Sustainable Water Supply Management in Bangalore City Karnataka, South India

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Abstract

Bangalore, the capital of Karnataka, is an important social, economic, cultural, administrative, educational and political centre of State known for *Garden city* and wide. A phenomenal growth of population together with massive immigration from rural areas and neighboring states to urban center results in change in urban Structure. This has resulted in widening gap between available resources and their demand in urban areas. Urbanization is considered as an indicator of development but at the same time it is creator/producer/generator of many problems among them the most important is water problem. Therefore, there is urgent need to take necessary measures to create enabling measures to cope with. Bangalore has a well-planned water supply and sewage system, which is designed to meet the incremental demands of its population. Many citizen-centric measures have been initiated by the Bangalore Water Supply & Sewerage Board (BWSSB) to improve the efficiency and to enhance the capacity for providing better quality of services to meet the growing demands of its citizens. Although there is no over-all deficit like situation in Bangalore as far as water supply and sewage facility is concerned, definitely there is a question of inadequate access to the facility by disadvantage and poor groups on one hand and rapid rise of water demand on the other, making it imperative to look into the governing process of BWSSB. This paper presents an evaluation of the overall performance of BWSSB not only depends on an effective determined by the strength of the structural and functional components like water management capacity, accountability pattern, and sustainability and consumer orientation. These aspects provide us insights into the current status of amenability capacity, adaptive to innovation, openness to changing needs and requirements and promote responsiveness.

Introduction:

Population plays a major role in the urban growth. Increase in population and land transformation goes hand in hand. It is one of the most important factors of land transformation with extensive history dating back to millions of years back. This conversion has not stopped till date rather got accelerated and diversified resulting in multitude of problems.

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providing better quality of services to meet the growing demands of its citizens. Although there is no over-all deficit like situation in Bangalore as far as water supply and sewage facility is concerned, definitely there is a question of inadequate access to the facility by disadvantage and poor groups on one hand and rapid rise of water demand on the other, making it imperative to look into the governing process of BWSSB.

The pace of urbanization is rather fast in the State. With most of its land under cultivation Karnataka has fast urbanization rate due to the increasing tendency of the population to move towards urban areas. The urban population is 5.68 millions in 2001 instead of 4.13 million in1991. With the rapid increase in size of population existing urban structure of Bangalore City is not able to accommodate the increasing population and results in growth water scarcity and faulty drainage system.

Study area:

Bangalore, a tiny village in 12th century grew through times to become one of the fastest growing cities in the world in the 21st century. It has a history of 469 years. This capital city of Karnataka is the fifth largest city in the country and has population about 5.7 million. It was the 16th biggest country in 1941 and grew to become the eighth largest country in the very next decade. Its geographical location in the heart of South India and its salubrious climate (maximum temperature of 33° C to lowest minimum of 14 ° C) has contributed to its growth and importance. The city is 949 meters (3,113 feet) above mean see level and at 12° 58| to 13° 0| North Latitude and 77° 37| to 78° 18| East Longitude. It covers an area of about 2190 Sq. Kms. The swift growth of Bangalore that stands as Silicon Valley of India in today's computer ramp has grown on the extent of valuable and productive agricultural land. It observed that the population of the population of Bangalore city stands at 5.7 million as per 2001census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively.

Industrialization of Bangalore city is rapid since 1951 where the employment opportunity increased. Large-scale construction activities, educational opportunities, medical facilities, business and industrial activities etc are available in Bangalore has attracted large number of migrants. The number of literate population has also increased and is ever increasing. Though these increases make us happy, there are also increases in sky scrapers, vertical developments of residential units.

Objective: For the sustainable water supply management in Bangalore City it is necessary to follow certain objectives are as follows:

- Growths of Bangalore City form its origin to till date.
- Integrated approach for the development of water supply.
- To investigate adequacy of water supply for domestic purpose in Bangalore City.
- To prepare and implement plans and schemes for supply of water for domestic purposes within the Bangalore City to the required standards.
- To prepare and implement plans and schemes for proper supply of water in Bangalore City in future.

Methodology:

In the present study of sustainable water supply management in Bangalore City, data

from secondary as well as primary sources like Bangalore District Census Hand Book, data from Bangalore Water Supply and Sewerage Board (BWSSB), Handbook of Statistics from various decades 1991-92 & 1992-93, 1993-94 & 1994-95, 1995- 96 & 1996-97, 1997-98& 1998-99, and Annual Reports: 2002-2003, BWSSB, Bangalore. And data of Ban galore Metropolitan Area (BMA) covered area has been collected and analyzed. As the study is qualitative in nature simple tables and suitable maps have been generated. Since Bangalore City is a dynamic metropolis there are a series of popular articles published in leading dailies from which information has been elicited.

