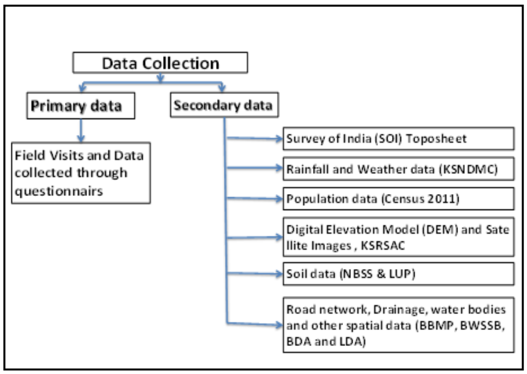

Figure 2. Flow Chart Depicting Data collection

In-Situ studies was taken an area of about 38 km2 around the BBMP area has been mapped geographically and geomorphologically, corresponding to the base map. The outcrops of the study area and the variations in the strike and dip of foliation and folding are demarcated. The existing built-up areas have been photographed to illustrate their field evidence. The STPs and drainage pipelines of BBMP outside the study area have been taken care of.

Aim and Objective

To conduct a detailed study of water distribution and to suggest best recommendations to overcome the problems plaguing the city of Bengaluru.

Given the above-stated aim, we identified the following objectives that needed to be studied: To identify the problems and key challenges regarding water distribution. To identify the supply and demand gap of water supply in Bengaluru and provide solutions for effective water distribution in Bengaluru. To examine the government policies and programmes and suggest recommendations for their improvement.

Literature Review

Environmental issues finds the necessity of ground water recharging. The main difficulties faced are with regards to functioning and maintenance of the water distribution system [6]. However, the limitation of this paper is that it does not address the leakage issues prevalent in the current water distribution system.
The number of challenges and constraints with regards to water supply and distribution requirements in Bengaluru were analyzed [7]. The paper establishes that BWSSB experiences poor cost recovery and concludes that water tariff should be increased. The main limitation of this study lies in the fact that it considers only a few of the National water distribution policies.
The misuse of water in the city of Bangalore were discussed in [9,10] and the reasons behind water loss. In parallel studies show that the water management undertaken by Singapore [3]. The water management system in Mysore is elucidated [11,5] and the steps undertaken for prevention of loss and misuse of water was also discussed. Lastly, the water situation in rural Karnataka is analyzed [8].

Result and Discussion

Bangalore, the capital city of Karnataka is the third largest city and the fifth largest metropolitan area in India and is one of the fastest growing metropolitan cities. It is a centre for education, IT & BT industries, sophisticated high tech health care and many MNC industries which are attracting people to the city. As per Census 2011, the population of Bangalore city was about 8.5 million. The Bangalore Water Supply and Sewerage Board (BWSSB) is responsible for providing water supply to BBMP area of 800 sq. km.

Cauvery River

Water to city Bengaluru is drawn from river Cauvery abstracted at Shiva Anicut and conveyed through a channel to Netkal Balancing Reservoir and transferred to treatment complex at Tore Kadanahalli, which is about 95 Kms from Bangalore on Kanakpura Road. Through gravity mains, here water is treated at thetreatment plants of Cauvery. Water Supply Scheme stage 1, 2, 3, and 4. Filtered water is pumped to city through 3stage of pumping with the pumping stations located at T.K. Halli, Harohalli, (about 95& 40 Kms. from Bangalore respectively) Tataguni (about 20 Kms. form Bangalore) through steel transmission mains. At present, the total supply from Cauvery is about 850MLD. The details of the scheme are as follows.
Cauvery Water Supply Scheme Stage 1:
The scheme was commissioned in the year 1974 with capacity of 135 million litres per day at the total cost of the project was Rs.36 crores Water is pumped through 1200 mm dia steel transmission main, 5 pumps are installed at eachof each of the pumping stations with 3 pumps running round the clock.
Cauvery Water Supply Scheme Stage 2:
The scheme was commissioned in the year 1982 with capacity of 135million litres per day at cost of Rs.85 crores. Water is pumped through 120mm dia steel transmission main 5 pumps installed at each of the pumping stations with 3 pumps running round the clock.
Cauvery Water Supply Scheme Stage 3

This scheme was commissioned in the year 1993 augmenting about 270 million liters per day to the city, water is pumped through 1750mm dia steel transmission main 8 pump are installed at each of the pumping stations with 5 pumps running the clock. Estimated cost of the scheme was Rs.240.00crores.

The designed capacity of the scheme is to supply 270 million litres of water per day. Water is pumped through 1950mmdia steel transmission main. At present 4 pumps out of 8 pumps installed at each of the pumping stations are running round the clock supplying about 240 million litres of water per day. The scheme was commissioned on 29-07-2002.The project was implemented at a cost of Rs.1072 crores, part of which (Rs.804 crores) is funded through financial assistance from Japan Bank for international co-operation.

