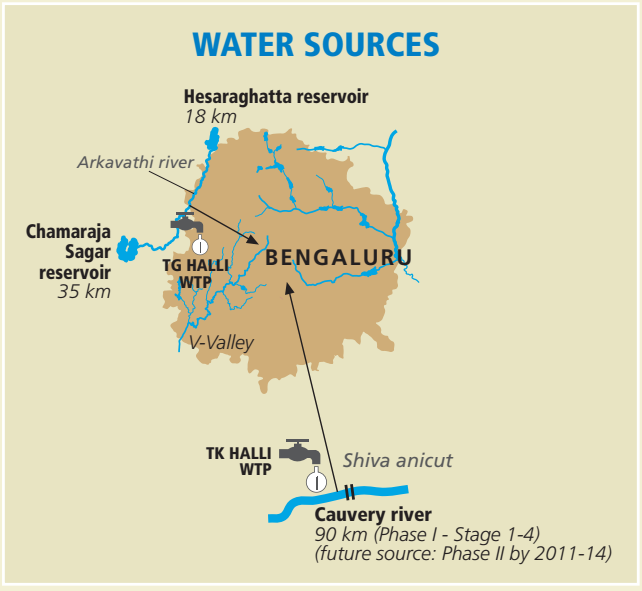
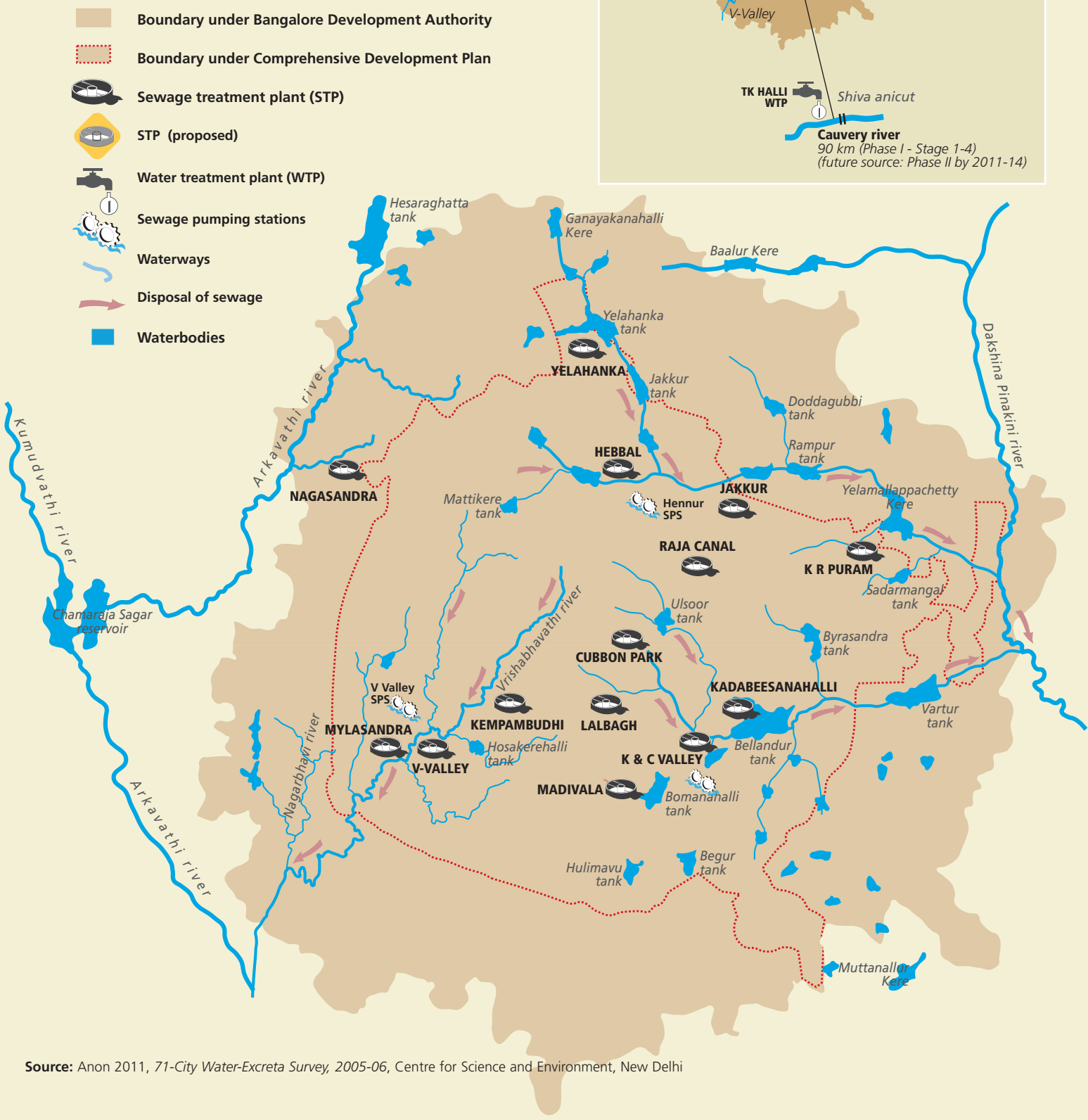
BENGALURU

THE WATER-WASTE PORTRAIT

Despite its highrises and malls, the 'Silicon Valley' and 'Garden City' of India fares badly as far as infrastructure is concerned, and has lost its famous lakes to indiscriminate disposal of waste and encroachment





Source: Anon 2011, *71-City Water-Excreta Survey, 2005-06*, Centre for Science and Environment, New Delhi

KARNATAKA

Bengaluru

'Bangalored', a slang for being rendered jobless, is a term made famous by the city's outsourcing business; ironically, this very business has brought jobs and growth to the capital city of Karnataka. The software boom hit the city in the 1990s, followed by massive urban growth turning the city into another mega sprawl, a far cry from India's 'garden city' with its boulevards and pleasant weather.

Renamed Bengaluru in 2007, this is the third largest city and the fifth largest metropolitan area in India. It comprises of a municipal area of 561 sq km and a number of municipal councils and villages, all under the Bruhut Bengaluru Mahanagara Palike, or BBMP.

The city has grown exponentially. Between 1990 and 2000, its decadal population growth was recorded at being over 37 per cent[1], the second highest in the country after Delhi. To accommodate this surge – driven by new and old businesses – the city has had to extend its reach repeatedly to acquire new territory in the neighbourhood. The 2006 *City Development Plan* has chronicled this phenomenal growth. It maps how the city, from a population of some 0.4 million spread over 70 sq km in 1941, has grown to one holding over 6 million people on 561 sq km in 2001 (see Map: *Growth of Bengaluru*).

This has had the inevitable fallout. With growth has come the loss of agricultural fields, open spaces and (what is of utmost concern) the city's lifelines – its lakes and ponds. These are now either repositories for sewage or have been turned into real estate. The same goes for the wetlands and open areas outside the city. As a result, even with the huge investments in bringing water to the city, its water crisis has become real and a regular affair. Groundwater contamination, with untreated sewage making its way into open channels, compounds the crisis.

In 2005, Bengaluru was swamped by the worst floods in its memory. This was a clear warning that its water sponges – its protective lakes – were lost.[2]

But the city is fighting back. Its people, citizens of one of the most technology-rich urban centres in the country, are demanding change, and the most important struggle they have today is to win back their waterbodies.

THE CITY	
Municipal area	561 sq km
Total area	740 sq km
Population (2005)	6.5 million
Population (2011), as projected in 2005-06	7.5 million
THE WATER	
Demand	
Total water demand as per city agency (BWSSB)	1125 MLD (2010)
Per capita water demand as per BWSSB	173 LPCD
Total water demand as per CPHEEO @ 175 LPCD	1138 MLD
Sources and supply	
Water sources	Cauvery and Arkavathi rivers, groundwater
Water sourced from surface sources	93%
Water sourced from the ground	7%
Total water supplied	900 MLD (2010)
Per capita supply	138 LPCD
Leakage loss	40%
Actual supply (after deducting leakage losses)	540 MLD
Per capita supply (after leakage losses)	83 LPCD
Population served by water supply system	100%*
Per capita supply in served area	83 LPCD
Demand-supply gap (after leakage losses)	585 MLD
Treatment	
Number of WTPs	4
Total treatment capacity	810
Actual treatment	NA
Future demand and supply	
Demand (2011), as projected in 2005-06	1298 MLD
Augmentation needed to meet the demand	398 MLD
Required increase in supply	44%
THE SEWAGE	
Generation	
Sewage generated as per CPCB	819 MLD
Sewage generated as per city agency	1110 MLD
Collection	
Length of sewerage network (trunk and small)	3610 km
Population covered by sewerage network	45%
Area covered by sewerage network	40%
Treatment	
Number of STPs	14
Total treatment capacity	721 MLD
Actual sewage treated	302 MLD
Disposal	Vrishabhavathi Valley, Hebbal, Koramangala and Challaghatta tanks