Urban Growth:

The population of Bangalore city stands at 5.7 million as per 2001 census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively. With the Information Technology (IT) boom, Bangalore is one of the fastest growing cities in India and Asia. With the emerging Bio-Technology (BT) boom, Bangalore's population growth may be even faster in the forth-coming decades. Bangalore is booming with other growth which is evident from its nicknames viz. "India's Silicon Valley", "Fashion Capital of India", "The Pub City of India", and so on. All these factors contribute to the growth of population of city. The table 1 below shows the growth trends.

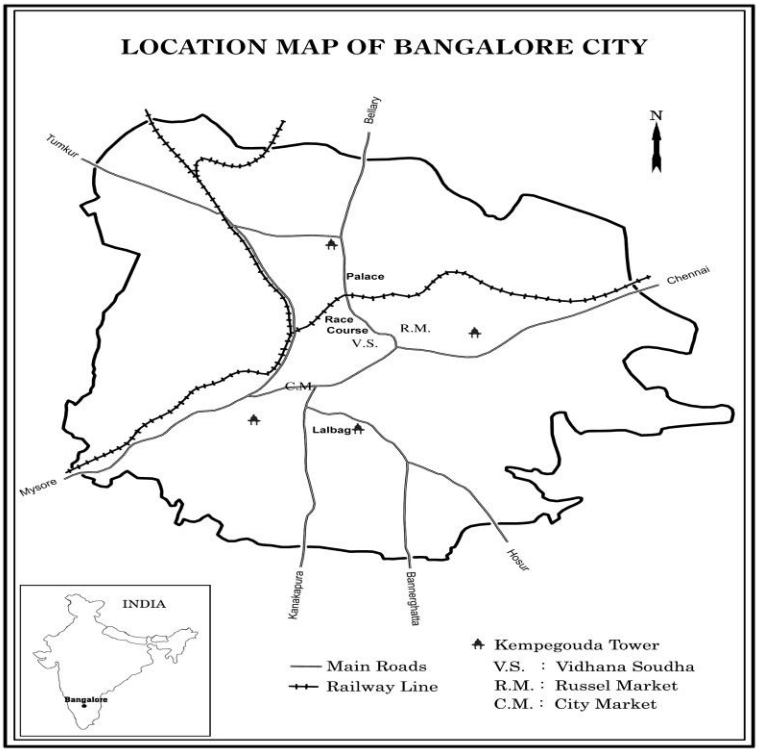
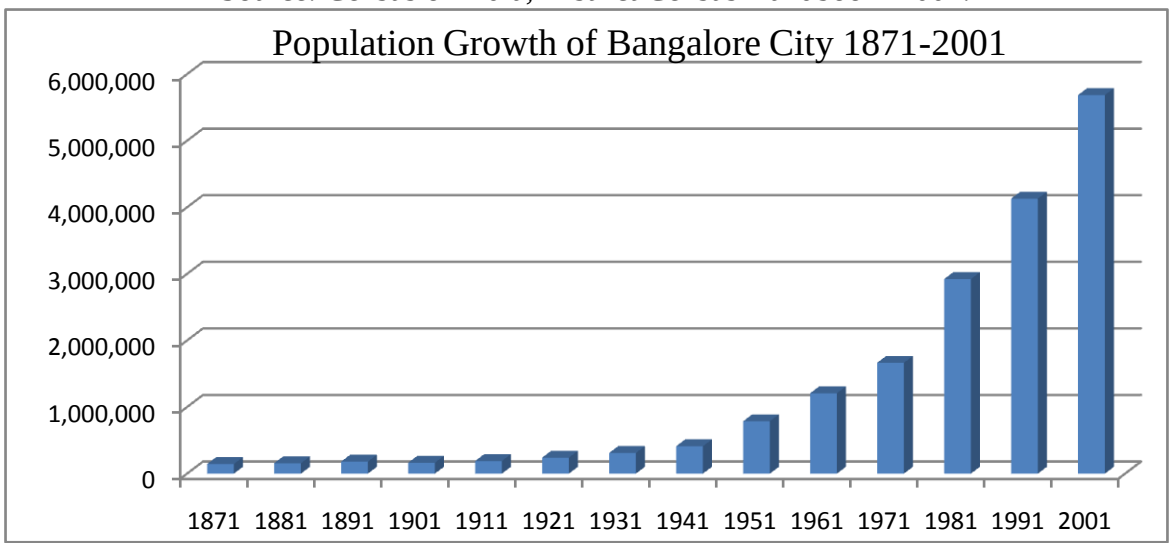


Table 1: Population Growth of Bangalore City 1871-2001

Year	Area (in km2)	Population	Sex Ratio	Density	Decadal Variation in %
1871	NA	144,479	NA	NA	--
1881	NA	155,857	1,128	NA	7.88
1891	NA	180,366	981	NA	15.73
1901	NA	163,091	962	NA	-9.58
1911	60.35	189,485	938	NA	16.18
1921	NA	240,054	893	NA	26.69
1931	NA	309,785	903	NA	29.05
1941	NA	410,967	900	NA	32.66
1951	NA	786,343	883	NA	91.34
1961	501.21	1,206,961	874	2,408	53.49
1971	177.30	1,664,208	875	9,386	37.88
1981	365.65	2,921,751	896	7,991	75.56
1991	445.91	4,130,288	902	9,263	41.36
2001	531.00	5,686,844	906	10,710	37.69

Source: Census of India, District Census Handbook -2001.



