Challenges in urban water management in a changing environment – case study from a growing tropical city

Les défis de la gestion des eaux urbaines dans un environnement en évolution – étude de cas d'une ville tropicale en pleine croissance

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RÉSUMÉ

La gestion et la conservation d'eau urbaine sont devenues une question de développement sérieuse dans beaucoup de pays en développement. La population et les besoins d'eau croissent rapidement, tandis que l'approvisionnement en eau diminue en raison de la gestion inefficace et de la détérioration de la qualité de l'eau. Même des villes comme Kochi sur la côte sud-ouest de l'Inde, située dans une région qui compte de fortes précipitations, doivent affronter maintenant un manque d'eau potable. L'eau dans la ville est polluée bien au delà des limites de sécurité. La machinerie du gouvernement est inefficace dans la résolution des problèmes concernant l'approvisionnement en eau et le traitement des déchets. La croissance de la population urbaine aggrave la situation dans la ville et la vie devient plus difficile.

ABSTRACT

Management and conservation of urban water has become a serious development issue in many developing countries. Population and water need rise rapidly, whereas, water availability is decreasing due to inefficient management and deterioration. Even cities like Kochi in the southwest coast of India that lies in a heavy rainfall region now face shortage of reliable water. Water in the city is polluted far above safety limits. Government machinery is inefficient in solving problems related to water supply and waste disposal. Increasing urban population is worsening the situation in the city and life is becoming more inhospitable.

KEYWORDS

Population rise, Climate change, Kochi, Urban water, Urban water policy, Water degradation

1. INTRODUCTION

In many part of the Globe, population growth and urbanization are increasingly becoming challenges to Governments. According to the information from the International Year of Freshwater (2003), by the year 2020, some 60% of the global population will live in urban areas. Currently, more than 80 countries, with 40% of the global population suffer from severe water shortages. In the developing countries of Asia urban water supplies have progressed little in the last 20 years. Uninterrupted supply of potable water is not provided in almost half of the cities. Adequate coverage with sewerage is much lower. Unaccounted use of water still averages about 35% of production. Asian Water Supplies will be of greater challenge to government agencies, local administrations and planners in the coming years. Condition in Indian cities is growing worse compared to other Asian countries because of tremendous growth in population. There are 35 cities in India with population more than a million (Table 1**)** and there will be new additions soon.

1	Mumbai	19	Ludhiana
2	Kolkata	20	Kochi
3	Delhi	21	Visakhapatnam
4	Chennai	22	Agra
5	Bangalore	23	Varanasi
6	Hyderabad	24	Madurai
7	Ahmadabad	25	Meerut
8	Pune	26	Nashik
9	Surat	27	Jabalpur
10	Kanpur	28	Jamshedpur
11	Jaipur	29	Asansol
12	Lucknow	30	Dhanbad
13	Nagpur	31	Faridabad
14	Patna	32	Allahabad
15	Indore	33	Amritsar
16	Vadodara	34	Vijayawada
17	Bhopal	35	Rajkot
18	Coimbatore		

Table 1. Cities with population more than one Million (as on 2001), according to rank

Population growth is more prevalent in urban areas, as it provides better economic opportunities. Better education, employment and health facilities in cities always encourage migration from rural areas and this has become a major social, environmental and political issue in India. In India, a region is called urban if population density is at least 400 persons per.Km^2 and at least 75 per cent of male working population is engaged in non-agricultural pursuits. Urban areas account for about 28 % of Indian population and 60% of the Gross National Produce (GDP) of the country. It creates 57% of India's employment excluding agriculture sector. Urban areas in India are in severe crisis. Planning process has proved to be intrinsically defective, the cities are over crowded and urban land has become extremely scarce. Services are breaking down and city management is often ineffectual and human misery has increased beyond imagination. The urban infrastructure has become outdated. Coastal cities such as Kochi face challenges from changing climate. One metre rise in sea level may submerge almost 80% area of the city. Changing intensity, frequency and tracks of tropical storms in the Arabian Sea may bring disasters in future.