Source: Anon 2011, *71-City Water-Excreta Survey, 2005-06*, Centre for Science and Environment, New Delhi; Anon 2006, *City Development Plan for Bangalore*, JNNURM, Bengaluru; and V C Kumar 2011, 'Wastewater treatment', presentation made to Union ministry of urban development, Delhi, *mimeo*
Notes: *In municipal area; BWSSB: Bangalore Water Supply and Sewerage Board

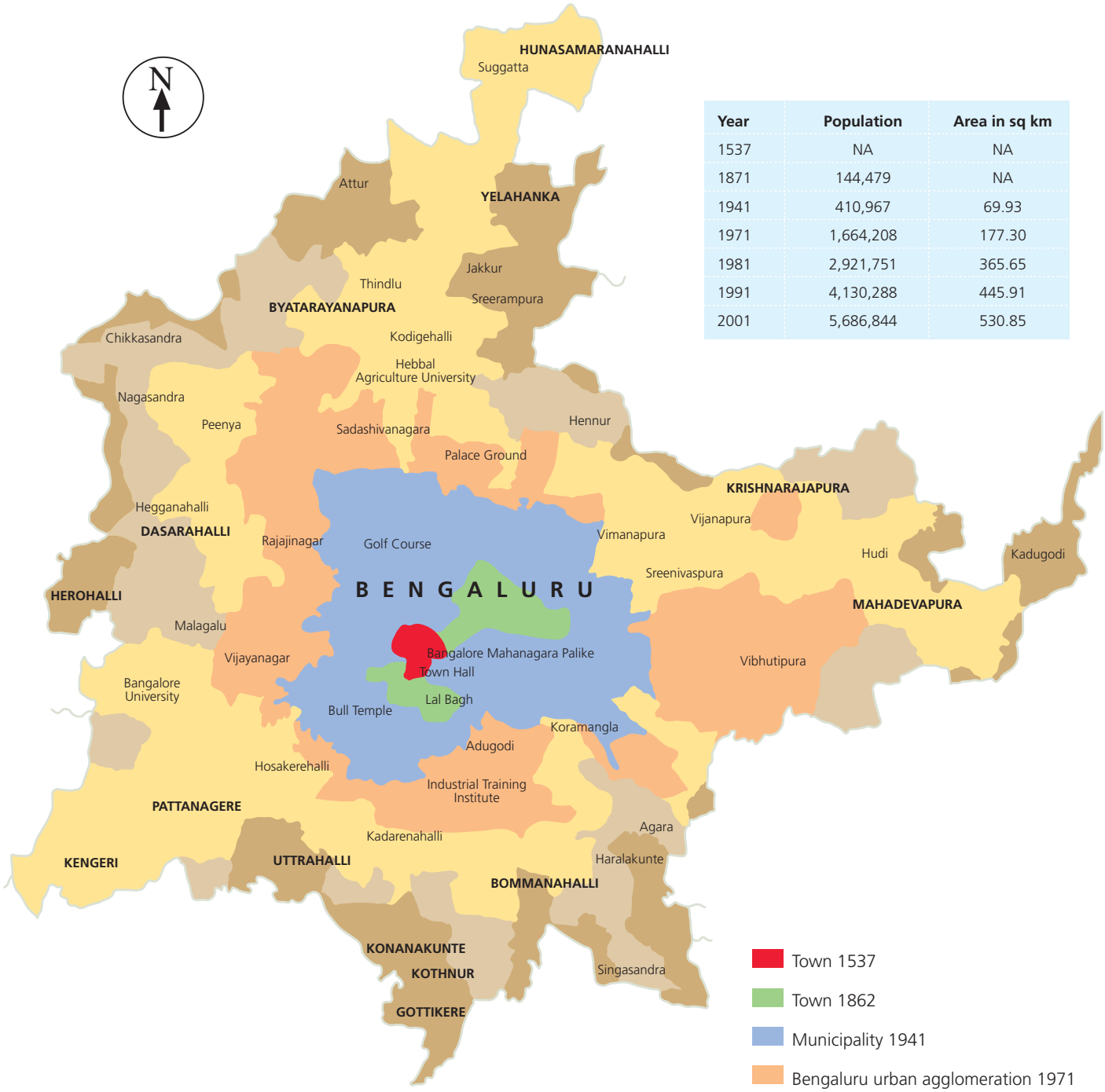
WATER

DEMAND AND SUPPLY

According to estimates arrived at in 2010, the Bangalore Water Supply and Sewerage Board (BWSSB) computes the demand for water to be 1,125 million litre per day (MLD). It claimed a supply of 900 MLD, without accounting for distribution losses of

MAP: **GROWTH OF BENGALURU**

The city has rapidly increased in size and population over the last 60 years



Year	Population	Area in sq km
1537	NA	NA
1871	144,479	NA
1941	410,967	69.93
1971	1,664,208	177.30
1981	2,921,751	365.65
1991	4,130,288	445.91
2001	5,686,844	530.85

Source: Anon 2006, *City Development Plan for Bangalore*, Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Bengaluru

40 per cent.[3] While coverage in the municipal area, says the government, is 100 per cent, city authorities are struggling to reach water to the newer development zones.

THE SOURCES

Bengaluru's location in the semi-arid peninsular plateau region makes it naturally water-scarce. The Arkavathi and Cauvery rivers are there, but flow several kilometres away; the Dakshina Pinakini traces the north-east border. The Vrishabhavathi, a minor tributary of the Arkavathi, is the only stream originating within and flowing through the city. All the rivers are seasonal and become dry in the month of February.

But the lack of rivers should not have become a concern as this is a city of lakes. According to land use classification, as much as 4 per cent of the metropolitan area – some 4,000 hectare (ha) – is under waterbodies. It is this wealth of water that provided the city its drinking water in the past. Most importantly, these waterbodies recharged the groundwater.

Bengaluru's first official water supply was from these waterbodies – the 100-year-old Hesaraghatta Lake (Chamarajendra reservoir) on the Arkavathi at a distance of 18-20 km from the city. In 1932, the T G Halli reservoir (Chamaraja Sagar reservoir) was built at the confluence of the river Arkavathi and Kumudvathi 35-40 km away.[4]

But soon the city ran out of patience with its local waterbodies. It wanted a 'reliable' water source. The Cauvery project – officially named as Cauvery Water Supply Scheme (CWSS) – was conceived, with the first phase starting in 1969. The only problem was that the Cauvery river, located about 90 km away, required water to be pumped up to a height of 490 m. But this did not deter city planners in making the river's waters available to the city in three different phases and at increasing costs.

Presently, water is drawn from Stages 1, 2, 3 and 4 of Phase I. Work on the next stage, called Stage 4, Phase II, has begun; the city hopes to complete it in March 2012 and augment its supply by 500 MLD. Currently, on an average, about 810 MLD is pumped in the four stages and transported over the 100 km distance (see Map: *Water supply*). The 50 megawatt (MW) of power required to pump this enormous quantity of water to the city proves very expensive.[5]

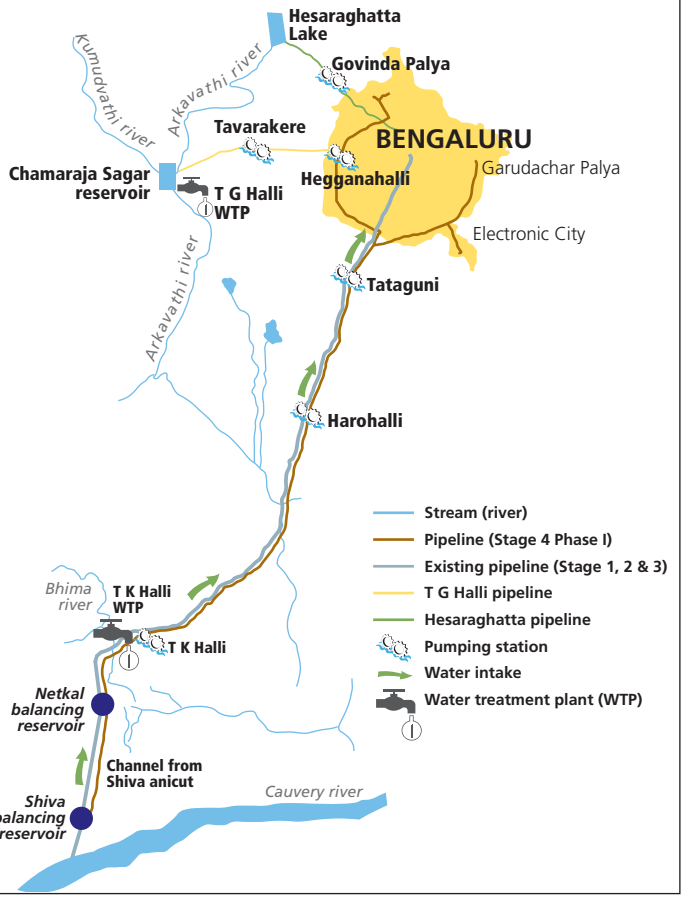
Officially, besides the 810 MLD from Cauvery, the city also has an installed capacity of 184 MLD from Arkavathi and 70 MLD from groundwater.[6] However, given the general water scarcity of the region, the daily release is lower. The city also has an official distribution loss of 40 per cent – in other words, roughly half the water sourced and supplied is not delivered.