The spatial extent of Bangalore City in the year 1971 was about 177.30 sq.km. this increased to 365.65 Sq.Km. in 1981 and 445.91

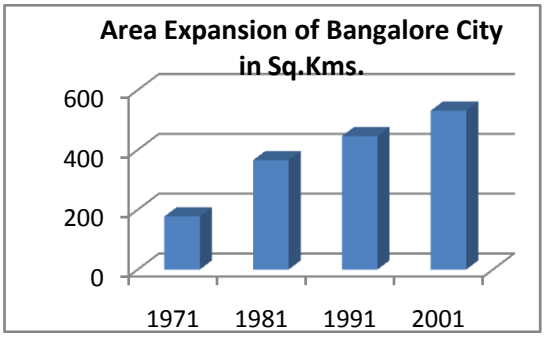
Sq.Km. in 1991 to 531.00 Sq.Km. in 2001 respectively. As it is evident from the census figures (Table 1) urbanization in 1971-81due to expansion of urban area, we can see the real emergence of city
outgrowths. Of course this includes factory type of urbanized areas plus the enormous outgrowth of urbanized fringe villages with new layouts with or without civic amenities. Where the latter is a kind of phenomenon that exists in these newer urbanized areas even at all India level (B.K.Ray1993). In the year 1981 the Bangalore City along with its outgrowths has a population of 2.9 million, which increased to 4.1 million to 5.6 million in 1991 and 2001 respectively. It attributes fastest growth in aerial expansion of Bangalore City.

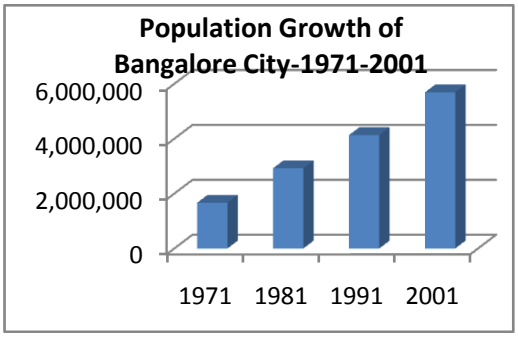
The urban aerial expansion of Bangalore city has shown remarkable growth in recent years. Table 2 shows temporal dynamics of urban sprawl of Bangalore City.

Table 2: Urban Sprawl of Bangalore City in the recent decades

Year	Area Sq.Km.	% Growth/year	Population	% Growth/year
1971	177.30	-	1,664,208	37.88
1981	365.65	27.35	2,921,751	75.56
1991	445.91	22.43	4,130,288	41.36
2001	531.00	18.83	5,686,844	37.69

Source: Compiled from population Statistics– Kendriya Sadana Koramangala, Bangalore.





Land use pattern of Bangalore City:

The other major effect of urban growth is the change in land use pattern of Bangalore City. In the year 1983 the total land area was 20283.18 hectares, which increased to 28400 hectares in 1990 to 42432 hectares in 2001, further it will be increased to 56462 hectares in 2011. The map below shows the growth of Bangalore from 1537 – 2001. And the table 3 below shows land-use classification of Bangalore City 1983-2011.