Bruhath BengaluruMahanagaraPlaike (BBMP) comprises of 800 sq kms consists of core area 245 sq.kmsarea while 7 CMC and 1 TMC 330 Sq Kms and 110 Village 225 Sq Kms BWSSB is supplying 1400 Million Liters per Day (MLD) of water from River Cauvery. It is estimated that about 400 MLD water is utilized from bore well supply (public + private). Total water supply is 1800 MLD.

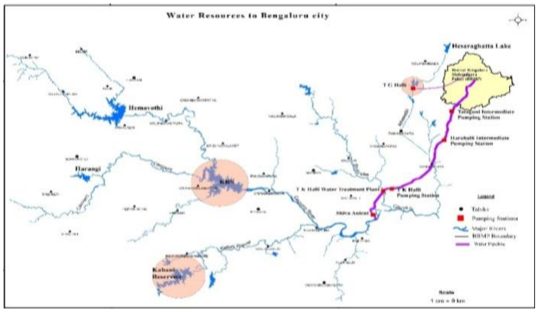

Figure 3. Water Supply to Bengaluru

Table 1. Present Water Supply (Source: BWSSB, GoK, 2016-17)

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
Average cost of water	28 Rs/kL

A major concern regarding water distribution is the rising gap between demand and supply conditions. To understand the current situation in Bengaluru and to evaluate the requirements in the future, we constructed the bar chart of the demand-supply gap as shown in Figure 1 below. Although the graph shows that the gap has almost been bridged by the year 2015, due to the rising population and problems related to water theft and leakage at

various points, BWSSB continuously struggles to be able to supply the required quantity of water to all areas of Bengaluru.

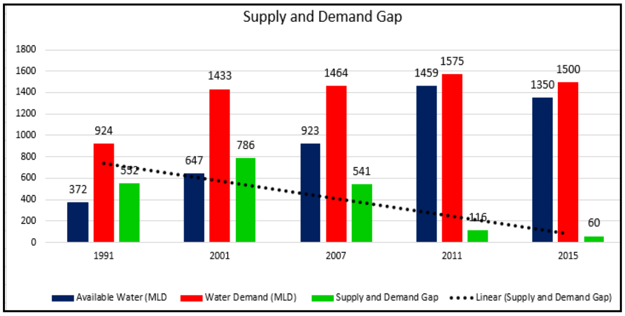

Figure 4. Demand-supply gap.

To evaluate the future requirement of water, we performed a regression analysis with the primary data gathered from BWSSB sources. Given that water requirement is the dependent variable, we forecasted the requirement in 2020 considering the population as predicted by the census. Table 1. gives the data used for the regression analysis and Table 2 provides the forecasted requirement for 2020.

Table 2. Forecasted demand for 2020Model

Predicted Population for 2020 =	136.2608
X1 is the Population for 2020	Y=.66,69=14.44xX1
2020=	1900.92

Year	Population/Demand (Lakhs	Potential Supply (MLD)
1901	1.63	14
1911	1.89	14
1021	2.4	14
1031	3.1	14
1941	4.11	14
1951	7.11	41
1961	12.07	62
1971	16.64	86
1981	19.22	157
1991	41.3	300
1994	46.7	705
2001	58.69	705
2002	60.37	959
2007	68.79	959
2012	89.11	1203
2015	100	1400
2020	136.26	!

Table 3. Future prediction of Demand and Supply for 2020 using Regression Model.

Table 3shows that the demand is forecasted to increase by 500 MLD by 2020. This indicates that BWSSB should be prepared to increase their capacity in their subsequent expansion Plans to bridge that gap.

Conclusion

As the water requirements continually increase with rising population, changing climatic conditions and other social and environmental factors, it becomes imperative to study alternative mechanisms which would help to restore the ground water situation and establish an ecosystem that encourages recycling along with usage. With a view to this, we performed a study of the National water policies act 36 of 1964 and its amendments in 1966, act 10 of 1966 and amending act 18 of 1984 for India and compared them with the water policies for Singapore [3] and Europe. We also studied the different mechanismsadopted to tackle the water crisis and leakage or theft situations in other cities of Karnataka, namely, Tumkur and Mysore [2,4]. Based on these, we provide the following recommendations:

Recommendation and Suggestions

Urban water management, flood management, water scarcity reduction like water efficient technologies, natural water retention, Green Infrastructure (planting trees, restoring wet land) to be practiced.

Bio diversity measures and scientific collaborations should be encouraged. Use of biological indicators for water quality assessment as they are less expensive. Interlinking the rivers to subsequent water bodies to ensure the potential level. Rain water harvesting should be extensively adopted wherever possible, which is the best natural source available.

Flood irrigation to be practiced to recharge the ground water level instead of just letting them flow as a waste. As the Red clayey soil of Bengaluru is conducive to water retention, water can be collected by digging pits. Leakage losses can be checked by replacing new pipelines periodically.

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