While the city bursts at its seams, water availability from these governmental sources is shrinking. The official water story does not include the use of private groundwater and the increasing reach of tankers supplying water in the outlying areas.

But Bengaluru is still looking to the Cauvery for more water. The Cauvery River Water Disputes Tribunal has earmarked 600 cusecs (or 1,470 MLD) of water from the river for the city. But the river water is contested, as farmers say their share is being taken away for cities and industries. The future of this city and its water is still untold. But it hopes (and plans) to get more from the river.

MAP: **WATER SUPPLY**

Currently, 810 MLD is pumped across four stages, and transported for about a 100 km distance



Source: Anon 2006, *City Development Plan for Bangalore*, Jawaharlal Nehru National Urban Renewal Mission, Bengaluru

GROUNDWATER

The BWSSB maintains over 7,000 borewells in Bengaluru, which supply around 70 MLD. Official sources do not know how many private borewells are there in the city; rough estimates point to around 80,000, which provide about 282 MLD. In 2001-02, this constituted about 28 per cent of the city's drinking water supply.[7]

A 2005 survey conducted by the Institute for Social and Economic Change (ISEC), Bengaluru, on private drilling companies in the city revealed that the number of private borewells supplying water to households is much higher – 2,61,573 – which yielded 261 MLD. While the exact numbers may not be available, what is apparent is that a huge volume of groundwater, nearly 30 per cent of the total supply, is extracted from private borewells in Bengaluru every day.[8]

The number of these borewells is bound to increase in the coming years, with 6,480 getting drilled annually.[9] According to

the ISEC survey, their total number has shot up from 5,000 to 4,50,000 over the past 30 years.[10]

The results are there for all to see. Groundwater levels have steadily dipped in the city; in fact, the level fluctuates seasonally, making it highly expensive to extract during summers.[11] In suburban zones, drying up of wells is a common feature. Zaheer Khan, councillor of Dasarahalli in Greater Bengaluru, says: "Over 60 per cent of the 600 tubewells dried up between 2001 and 2006." Yearly increment in the rate of consumption of groundwater in Bengaluru is about 7 per cent.[12]

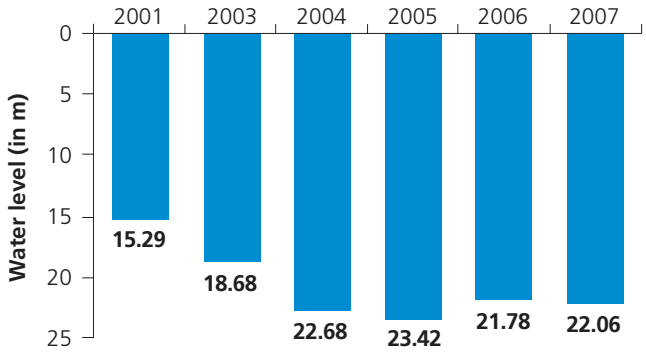
The decline in the number of waterbodies has also had a telling effect on the groundwater level. The water table has shrunk from 10-12 metre (m) to about 76-91 m in just two decades.[13]

The use of groundwater is intrinsically linked to the private business of water tankers. In Bengaluru, it is estimated that there are some 100-120 tanker companies, with 3,000 vehicles plying in the city. The big users of water source 30-40 per cent of their needs from private tankers and another 20 per cent from private borewells. This is also because water rates in the city are the highest in the country and groundwater is cheap or unpriced (see Box: *Counting wells in Bengaluru and Kolar*). As technology to pump deeper becomes more efficient and little is done to recharge aquifers, groundwater levels will keep declining.[14]

The Bengaluru situation is compounded by the fact that the city does not treat its sewage. A survey of groundwater quality in and around its vicinity found high levels of nitrates (see Graph: *Groundwater check*). Clearly, this information hub has much information to gather when it comes to water.

GRAPH: GROUNDWATER CHECK

According to the CGWB, between 2001 and 2007, the water level in Bengaluru has declined by 7 metre (m) at the rate of about 1 m per year



Source: National Data Centre, Central Ground Water Board (CGWB), Faridabad

COUNTING WELLS IN BENGALURU AND KOLAR

City water agency in dark on number of wells and tankers

In a 2005 survey on the dependence of south Indian cities on groundwater, researchers worked hard to compute the hidden groundwater factor. They discovered it was difficult to find answers. In Bengaluru, the city water agency had no estimations of the numbers of wells and said this was "too tedious" to find out. Borewell digging agencies were scattered all over the city and tubewell owners were not willing to reveal information.

In their survey, the researchers interviewed 71 such companies; surveyed water consumption in different sectors; examined private water suppliers; and conducted a pilot study of tubewells in parts of the city.

They found the following:

1. Out of the total number of respondents surveyed, 77 per cent used both groundwater and surface water for their needs, while 13 per cent were totally dependent on groundwater. In other words, in most cases, groundwater supplemented official water supply.
2. In certain areas of the city – its northern end of Dasarahalli and Vidyaranyapura – households had started a business of selling water to their neighbours, charging Rs 150-170 per month for alternate day supply. This supply is restricted to 15 pots (150-200 litre) beyond which the household has to pay more.
3. In the 120 cinema halls of the city, water consumption varied between 4,000 to 30,000 litre per day. The total consumption by all cinema halls in the city was computed to be 1.26 million litre a day (MLD), of which a substantial proportion came from groundwater. The expenditure incurred on groundwater ranged between Rs 3,000 to Rs 15,000 per month, against its official water bill of Rs 600 to Rs 12,000 per month. The situation was repeated in lodges and marriage halls.
4. The total number of tubewells drilled by the 71 companies surveyed worked out to 400,000 over the past 30 years. But it was also found that failure rate of tubewells was increasing day by day. Roughly, 75 per cent of the tubewells were for households and the rest were for irrigation.
5. When private water tanker owners were surveyed, it was found that the number of tankers (in the sample group) was 227; the capacity of each varied between 4,000-12,000 litre. Each tanker made 5.32 trips per day on an average, with summer trips going up to 12.62 per tanker. On an average, in the non-summer period, the tankers supplied 100 MLD of water, which jumped to over 200 MLD in summer.
6. In neighbouring Kolar city, researchers found that while the city municipal council had provided 119 tubewells, only 90 were in working condition. In addition, there were around 200 private tubewells. Water was also supplied through private tankers, which extracted water from neighbouring fields and hills.
7. But as in other places, the yield from wells was declining. Kolar has been already classified as a dark zone by the groundwater authorities, which means that extraction is unsustainable. Wells in the city were yielding water below 300 metre (1,000 feet).

Clearly, the groundwater economies of our cities need to be explored and factored in.[1]

DISTRIBUTION

Water is distributed in Bengaluru through a 4,400-km piped service; there are 46 ground-level reservoirs and an equal number of overhead tanks, holding 616 MLD and 41 MLD, respectively.[15] The water supply in the core municipality covers 100 per cent of the population, while for the smaller municipalities or urban local bodies (ULBs) which make up the Greater Bengaluru area, the coverage varies from 10 to 60 per cent.[16]

The piped supply comes through both gravity and pumping. There are about 3,67,579 piped connections, of which 3,46,793 are domestic and 10,981 non-domestic.[17] Every year, around 20,000 new connections are added.[18] In addition, around 15,182 community taps cater to the needs of the urban poor.[19]

In 2001, Bengaluru's slums held about 10 per cent of its total population. Estimation of current slum population is difficult, but the numbers have certainly increased and are closer to the population receiving free water through public taps.[20] Then there are the people who must venture out in search of water every day: they make up about 14 per cent of the city's population.[21]

Bengaluru's core area may boast of a fairly well-developed water distribution network, but most of it is 70-100 years old and in a decrepit condition. Water quality and availability have been gravely affected by corrosion and rusting of pipes, frequent leakages and damages and heavy traffic load. Replacement of this infrastructure is an urgent need, but the high population density and severely constricted roads make repair and renovation of damaged networks a daunting task.