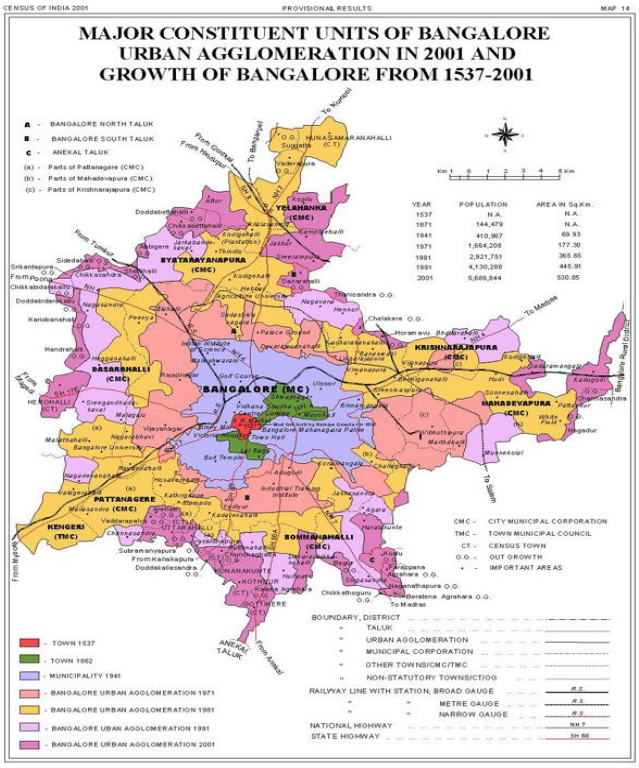
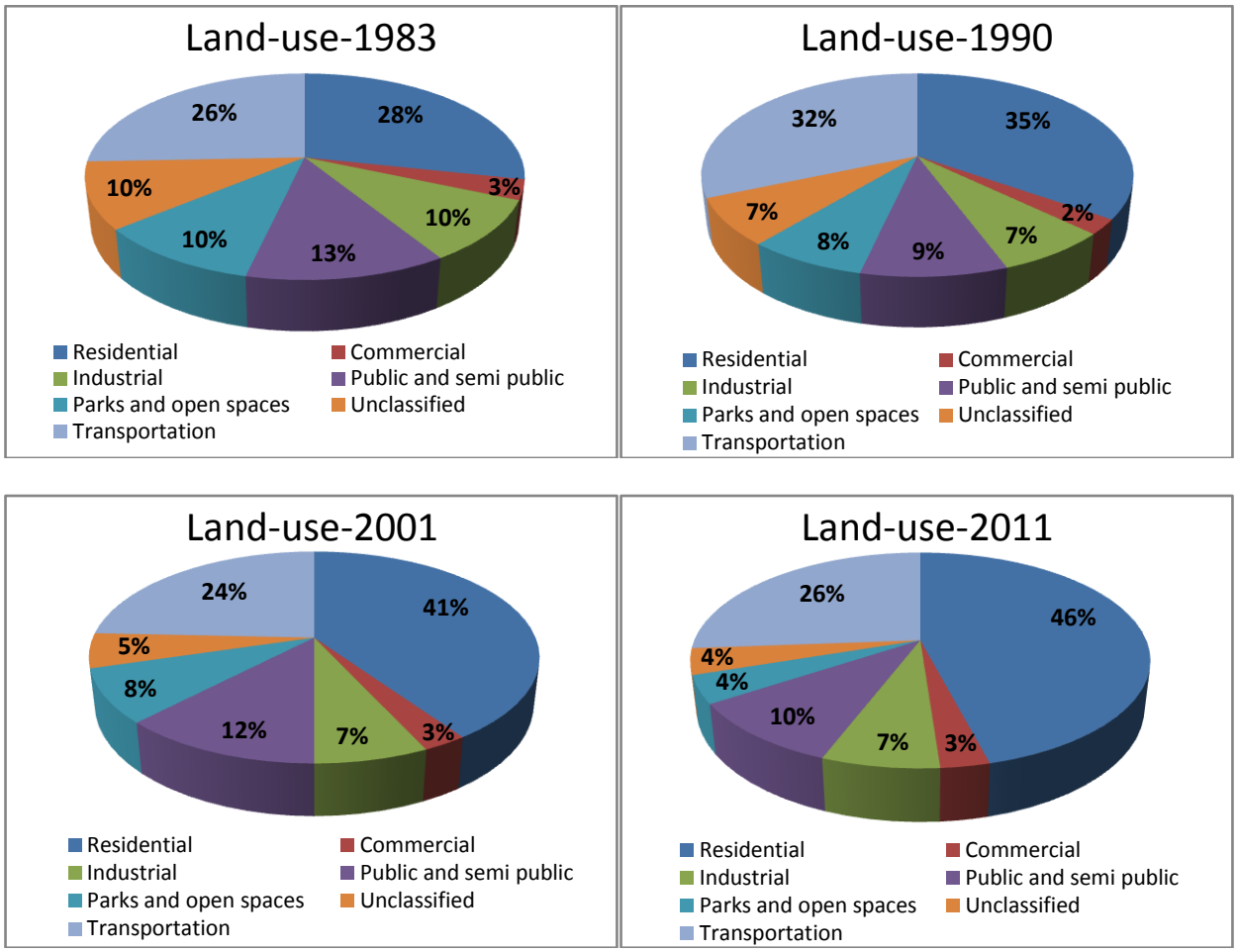


Table 3: Trends in land use in Bangalore City 1983-2001 and 2011

Land-use	**Area (Ha) (1983)**	**%**	**Area (Ha) (1990)**	**%**	**Area (Ha) 2001**	**%**	**Area (Ha) 2011**	**%**
Residential	5777.65	28.48	9877.65	34.88	17123	40.61	24369	45.94
Commercial	634.07	3.14	675.07	2.38	1159	2.85	1643	2.91
Industrial	1956.61	9.75	2038.61	7.18	2941	6.95	3844	6.98
Public and semi public	2533.64	12.60	2615.64	9.21	5201	12.25	4908	9.89
Parks and open spaces	2050.16	10.41	2132.16	7.67	3520	8.25	7788	4.17
Unclassified	2114.24	10.42	2114.24	7.45	2164	5.32	2213	3.92
Transportation	**5216.81**	**25.82**	**8946.63**	**31.60**	**10321**	**24.3**	**11697**	**26.19**
Total	**20283.18**	**100**	**28400**	**100**	**42432**	**100**	**56462**	**100**

Source: Data Collected and Compiled from BMP Master Plan.



The land-use for residential purpose was 28.48% 1983 which increased to 34.88% in 1990, to 40.61% in 2001 and it is likely to increase around 45.94% in 2011. This increase will be due to formation of new residential layout in outgrowth of Bangalore. Similarly land-use for commercial purpose was 2.38% in 1990, increased to 2.85% in 2001, and more or less it is going to be around 3% only. Land-use for industrial purpose will also remain around 7%. Whereas the land-use for Public and Semi Public was 12.60% in 1983, reduced to 9.21% in 1990 and it increased to 12.25% in 2001. But it is going reduce to further by 9.89% in 2011. This will be attributed to Public and Semi Public (soft ware sector) already established in the last decade. The land-use for parks and open space was around 10.41% in1983, reduced to 7.67% in 1990 and 8.25% in 2001. It is going to be around only 4.17% in 2011- all due to the upcoming Bangalore Metro and widening of roads in around Bangalore City. Whereas the land-use for unclassified sector was 10.42% in 1983, reduced to 7.45% in 1990 and further declined to 5.32% in 2001, and it is further going to reduce to 3.92% in2011, due to urban developmental activities of the city. The land-use for transportation was 25.82% in 1983, 31.60% in 1990. It reduced to 24.3% in 2001 and it is further going to increase by around 26.19% in 2011.

Formation of Bangalore Water Supply & Sewerage Board (BWSSB):

The BWSSB is relatively old institution. The Board was constituted in 1964. Previously the formation of the Board, the task of providing water supply to the city was with the Bangalore City Corporation in the cantonment area and by Karnataka Public Works Department (KPWD) as the city area. From 1961 onwards the entire distribution system except the head works was transferred to BCC (Ban galore City Corporation) for its maintenance. In a number of states, statutory Water Supply and Sewerage Boards are created to with a main objective of introducing commercialization in the water supply and sanitation sector management and bring more accountability. In fact it was at the instance of World Bank that came first hand appraisal of the project insisted upon the need for creating an autonomous Board with water and sewerage authority, which would handle with greater financial and operational autonomy, as well as emphasis on accountability to its citizens. Accordingly, it was also accepted that this move would help towards cost recovery through user fees, which could avoid political interference and generate a substantial proportion of the resources needed to augment bulk water supply.

Current Trends Bangalore Water Supply & Sewerage Board (BWSSB):

The people of Bangalore were supplied unfiltered water for a long time in the Karanjee system from number of tanks viz ., Dharmambudi, Sampangi, Sankey, Ulsoor etc. in addition to tanks, local wells and ponds constituting the water sources. The first scheme to provide protected water supply to Ban galore was under taken under 'Chamarajendra Water Works' in the year 1894 was initiated by Sir K. Sheshadri Iyer, the then Dewan of Mysore. The source of supply was Hessarghatta (The Hessarghatta lake is situated at a distance of 18 kms to the North West of the City) Lake on the river Arkavathy River. Due to drying up of the river and increase in demand 'The Chamarajasagar Reservoir' at T.G Halli across the river Arkavathi was constructed and was put into service in 1933. After the formation of the board (the 'Board' or BWSSB), the total supply of water from Hessarghatta and C.R.S reservoir which was initially 6 MLD (million liters per day) and 27 MLD was gradually increased to 22.5 MLD and 143.00 MLD by increasing the storage capacity of the reservoirs. Keeping the view the increasing demand of water, growth of the city and long-term requirements of water supply a comprehensive scheme was mooted. For the first time tapping River Cauvery was considered, the government during April 1964 accepted and Cauvery Water Supply Scheme (CWSS) I stage project was launched in 1974. And subsequently CWSS II stage was also commissioned in 1982 (together 270 MLD). To cope up with the ever-increasing population and demands the CWSS III stage was taken up during 1985-86 (to generate additional quantity of 270 MLD of water). The standard level of water supply was 140 liters per capita per day could not be served to the increasing citizens of Ban galore from 41.30 lakhs during 1991 to nearly 60 lakhs during 2004. The BWSSB therefore formulated CWSS-IV Stage Phase I scheme to maintain the level of supply of 140 LPCD (litres per capita per day) and bring an additional 270 MLD of water at an estimated cost of Rs 1072 crores, and CWSS-IV Stage Phase II to bring in additional 500 MLD of water from T.K Halli to Ban galore at an estimated cost of Rs.2000 crores. The source-wise water supply, drinking water potential and capital investment is indicated in the table (see table 4).