There is huge disparity in water distribution between different parts of Bengaluru. Domestic consumers get meagre and intermittent services hardly exceeding three to four hours, and industrial users get water for just four to six hours – both on alternate days.[22] Sometimes, the service plummets to just two hours every alternate day. The southern and western parts of Bengaluru, situated close to where the massive pipelines sucking water from the Cauvery enter the city, get the best access to the supply system, while the northern parts remain deprived.[23]

The city has initiated projects to supply water to the outskirts of the city. The Greater Bangalore Water and Sanitation Project (GBWASP) was initiated in 1998, with an aim to be 'market friendly' – in essence, coming up with bankable schemes for which it can source funds from future customers through upfront payments. However, the skewed nature of the distribution is apparent. A 2009 study by Indian and US researchers which examined the implementation of GBWASP found a wide disparity between different groups of people and their access to water and other basic services. More importantly, the study noted that while peri-urban populations had paid in advance for getting water

ASHWANI KUMAR / CSE

Water for the lucky few: the southern and western parts of Bengaluru, from where these pipelines enter the city, get the most water. The northern areas have to contend with erratic supply

NEGOTIATING ACCESS TO WATER SERVICES

Bengaluru's experiment with bonds and markets for water

In a paper that looks at the performance of the Greater Bangalore Water and Sanitation Project (GBWASP), Indian and US researchers have studied how residents living in the sprawling metropolitian area of Bengaluru negotiate access to water services. The GBWASP has seen many incarnations – starting in 1998 and then in 2003, when the Karnataka government recruited Indo-USAID's Financial Institutions Reform and Expansion-Debt (FIRE-D) Component Project to develop a market-based financing framework for water services. Under this programme, the aim was to create 'pooled financing' models for infrastructure delivery.

This is similar in approach to the US bond bank, where by pooling finance, bonds are repaid by local borrowers, thereby diversifying the risk and lowering interest rates. In India, this was first attempted in Ahmedabad (also under USAID support); later, FIRE-D designed a similar mechanism with municipal bonds for 14 urban local bodies (ULBs) in Tamil Nadu.

In the case of Karnataka, in June 2005, the Karnataka Water and Sanitation Pooled Fund – which acts as an intermediary between financial markets and municipalities – floated 1,000 tax-free municipal bonds each valued at Rs 10 lakh (a total of Rs 100 crore), with an annual interest rate of 5.95 per cent and a lifetime of 15 years.

But the study highlights some worrying aspects in this state. Say the researchers, "It is questionable whether the urban bodies were in a position to take on the debt burden for such capital-intensive projects." It cites studies which show that the urban bodies were in no position to repay, given their fiscal handicaps. But worse, that there was no consideration given to reduce the project costs and to look for viable alternatives.

In this case, the initial cost of the water distribution project was estimated at Rs 340 crore, around 50 per cent higher than that estimated by the feasibility report. After the pipes were laid in the periphery, it was learnt that the project had not taken into account the haphazard growth and the fact that it would need more investment. As a result, another Rs 106 crore was added to its cost.

In all this, while the contribution of the market through borrowing was roughly 29 per cent (Rs 100 crore), it was the ordinary people who paid the bulk of the project costs: the 'beneficiary' contribution was Rs 119 crore, or 35 per cent of the costs. The researchers had estimated that people would pay over 50 per cent of the project cost; this, when the costs of connection have been steep and even been resisted in the poorer settlements. The terms were tough, as the people were told that there would be penalties in case of delayed payments and monthly fines were demanded.

But with all this done, the "payment has not guaranteed customer entitlements", find the researchers. In many places, people have not received water. As in all such cases, poorer places, with difficult access, have been left out. Even after the completion of the distribution pipelines, only 100,000 connections were provided against the total estimated 450,000 which need to be reached in these areas.

But as the debt needs to be paid, market compulsions are stepping in. A preference is given to those areas that can be billed for water consumption. This preferential treatment is more likely as there is a clear mismatch between availability and demand of water. The 2003 USAID report which launched the programme claimed that 135 MLD would be allocated to peripheral areas after the completion of Cauvery IV (Phase I). But in truth, this water was absorbed by Bengaluru city – the core – itself, as its demand was galloping. To make up for this 'lost' water, the water board is now using Central government funds to install pumps on the transmission lines to supply some 100 MLD. But this supply will be constrained. Water is being shared among the core city and peripheral areas on a staggered basis. Now, project authorities are waiting for more water, which will come when the next phase of Cauvery IV gets completed.

What is clear is that this market-based model needs to be carefully re-examined. The conditions of debt repayment make it obligatory to pay market investors first. But it is the people who have paid for the water service, before time and with fear of penalty, who are still not getting the service. It is they that are left behind, as the market moves ahead, once again. The researchers ask in conclusion, "Can we justify burdening customers living in the periphery with these costs, when those living in the core area did not bear these costs and are not sharing them now?" Clearly, this study has important lessons for future market delivery models.[1]

connections (unlike the people living in core areas), there is little water to distribute (see Box: *Negotiating access to water services*). The market seems to be made up of poorer people, who have no say in the dealings.[24]

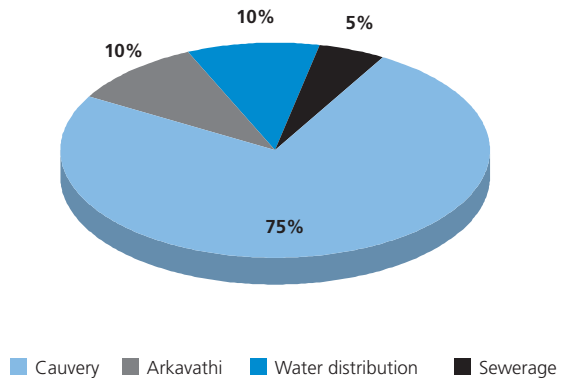
The project also led to vocal opposition against the move to hand over water supply to private operators. The city-wide campaign against water privatisation alleged that there was a move to "introduce privatisation for operation and maintenance" of water. The cost that people had to pay for water connections also led to protests; initially fixed at Rs 8,500 for domestic properties and Rs 17,000 for others, the costs had to be revised downwards. But the big issue concerning people already was the mirage of water in this water supply project. The demand was estimated to be 180 MLD, but the board was promising to supply 100 MLD. This was to be divided between 1.3 million people, giving them a miserly 65 MLD, without factoring in the distribution loss of 40 per cent. People said that when they paid for the connection they were assured sufficient water.[25] But this was clearly not in the offing. As it turned out, their fears came true as most of the water just disappeared into thirsty Bengaluru.[26]

TREATMENT

The city water planners will tell you that they have inherited a rich legacy in terms of water treatment technology. As early as in 1896, the first protected water supply system was constructed in Bengaluru, bringing supply from Hesaraghatta Lake across the Arkavathi river and the Chamarajendra reservoir at T G Halli,

GRAPH: THE ENERGY EATERS

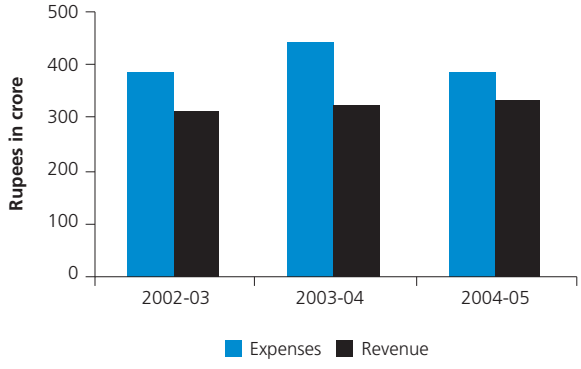
In Bengaluru, the maximum amount of power is gobbled up in pumping water from Cauvery



Source: Anon 2006, *City Development Plan for Bangalore*, Jawaharlal Nehru National Urban Renewal Mission, Bengaluru

GRAPH: THE BALANCE SHEET

Revenues from water and sewerage services have remained almost static, while expenses have fluctuated



Source: Anon 2006, *City Development Plan for Bangalore*, Jawaharlal Nehru National Urban Renewal Mission, Bengaluru

35 km east of the city. This water supply had a treatment system, which has continued with some technology inputs over the years. But the principles remain the same, much to the amazement of municipal engineers.

The city has no real problem with the quality of its input water – most of it is from Cauvery. It has four plants, with a total installed capacity of 810 MLD. It is building another plant of 500 MLD. Clearly, the city will have adequate capacity to treat its water. The challenge it faces is to find the water to treat.

THE ECONOMICS

In 2005-06, the BWSSB recovered Rs 403 crore, after spending about Rs 418 crore.[27] Of the total costs incurred, energy costs had a huge share; the BWSSB paid about Rs 251 crore to the Bangalore Electricity Supply Company (BESCOM) in 2005 – 60 per cent of the total costs[28] (see Graph: *The energy eaters*).