Table 4: Source of Water Supply in Bangalore City

Source of Water Supply	Established in the Year	Distance (In kms)	Potential (In crores)	Investment (In crores)	Average Unit Cost per thousand liters after completing of project
1. Arkavathy	1896	18	22.5	NA	0.45
a) Hessarghatta	1933	28	143.0	NA	
b) T.G Hally					
2. Cauvery					
a) Stage- I	1974	98	135.0	35	1.70
b) Stage-II	1982	98	135.0	80	2.70
c) Stage-III	1993	98	270.0	240	4.63
d) Stage-IV					
Phase – I	2001-03	98	270.0	1072 estimated	-
Phase – II	2003	98	500.0	2400 estimated	-
Phase - III	2005 (Will be commencing	98			

Source: Handbook of Statistics (BWSSB), 1997-98 and 1998-99

The above details clear shows that the capital investment across the river Arkavathi was less than the capital investment on the CWSS I, II, III and IV Stage projects which was undertaken recently which involved increased cost of materials and labor charges. Again, it can be observed from the table that capital investment in CWSS I, II and III & IV varies by two folds to bring the same quantity of water. Even the average cost of water, which was Rs. 1.70 per thousand liters, increased to Rs. 4.63, when Stage-III project was completed. Though there is ample scope for development of water resources in Bangalore (Ban galore is one of the few cities in India, which has assured drinking water supply system for the last 100 years). But the cost of bringing additional water to Ban galore in the near future would sharply rise in the cost of construction of projects and their maintenance. Moreover, presently the Board is running under deficit budget, and the expansion of metropolitan region may make it difficult to obtain the land for laying the pipelines for

transport and distribution due to the rise in capital costs of land.

The quantum of water available at present from all the four sources together is 705.50 million liters per day. But due to failure of monsoon in the Arkavathi river, the entire potential is not been utilized which considerably varies from year to year which is indicated in the table (see table 4). The table clearly indicates that as against the potential availability of water the per capita availability of water is less. This is far below the national standard recommended by CPHEEO: - (*The Standard Norm recommended by CPHEEO is 150-200 LPCD for a city of the size of Bangalore)*. As Bangalore Metropolitan Area (BMA) is increasing considerably *(The present Metropolitan Area comprises of 595 sq kms.)* augmenting the existing water supply system of Bangalore City becomes imperative. Due to the different pattern of consumption by the various socio-economic groups of urban population and conservation measures, the water demand for the city hence is much lower than the projected demand (Sastry).

On the basis of population projections from 2001, 2010, 2015, 2021 and 2036 A.D the requirement of water, probable demand and supply and the resultant shortage for respective years are also calculated which are presented below (see table 5):

Table 5: Population projection-demand and supply of water in Bangalore City

Year	Population (lakhs)	Water Demand (MLD)	Water Supply (MLD)	Shortfall (MLD)
2001	53.79	870	540	330
2010	75.00	1125	900	225
2015	88.00	1500	1470	300
2021	100.00	1800	1470	330
2036	125.00	2500	1470	1030

The BWSSB, ready with many plans on paper, is certain that the water demand will only rise this year. For, Bangalore has no major river and the existing tributaries are all polluted. As the Board chairman himself puts it, Bangalore needs 1,125 mld (million liters per day) but only 900 mld of water is being supplied now. There is demand for an additional 225 mld. In 2002, there were only 3,10,000 water connections in the City, which almost doubled to 6,23,000 by 2010. As many as 35,000 new connections were added annually.

With the Centre's approval, the State Government had earmarked 14.52 tmc ft of Cauvery water for drinking water to Bangalore. Out of this, 6.5 tmc ft has been utilized in the III stage and 8 tmc ft for the IV stage II phase Cauvery water distribution. As things stand, river Cauvery continues to be virtually the only source of water for the City. Only three per cent of the total water supply is sourced from the Tippagondanahalli (TG Halli) reservoir. Despite its capacity to meet a larger requirement, the reservoir has no defence against the industries and housing developments.

BWSSB Agenda in Bangalore City:

To address the current water shortage and the looming threat of the near future, BWSSB has now come up with an array of long-term and short term projects. This, the Board believes, will help the City meet the water demand over the next 50 years. An expert committee set up by the State Government, with former BWSSB Chairman, B N Thyagaraja as chairman, will work on these proposals. Protection of indigenous water resources is high on Thyagaraja's agenda. "River Arakavathi, which originates from Nandi Hills and river Kumudavathi from Shivaganga needs immediate attention by protecting and

rejuvenating them for our water conservation. The Government must take stringent action against sand mining and unauthorised irrigation pump sets which is hampering the river catchment area," Thyagaraja says.Since Bangalore is landlocked and does not have any major river, its development would be restricted, warns Thyagaraja. For that not to happen, the Government had to wake up, for instance, to stop the indiscriminate sinking of borewells. Unlike in Tamil Nadu, which has adequate regulations, Karnataka does not have any law protecting the ground water.