About 95 per cent of the water supply connections in the city are metered, says the BWSSB.[29] However, in spite of a meter-testing laboratory conducting routine tests and repairs on 3,500-4,500 meters every month, a large amount of unaccounted for water (UFW) – owing to poor metering – remains the harsh reality[30] (see Graph: *The balance sheet*).

The ratio of staff to number of connections is low: for every 1,000 connections, there are only 8.4 employees.[31] Bengaluru also has one of the highest water tariffs in the country, particularly for industrial water use (see Table: *Water tariff indicators*).

TABLE: WATER TARIFF INDICATORS

The major consumers account for less than 15 per cent of the revenue generated, as tariffs are way below the cost of production

Category	Tariff	Consumption
Domestic	Rs 6 per kilolitre (kl)	First 8 kl
	Rs 36 per kl	75 kl and above
Non-domestic/commercial	Rs 36 per kl	First 10 kl
	Rs 60 per kl	Above 100 kl
Industrial (no slabs)	Rs 60	Each kl consumed
SEWERAGE CESS		
Domestic	Rs. 15 per month at flat rate	For consumption of 0 to 25 kl
	15 per cent of water supply charges per month	For consumption of above 25 kl up to 50 kl
	20 per cent of water charges per month	For consumption of above 50 kl
Non-domestic/commercial	From 10 per cent to 20 per cent of water charges per month	

Source: http://www.bwssb.org/water_tarriff_prorata.html, as viewed in July 2011
Note: Water supply cost in 2004-05 was Rs 12-13 per kilolitre

SEWAGE

GENERATION AND COLLECTION

Bengaluru's rapid urbanisation has also meant growing mountains of waste. City municipal engineers estimate that roughly 1,000 MLD of wastewater flows through its three valleys – the Vrishabhavathi, the Koramangala-Challaghatta, and the Hebbal.

The city's sewage generation estimates vary widely, indicating that authorities have poor knowledge about the actual water consumed by the population. The actual amount of sewage generated would be higher since a large number of private borewells exist and there is no scientific estimate of the quantity of water withdrawn from them.

Bengaluru's sewerage system has been developed along its major drainage lines, but this is highly inadequate for a city as big and as rapidly expanding as Bengaluru. The total trunk sewers is 243 km (smaller drains are around 3,367 km), all of which are mostly in the core old municipality areas of the city.[32]

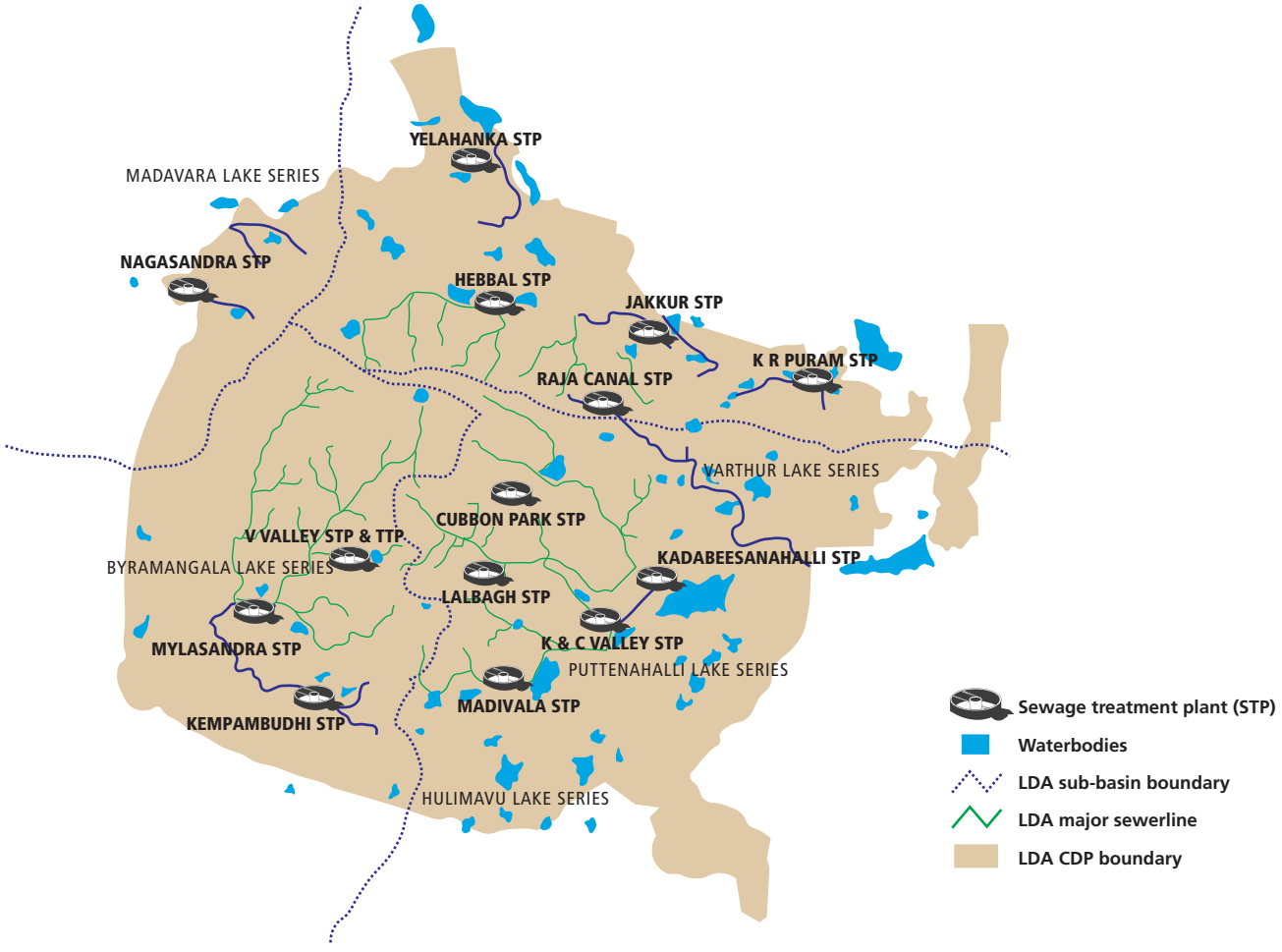
The remaining areas of the city, which also include less-developed parts like slums, revenue pockets and unauthorised colonies, do not have any sewerage facilities. Slum dwellers and the urban poor draw their water from open sumps and wells, which contain water of dubious quality and therefore, not fit for human consumption. Outbreaks of water-borne diseases and malaria are common in these areas.[33]

TREATMENT AND DISPOSAL

While Bengaluru's first sewage network was developed as early as 1922, treatment of wastewater started only in 1974. The city has since then built many new sewage treatment plants (STPs). By 2010, there were 14 plants (see Map: *Location of sewage treatment plants*) with an installed capacity to treat 721 MLD – roughly

MAP: **LOCATION OF SEWAGE TREATMENT PLANTS**

The city has built 14 plants over 30 years, but uses only half the capacity, leaving a large amount untreated



Source: V C Kumar 2011, 'Wastewater treatment', presentation made to Union ministry of urban development, Delhi, *mimeo*
Notes: TTP: tertiary treatment plant; STP: sewage treatment plant; LDA: Lake Development Authority; CDP: City Development Plan

TABLE: **STPS OF BENGALURU**

With substantial treatment capacity at present, the plants wait for sewage to reach them

Location of STP	Designed capacity (MLD)	Technology used	Capacity utilised (2010, MLD)
Vrishabhavathi (V) Valley (secondary)	180	Secondary: trickling filter	66
Koramangala-Challaghatta (K & C) Valley	248	Secondary: activated sludge process	102
Hebbal Valley	60	Secondary: activated sludge process	35
Madivala (mini STP)	4	Secondary: UASB + oxidation ponds + constructed wetlands	4
Kempambudhi (mini STP)	1	Secondary: extended aeration	1
Yelahanka	10	Activated sludge process + filteration + chlorination (tertiary)	2
Mylasandra	75	Secondary: extended aeration	33
Nagasandra	20	Secondary: extended aeration	4
Jakkur	10	Secondary: UASB + extended aeration	4
K R Puram	20	Secondary: UASB	3
Kadabeesanahalli	50	Secondary: extended aeration	31
Raja Canal	40	Secondary: extended aeration	15
Cubbon Park	1.5	Membrane	0.9
Lalbagh	1.5	Extended aeration + plate settlers + ultra-violet disinfection	0.9
Total	**721**		**302**

Source: V C Kumar 2011, 'Wastewater treatment', executive engineer, Bangalore Water Supply and Sewerage Board (BWSSB), presentation made to Union ministry of urban development, Delhi, *mimeo*
Note: UASB: upflow anaerobic sludge blanket; UV: ultra-violet

equivalent to what the city generates. But in spite of this hardware, the city only uses half the capacity – it treated some 302 MLD of waste in its sewage plants in 2010 (see Table: *STPs of Bengaluru*).[34] In other words, a substantial part of the sewage goes untreated. It is no surprise then that the waterbodies of the city, its official conveyance zones, are so polluted.

But the city certainly has ensured that it keeps its reputation for being the technology centre of the country, even when it comes to sewage treatment. It has experimented with and built every kind of sewage treatment system, becoming a ready laboratory for these technologies in the country. But in spite of these impressive wastewater treatment facilities, it continues to struggle with the management of its sewage because it does not have the drains to bring the sewage to the plants. It faces the same problems as that of most cities – outdated sewage infrastructure, which demands repair and refurbishment even as more needs to be built. It is not able to trap its waste and convey it to the treatment plants.

The city is now drawing up massive plans for rebuilding and extending its sewage network. According to the estimation of the city's authorities, it needs to build more than what it has built till date (see Table: *More drains*). Till it completes these grand plans, the pollution of its waterbodies will prevail. The state of the Bellandur Lake, for instance, is dismal because of the sewage that makes its way into the lake. Its people are fighting to find solutions.[35]

TABLE: **MORE DRAINS**

The city is drawing up plans to extend the sewage network by over 500 km

Name of valley	Current sewage network (km)	Sewage network to be built (km)	Cost (Rs/crore)
Koramangala-Challaghatta (K & C)	1,481	1,940	1,356.00
Vrishabhavathi and Arkavathi	1,649	1,209	1,000.00
Hebbal	480	1,022	511.00
Total	**3,610**	**4,171**	**2,867.00**

Source: Anon 2011, 'Action plan for proper wastewater disposal in Bengaluru to prevent pollution of waterbodies', Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru, *mimeo*

IMPACTS

LAKES: BENGALURU'S AGONY

"At the heart of the loss of our lakes is corruption. It is not as if our planners do not know that lakes are important": this comment from actor Girish Karnad, speaking at a public rally against the destruction of one of Bengaluru's wetlands, the Koraniangala, captures the crisis.[36]

The city has a rich treasure trove of tanks – built in pre-British India – which provided water security in a region with variable rainfall and seasonal rivers. Kempe Gowda, who founded the city, was one of the most important tank builders in the 15th century in this region. By the 1860s, the region and its cities had evolved an intricate system of harvesting water. But modern Bangalore discounted this security system. It seems to have given up on its tanks which stored rainwater and recharged its groundwater. It had the money to bring water from Cauvery, and so the massive water withdrawal began. It was only when its 'dream' of water started crashing that the city planners began to pay attention to the logic of holding water where it falls.

But by then, many waterbodies had already been destroyed (see Table: *Lakes lost*). The government had wilfully and deliberately taken over waterbodies and built over them. For instance, the city corporation built the city terminus after filling the Dharmambudhi tank; the Kanteerva Stadium is on the graveyard of another tank; while the Siddikatte tank has been turned into a local market.

As a result of this abuse, tanks and ponds have lost land. By mid-2006, waterbodies occupied only 4.8 per cent of Greater Bengaluru's geographical area, and many had been reduced to nothing more than cesspools due to the direct discharge of industrial effluents and domestic sewage into them.

In fact, the lakes of Bengaluru are its official wastewater carriers. They drain into three valleys – the Koramangala-Challaghatta, Vrishabhavathi and Hebbal – carrying their untreated wastewater into them (see Maps: *The lake clusters*).

The valleys have four drainage zones: the Koramangala, Challaghatta, Vrishabhavathi and Hebbal. Three lake series fall into the Koramangala and Challaghatta zones. The Varthur Lake series consists of 10 waterbodies covering an area of 733 ha; the Puttenahalli Lake series (which includes the famous Lalbagh) has five waterbodies over 58 ha, while the Hulimavu Lake series with four lakes adds up to 44 ha. In the Vrishabhavathi drainage zone, the Byramangala Lake series has 11 waterbodies covering some 562 ha. The Hebbal Valley has two separate lake series – Yellamallappa Chetty and Madavara.

There has been little enumeration of these waterbodies, but what is clear is that the numbers are going down. It is a loss that is costing the city dearly. The citizens of Bengaluru, however, are not giving up without a fight. They are waging the battle to keep the lakes wet and clean through courts and public awareness.

It was in mid-1990s that the city began the battle to save its lakes. In 1995, ornithologist Zafar Futehally filed a case in the Karnataka High Court against the indiscriminate occupation of tank beds in and around Bengaluru. In 1996, the Bellandur *gram panchayat* filed a case to save its tank, which is located at the southern end of the city (see Box: *Battle to clean Bellandur*).[37]

In 2007, citizen groups learnt that the Lake Development Authority – a statutory body created to protect waterbodies with jurisdiction across the state – had started leasing lakes to hotels. The scheme started in 2004, when the city's Nagwara Lake was leased to a private company, Lumbini Gardens, to build hotels and amusement parks. Then in 2006, the Hebbal Lake was leased to East India Hotels for a floating park and other 'recreational activities'. In 2007, the Agaram Lake was leased to Biota Natural Systems.

In all the cases, the plea was that the private entrepreneur would bring in the necessary financial and managerial investment to clean and protect the lakes. "There are 2,779 lakes in Bengaluru and it is not possible for the government to spend money on conservation and cleaning. We need private investment," argued officials of the authority.[38]

But environmental activists were not convinced. Leo Saldanha of the Environment Support Group filed a petition in the state high court against the move. His argument was that the government had already spent funds through an Indo-Norwegian programme to restore the Hebbal Lake. Now this restored and rejuvenated lake was being handed over to profit-making entities. Privatisation would restrict people's access to open spaces. The Agara Lake was commonly used by local people for daily recreation; the Hebbal, for fishing, grazing and irrigation.

The Karnataka High Court has taken the case seriously. In November 2010, the chief justice hearing the case constituted a committee to "examine the ground realities and to prepare an action plan for the preservation of lakes in the city of Bangalore".

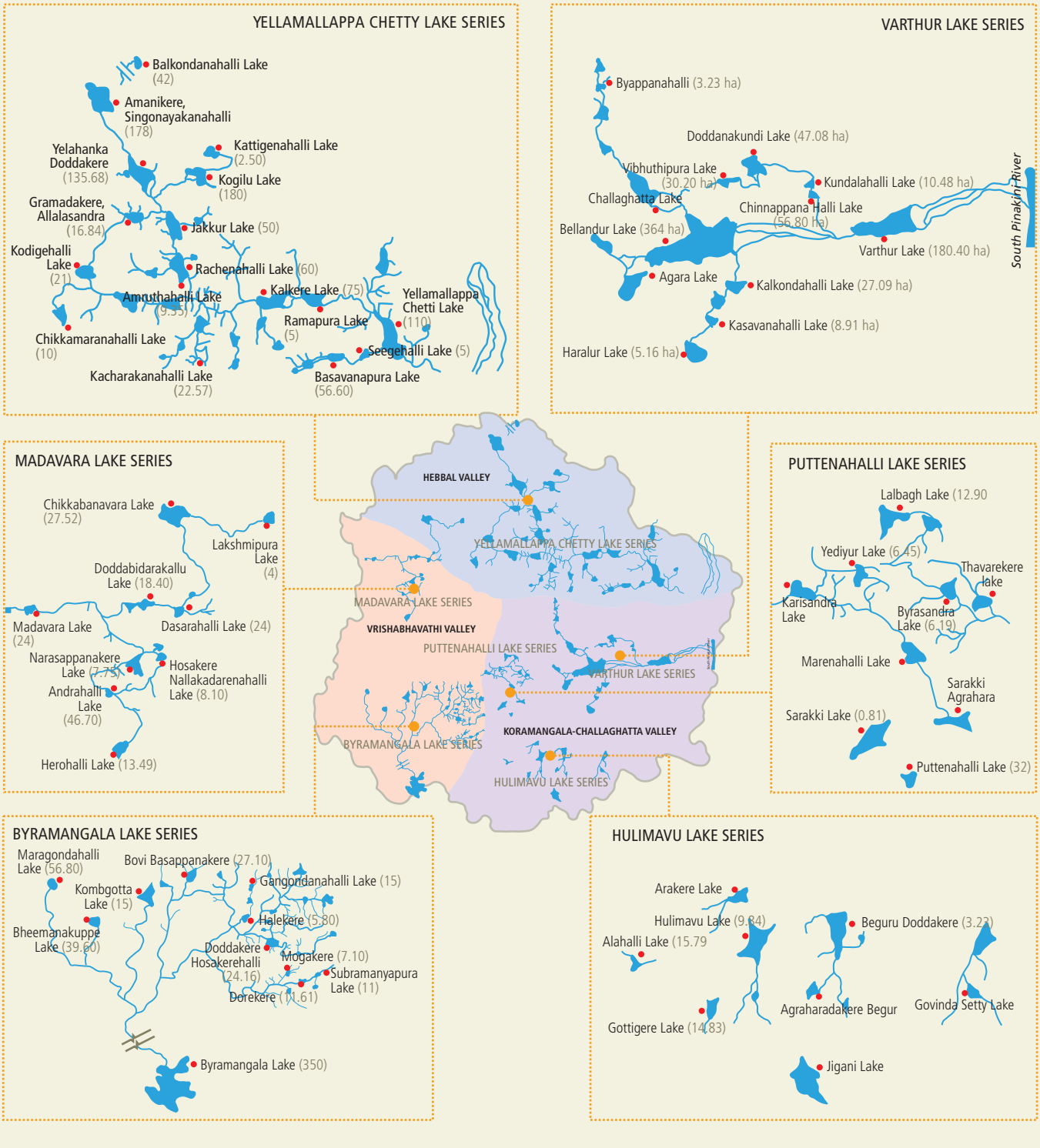
TABLE: **LAKES LOST**
Bengaluru's waterbodies are going extinct