The acute water crisis of 2011 was primarily because of this groundwater depletion. In many areas such as K R Puram and Mahadevapura, the groundwater has depleted to such alarming levels that not a drop could be found even at a depth of 1,000 ft. Incidentally, there are about 4,000 borewells dug by BWSSB and another 1,000 drilled by the BBMP.

Long-term plans:

A dam with a capacity of 45 TMC near Mekedatu is a major part of BWSSB's long-term strategy to address the City's water shortage. Both the Karnataka and the Tamil Nadu governments along with the Centre are to be partners in this mega project. Also on the agenda is a hydro power plant and to build a huge reservoir at the gauge-point where surplus water will be let out to Tamil Nadu. The plan is to pump three to four tmc of water to Thorekadana Halli (TK Halli) which can be supplied to the City from 70 kms.

The ambitious-sounding project to draw water from river Krishna is another biggie on the BWSSB list. The Board has plans to draw 12 tmc ft of water from Alamatti dam from a distance of 400 kms to be supplied to the City. However, this project has just been proposed as the expert committee is yet to meet to discuss the subject.

Expert panel chairman Thyagaraja has also suggested certain projects, which may not go well with the environmentalists. The proposal to draw 12 tmc ft of water in Gorur dam across river Hemavathi over a distance of 200 kms, would mean that has to pass through the Western Ghats. There are also other contentious proposals such as the one to divert a part of water of west-flowing rivers such as Nethravathi and Kumaradhana to the east, for irrigation, industrial and drinking purposes. Water could be drawn from Nethravathi too for irrigation purpose through a canal form Tumkur.

Short-term plans:

Curbing water leakage, which currently stands at a staggering 38 per cent, is one of BWSSB's immediate plans. Out of the 900 MLD water being pumped from river Cauvery, nearly 342 mld is being wasted through leakages, recorded as 'unaccounted for water' (UFW).Comprehensive plans are being drawn up to reduce the UFW. Replacing the old corroded pipelines in many areas of the City is one measure to reduce leakages. There are also 'leakage repair gangs' appointed to attend to complaints reported through the BWSSB Call centre line. With amendment to the BWSSB Act on water theft and unauthorized sanitary connections, the Board is set to intensify its inspection of these connections. Stringent action is planned against anyone found guilty of water pilferage. The maximum punishment can go up to three years of imprisonment and a penalty of Rs 5000. BWSSB is also planning to increase the number of Sewage Treatment Plants (STPs) and to distribute the treated water to the industrial areas. Thyagaraja has suggested a revival of the existing reservoir at Byramangala near Bidadi, where treated water from Vrishabhavathi valley flows.

The treated water can then be stored in the reservoir and used for irrigation purpose.

The surplus of treated water from Bellandur and Varthur Lakes flows to a valley into Tamil Nadu. BWSSB has proposed a reservoir to cap the water before it enters Tamil Nadu. Getting the treated water back to the City is the plan.

Depletion of water sources in Bangalore City:

The consequences of urban development are increased peak discharge and frequency of floods. As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainwater. Conversion of water bodies to residential layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachments of natural drains, alteration of topography are the prime reasons for frequent flooding even during normal rainfall post 2000. The urbanization process in Bangalore has resulted in loss of aquatic ecosystems by 79 per cent during 1973-2010 in the erstwhile Bangalore City limits and 75 per cent decline in vegetation.

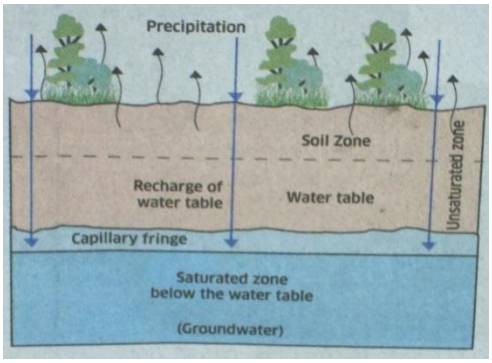
In areas like K R Puram and Mahadevapura, the groundwater has depleted to such alarming levels that not a drop could be found even at a depth of 1,000 ft. That changed quickly with the formation of new layouts in the region, leading to the drastic decline in the groundwater table. The good lake which once was home to hundreds of migratory birds is now dry, despite the 'rejuvenation' by the State Government in the year 2000. The residents around Thindlu are now facing a severe water crisis with the water level having dipped below 700 feet.