Region	No of tanks (1973)	No of tanks (1996)	Percentage loss (No of tanks)
North	138	96	30.43
South	241	150	37.75
Total	**379**	**246**	**34.09**

Source: R S Deepa, R Kiran and T V Ramachandra 1998, 'Comparative water quality assessment of Bannerghatta and Yediyur lakes of Bangalore', proceedings of the National Seminar on Environmental Pollution, Bengaluru, mimeo

MAP: **THE LAKE CLUSTERS**

The lakes of Bengaluru are its official wastewater carriers. These drain into three valleys – Koramangala-Challaghatta, Vrishabhavathi and Hebbal. All the lakes lie in these valleys and each lake is linked to the other through a series of waterbodies and channels. Untreated wastewater and sewage makes its way into the valley through the lakes



Source: Anon 2006, *City Development Plan for Bangalore*, Jawaharlal Nehru National Urban Renewal Mission, Bengaluru

BATTLE TO CLEAN BELLANDUR

13 years since case was filed and won, no changes on ground

The Bellandur tank, a 130 year-old water body, is spread over an area of 361 hectare (ha) in east Bengaluru. It is a part of the Bellandur drainage system that drains the southern and the south-eastern parts of the city. The tank is connected to chains of tanks: one chain originates in the north from Jayamahal, another from the central part of the city, and the third through the south-west. The catchment area of Bellandur is about 148 sq km. Water from this tank flows further east to the Varthur tank, from where it goes down the plateau and eventually into the Pinakani river basin.

In the 1970s, people from 18 villages depended on the waters of this tank. But by the 1980s, the chain of tanks feeding Bellandur had broken up. Rainwater did not recharge the tank. Instead, untreated sewage and effluents flowed into the water body. Birds stopped coming. The tank died.

In 1996, a case was filed by the Bellandur *gram panchayat* in the Karnataka High Court to prevent pollution of the tank. This led to the upgradation of the sewage treatment plant at the inlet of the tank. In 1997, fisherfolks' groups from Yemlur, Kempapura and nearby places petitioned against the then chief minister of the state as the polluted tank was affecting the fish yields. The petition was passed to the fisheries department, which released fishling into the tank to increase their production; but these fishling did not survive.

KANNANOKANNAN

By the 1980s, untreated sewage and effluents had filled the Bellandur tank, which a decade back had provided water to 18 villages

In 1999, the Karnataka High Court ordered the Bangalore Water Supply and Sewerage Board to supply potable water to residents in Bellandur and to ensure treatment of the sewage. But nothing changed. A contempt petition was filed. The case is pending before the Lok Adalat.

In February 2011, the report of the committee, headed by justice N K Patil, a sitting judge at the court, set out a clear agenda for the lakes of the city (see Box: *A timeline of citizen's action*).[39]

The report identified 189 lakes in the Greater Bengaluru area (see Table: *Lake count*). It directed the government to ensure that all these lakes were protected and developed by 2014. The committee made several recommendations which have been accepted by the high court. Most importantly, it has directed that the government must recognise that "lake preservation is not limited to the lake area, but is dependent on the catchment area and the drains that bring rainwater into the lake. The buffer prescribed for drains in the valley must be religiously implemented." It has also asked for the norm of providing a 30-m buffer – the legal boundary – to be "increased progressively by 2 m every 5 ha of increase in lake area beyond 40 ha". Lake preservation, including control of pollution, has to be integral to the layout development plans. All the lakes must be surveyed and marked on the ground.

In March 2011, the report of the committee was accepted by the Karnataka High Court.[40] "The recent court order has set a legal framework to carry out the restoration work and indicates the extent to which the lakes have been encroached, polluted, and protected and the agency which is the custodian of the lake," says Leo Saldanha. The only matter which remained is the decision regarding the lease agreements to privatise four lakes. The city's battle for lakes is not over.

TABLE: **LAKE COUNT**

Over a hundred lakes, looked after by four departments

Agency	Number
Bruhut Bengaluru Mahanagara Palike (BBMP)	129
Bangalore Development Authority (BDA)	44
Lake Development Authority (LDA)	11
Karnataka Forest Department (KFD)	5
Total	**189**

Source: Based on information received from BBMP and other agencies

Of flowing 'gutters and drains'

Waterbodies in and around the metropolis are a victim of the region's growth and prosperity. The Bellandur Lake is a case in point: industrial effluents from 181-odd industries around it, together with domestic sewage and phosphate-rich agricultural run-off, have polluted the lake waters, and contaminated the drinking water of people in neighbouring Tamil Nadu.[41]

The Vrishabhavati river suffers a similar fate. It receives improperly treated and untreated effluents and domestic waste from the BWSSB treatment plants. Erratic power supply leads to release of untreated sewage into it and other waterbodies. Significantly, a series of agricultural canals and weirs, which siphon freshwater from the rivers, have virtually starved the latter of their crucial environmental flows. Poorly planned urbanisation and infrastructural obsolescence have not only choked the

A TIMELINE OF CITIZEN'S ACTION

Bengaluru's fight to save its wetlands

1995: Zafar Futehally files a writ petition in the High Court of Karnataka against large-scale indiscriminate grants and unauthorised occupation of tank bed areas in and around Bengaluru. The high court issues direction to the state "not to make any grant or allotment of the lands situated in the Bangalore metropolitan area until further orders" with specific regard to tanks.

July 2002: The government of Karnataka, vide its order no FEE 12 ENG 2002, constitutes the Lake Development Authority (LDA) as a "non-profit organisation working solely for the regeneration and conservation of lakes in and around Bangalore city".

December 2003: The government issues a corrigendum stating that the jurisdiction of the LDA had expanded to include the metropolitan areas of Bengaluru and would cover the area notified under the Bangalore Metropolitan Region Development Authority (BMRDA). It would also include lakes in the green belt of Bengaluru. The LDA would also have jurisdiction over the lakes in the other urban municipal corporations of the state as well as the lakes in those city municipalities, which are the main sources for drinking water.

2004: The LDA agrees to lease the Nagawara Lake to Lumbini Gardens for a period of 15 years, for a monetary consideration.

2006: A PIL is filed by B K Bhat against the state government of Karnataka and the LDA in particular to ensure that no sewage enters the lake and tanks of the state.

June 2006: The LDA signs an agreement with East India Hotel for leasing out the Hebbal Lake for a period of 15 years for a monetary consideration of approximately Re 1 per sq ft per year.

April 2007: The LDA signs an agreement with Biota Natural Systems (I) Pvt Ltd for leasing the Agaram Lake for a period of 15 years.

August 2007: A letter is issued by the deputy conservator of forests (Bangalore Urban Division) to the conservator of forests (Bangalore), seeking initiation of proceedings under the Wildlife Protection Act (1972) against EIH Ltd (Respondent 16) for destroying aquatic life in Hebbal tank.

2007: The founder secretary of a non-governmental organisation, Vishwa Adhyatma Vikasa Prathisthana, files a PIL questioning the action of the state and its agencies in not maintaining the 81 tanks in the Bengaluru metropolitan area. A division bench comprising chief justice Cyriac Joseph and justice Ashok B Hinchigeri asks government to verify the facts on the issue and place the material before the court.

April 2008: The Environment Support Group (ESG) and its director, Leo Saldanha file a PIL in the high court against the privatisation of lakes. It asserts that only the government was entitled to lease them. The LDA had, therefore, overstepped its authority and not completed its task of rehabilitating the lakes. The ESG demands the cancellation of the three leases and opposes the decision of the LDA to lease out 12 more lakes to private real estate and hotel builders.

June 2008: In a new protest against privatisation of lakes in the city, almost 500 residents sign appeals – online and in person – urging the then principal chief conservator of forests Dilip Kumar to "abandon" the programme of handing over lakes to private companies to develop them into recreation hubs.