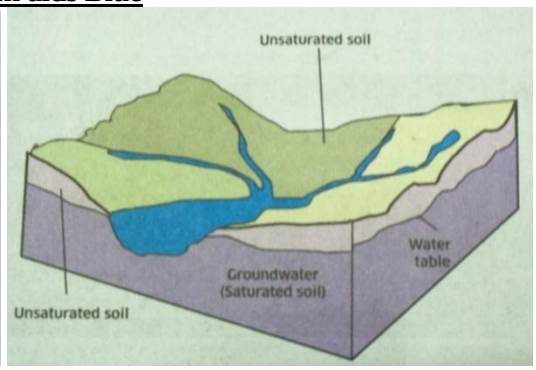
The situation faced by the residents of Koramangala Games Village is not much different. The vegetation has been removed and replaced with concrete structures of stadium and apartments that has prevented rainwater seepage. As a result, the water table has gone down by 600 feet and the residents are feeling the heat of water scarcity. It is evident from these examples that vegetation plays a significant role in recharging the groundwater table and the City's growing built-up area is the reason for the depletion of water sources.

Trees can raise groundwater table in Bangalore City:

Experts at the Indian Institute of Science (IISc) cite several examples about how vegetation rich areas like its campus have seen an increase in water table. "Land cover is important in deciding water availability. Vegetation allows percolation and enriches the water table," "Recharging groundwater requires 30-40 per cent of open space with vegetation. The vegetation makes soil pervious and helps in percolation." The vegetation holds the water filling in the saturated zone first, then the second layer above saturated zone known as widow zone, is filled up. The runoff seen in the monsoon is a phenomenon which happens only when both the layers are filled. Citing the examples of K R Puram, Whitefield and ITPL regions, experts notes that these places have lost vegetation drastically. Increased vegetation is the solution to depleted ground water table. But the best results would come if the vegetation is of native species. The study had found that the native species with their root structures percolates water much more than foreign species. "The native plant species have low rate of transpiration and high rate of recharge".

How Green aids Blue





Conclusion:

The Bangalore Water Supply and Sewerage Board is not devoid of governance reforms to rejuvenate its performance levels, as such a number of initiative have been taken to induce the substantive phase of institutional reform which aims at transforming BWSSB in terms of performance impact, and facilitative roles. The, BWSSB which is finding it difficult to meet the rising demand for water, has sunk five to 10 borewells in each wards. Besides the additional water tankers to supply Cauvery water free of cost in the coming days to areas that have no BWSSB connection. And frequent inspection on water theft and try to reduce leakages to manage water supply in Bangalore City.

Suggestion and measures to adopt future water demand in Bangalore City:

- Drawing water from existing sources such as Arkavathi and Cauvery.
- Harnessing underground water potential recharging and protecting existing lakes.
- Reduce of waste water for non-potable purposes after tertiary treatment.
- Rain water harvesting a scientific way.
- Linking of peninsular rivers such as Mahanadi, Godavari, Krishna and Cauvery.
- Diversion of Nethravathi water to Cauvery catchment.
- Awareness among public about the importance of water conservation.

References:

1. Bangalore City Corporation, Government of Karnataka, Bangalore.
2. Government of India Census of India (1991 & 2001) Kendriya Sadan,Koramangala, Bangalore.
3. Bangalore Water Supply and Sewerage Board (BWSSB), Handbook of Statistics: 1991-92 & 1992-93, 1993-94 & 1994-95, 1995- 96 & 1996- 97, 1997-98& 1998-99, and Annual Reports: 2002-2003, BWSSB, Bangalore.
4. Desphande C.D., B.Arunachalam, L.S. Bhat (1980) – *"Impact of Metropolitan City on the surrounding region"* Concept Publications, New Delhi.
5. Singh R.L. (1963) – *"Bangalore an Urban Survey"* – The National Geographical society of India, Tata Publications, Varanasi, UP, India.
6. Government of India (2001): Rural Water Supply and Sanitation in Karnataka: Strategy Paper 2000-2005, Bangalore: Rural Development and Panchayat Raj Department.

7. Saleth, Maria and G.S Sastry (2004): Water supply and Sanitation of Karnataka, India: Status, Performance and Change, Journal of Water Policy, 6: 161-183.
8. Menon, Parvathi (2000): The Ongoing Process of Corporatization of Water Supply in Bangalore has Important Implications, Frontline.
9. ORG-MARG (1999): Survey Report, Bangalore.
10. Sanbergen, Loes-Schenk (1996): Women, Water and Sanitation in the Slums of Bangalore:A Case Study of action research in Schenk, H (editor), living in Bangalore Slums.
11. Sastry, G.S (2004b): Urban Water Supply and Demand: A Case Study of Bangalore City: Bangalore City, Ecological Economics Unit, Bangalore, I.S.E.C.
12. TCE, (2004): Consulting Engineering Report, Bangalore: BWSSB.
13. Australia- India Development Cupertino (AUSAID) (2002): Water Supply Master Plan Bangalore Water Supply and Environmental Sanitation Master Plan, Bangalore Water Supply and Sewerage Board, Bangalore.