September 2008: In response to B K Bhat's PIL, the court directs that no sewage should flow into the lakes or tanks, the lake area should be surveyed by the revenue department and fencing should be done at the expense of the respondents. The forest department is ordered to plant trees and saplings, and the member secretary of the State Legal Services is directed to coordinate the work of the respondents.

November 2008: The High Court of Karnataka issues interim orders restraining state government and private parties from proceeding with any further investment or development of lakes based on the privatisation model.

February 2009: The court directs the State Department of Ecology, Environment and Forests to file a comprehensive report by March about the preservation of lakes.

August 2009: The High Court directs the government to provide details about all the lakes in Bengaluru, the steps taken to protect them, and the future measures to preserve them.

November 2010: The High Court constitutes a 10-member committee headed by Justice N K Patil of the Karnataka High Court to examine the ground realities and prepare an action plan for the preservation of lakes in Bengaluru.

February 2011: The report, 'Action Plan for Preservation of Lakes in Bangalore' sets out a clear agenda for lake protection in the city.

March 2011: According to the report, the city's water supply board will send treated water into the lakes by 2014.[1]

channels of flow (this aggravates flooding during rains), but have also caused drastic changes in the river *benthos* – marine life forms such as micro- and macro-invertebrates and worms living on the river-bed – and the food chain. The reduction in these vital life forms spells doom for species higher up on the food chain, such as fish.

By 2008, the state pollution control board had filed a case against BWSSB for not meeting standards for sewage discharge. It argued that the board was in contravention of the Water Act, 1974 which states, "No person shall without previous consent of the board discharge sewage to streams or wells." However, either no permission had been taken or the permission given was being flouted.[42]

Groundwater affected

The fast depletion of groundwater along with its increasing pollution presents a bigger threat in the face of a looming water scarcity. Untreated sewage flows from houses into open drains, reaches lakes and waterbodies and percolates slowly into water flowing below the ground.

In a recent study done by the Department of Mines and Geology[43], nitrate values in more than 35 per cent of the borewell samples studied showed high concentrations ranging from 50 milligramme per litre (mg/l) to 747 mg/l. Sources of nitrate pollution are earmarked as leachates from sewage drains, septic tanks, agricultural run-off, industrial effluents etc. Contamination from coliform bacteria has been remarkably high in areas like

BENGALURU'S UNDERGROUND PROBLEM

Inadequate sewage network is contaminating groundwater

The city that has made the world flat has a problem on its hands: it has found that its groundwater is too contaminated to use. In April 2003, the state's department of mines and geology collected 918 water samples from across 735 locations in the city. In over 370 locations (over 50 per cent), the groundwater was not suitable for domestic use, that is contamination exceeded levels laid down by the Indian Bureau of Standards for drinking water quality.

The key problem was nitrate pollution, indicating sewage-related pollution. In 262 samples, nitrate levels were found to be more than five times the permissible limit of 50 milligramme per litre (mg/l). In some samples, the nitrate values were as high as 666 mg/l, indicating a serious problem, for significant levels of nitrate pollution is known to cause the 'blue baby' syndrome in children.

To determine bacteriological pollution, 100 samples were collected and analysed for total coliform and faecal coliform. The results showed that over 74 per cent of the samples had bacteriological contamination. The permissible limit for drinking water is (without chlorinated) 0 MPN/100 ml; but the study shows that it ranges up to 23 MPN/100 ml.

The study concluded: "If the present trend continues, soon all the groundwater will be contaminated from one pollutant or the other. Since about 40 per cent of the city's domestic requirements of potable water is met from groundwater, there is an urgent need to protect it from pollution."

In 2006, on the orders of the Lok Adalat, the Karnataka State Pollution Control Board studied groundwater contamination in and around the city. This study also found that water in 161 borewells and open wells indicated the presence of pathogens. Nitrate, flouride and iron content in excess of permissible limits were found in the tested water samples from Koramangala, Challaghatta and Hebbal valleys.

The problem in the high-tech city is that its pollution management is still rudimentary. The city spends an extraordinary amount of money to bring water to its residents, but its sewage network is lacking and therefore, treatment remains inadequate. The city's highly priced water is now leading to more sewage which, in turn, is contaminating its underground water.[1]

slums, which do not have any underground drainage. Adverse effects on health cannot be ruled out when bacteriological pollution goes up to a high of 23 MPN per 100 millilitre, against the permissible limit of 0 MPN per 100 millilitre.[44] Given the degree of dependency on groundwater in Bengaluru, this is clearly a problem Bengaluru cannot afford (see Box: *Bengaluru's underground problem*).

LOOKING AHEAD

The city has tall orders for its money. Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), roughly Rs 2,800 crore has been sanctioned for various urban infrastructure projects, of which water supply and sewage is a key component. The city is busy doing what all cities do when there is money to get – make grandiose plans for new infrastructure development – without fixing the problems at hand. It will cost the city roughly Rs 2 crore per km to refurbish its existing sewage system. It also needs money to build more.

For its water, it is looking desperately for new sources. The BWSSB has set up a committee to identify new sources of water for Bengaluru. There is a proposal to take water from the Nethravathi – the BWSSB plans to sink a jack-well on the bed where the river joins the Arabian Sea. It is also looking at the possibility of tapping the water flowing in rivulets in Dakshina Kannada and Udupi districts, which it says is otherwise flowing into the sea. Another proposal being floated is to construct a desalination plant at Mangalore.[45]

But the city also has some plans with a difference. The question is, whether it will implement these different plans to make them a part of its water and sewage future?

Checking water losses

The city says it is serious about reducing the loss of water in its distribution system. In 2008, the BWSSB reopened its meter servicing and testing lab in Malleswaram, which it had shut down in the early 2000s. The objective is that the lab would calibrate new water meters and cross-verify the reading accuracy. The agency is also working to install multi-jet water meters in Bengaluru – these have much higher accuracy levels than single jet meters.[46]

Rainwater harvesting

In 2009, Bengaluru amended the Bangalore Water Supply and Sewage Act to notify the Bangalore Rainwater Harvesting Regulations. It made it obligatory for house owners to provide rainwater harvesting structures in all existing buildings with a built-up area of 2,400 sq feet and new buildings of 1,200 sq feet. If this is not done, the Board "may cause such rainwater harvesting structure and recover the cost from the owner or occupier as arrears of land revenue". The challenge is to ensure implementation of this act.

Lake protection

Driven by the active civil society and mandated by the judiciary, the city is being forced to pay attention to the preservation of its waterbodies. The big challenge for it is to ensure that not only the water structures, but also its inter-connecting channels are protected. More importantly, sewage needs to be treated so that these sponges of the city – sources of groundwater and protection from floods – do not become the receptacles of its waste.

Recycling sewage

This is one city where the water utility has decided to focus on water recycling technologies, aiming to give it new water. By

TABLE: **THE FUTURE IS HERE**
From sewage to freshwater, expensive to produce and profitable to sell in a water-deficient area

	Capacity (MLD)	Cost (Rs/kl)	Sale (Rs/kl)	User
V-Valley tertiary treatment	60	10-12	15-25	Power station and industries
Yelahanka	10		Rs 18 lakh/month	International airport, BEL, Rail wheel factory and others
Cubbon Park (membrane process)	1.5		Rs 6.75 lakh/month	Landscape irrigation of park
Lalbagh (extended aeration process)	1.5		Rs 6.75 lakh/month	Landscape irrigation of park

Source: V C Kumar 2011, 'Wastewater treatment', presentation made to Union ministry of urban development, Delhi, *mimeo*

2010, it had built four tertiary treatment plants to recycle and reuse wastewater, including a massive 60-MLD facility at V-Valley. In this plant – the biggest in India – wastewater is treated to near drinking water quality, close to 3 mg/l biochemical oxygen demand (BOD). The proposal is to supply this treated water to the Bidadi power plant, being built close to the city. It is also given to industries such as Arvind Mills.

The treatment, though expensive, is profitable in this water-deficit area. The production cost is Rs 10-12 per kl, while the board sells water for Rs 15 per kl if collected at the plant and Rs 25 per kl if supplied through a pipeline.[47] It has also designed smaller plants inside its green lungs, so that the treated water is used directly for gardening (see Table: *The future is here*).

The city had ambitious plans to take its treated water to its water source – the Hesaraghatta reservoir. But these met with resistance: residents of the city said they were not prepared to drink this treated sewage. This is the challenge for the modern metropolis: learning to reuse and recycle, so that it can make water from wastewater. This will be the future

The city government has proposed to upgrade all its sewage treatment plants – 340 MLD in the first phase – to tertiary level, at a cost of some Rs 500 crore.[48] The challenge now is to ensure that this nearly water-treated waste is also reused in the city. But clearly, the city is thinking big.