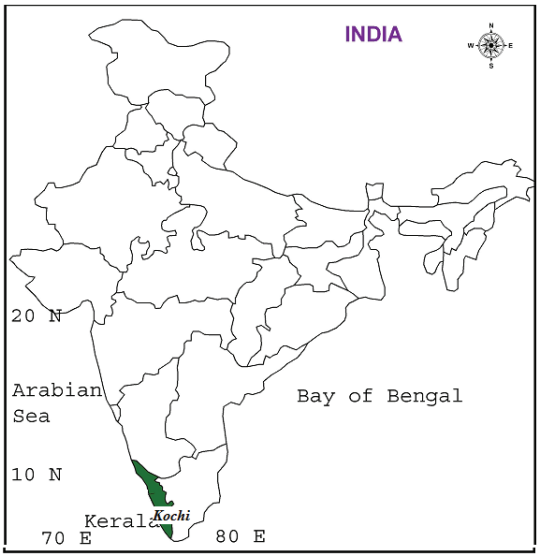

Fig.1 Location map

The metropolitan city of Kochi (formerly Cochin) is situated at 9°55'N and 76°15'E in the south-western coastal State of Kerala in India, adjacent to the Arabian Sea (Fig. 1). It has an area of 94.88Km^2 and an elevation ranging from 1m in the western side to 7.5m in the east. Western part of the city is separated from the mainland by the backwater Vembanad. Much of the city lies just above mean sea level, with a coastline of 48Km. The River Periyar that originates in the east-lying Western Ghats Mountain flows close to the city and provides water for it. In Kerala, 25.97% (82,67,135 out of 3,18,38,619) of the population live in urban areas. This is a little less than the National average. The city has a population of nearly 1.8 million and a population density 6250/km^2. The population is growing at the rate of 10.3% per decade, exerting tremendous pressure on water. However, unlike the other parts of the country, in terms of population and basic facilities, it is difficult to demarcate urban and rural areas in Kerala. An interesting fact is that when the urban content of the total population increased from 18.74 in1981 to 26.44 in1991, it showed a declining trend during the decade 1991 – 2001. With the current industrial development that started by the end of last millennium, trend has again become positive. The percentage decennial growth of urban population in the state was 60.89 during 1981-91. But, during 1991-2001 it was only 7.64 %. The main reason for urban population growth in Kerala is the increase in the number of urban areas and also growth of suburban areas, in addition to migration from rural areas. Reluctance to traditional jobs and setbacks in rural agriculture promote urban migration. Urban spread adds stress to the already shrinking water resources and agricultural areas. Kerala is not self-sufficient in food production because of social, political and economic reasons that include hiking wages and illegal and unjustifiable demands of trade unions and influence of foreign money (Kerala has the highest number of people working abroad and their income has impact on economic balance and urbanization). The economic potential of an urban area may depend on a number of factors like geographic location, availability of economic infrastructure, regional linkages, and propensities for accepting further investments and creating spread effects. Kochi has been a good port and good connectivity through roads to the interior. Economic expansion and industrial development attracts more population, even from other states, many of them living in slums. Most of this population are unaccounted and their demands and consumption of water are often not considered while planning projects. Kochi corporation includes suburbs Fort Cochin, Mattancherry & Ernakulam and the Greater Cochin Development Authority includes several municipalities around Kochi. The city is still growing, making life uncomfortable due to inadequate and unreliable water supply, heavy traffic and pollution.

2. METHODOLOGY

A comprehensive study of the rainfall and water balance condition of the Kochi urban area has been carried out using the data provided by the India Meteorological Department and the remote sensing data provided by the Department of Space, Government of India. Water balance of Kochi has been estimated using the method developed by Thornthwaite (1948) and Thornthwaite & Mather (1955) and as per the modifications suggested by GRDC (2000) for urban areas. Water availability in the area and runoff changes in the river have been computed from this. According to the water balance model,

water surplus represents the excess water after the actual evapotranspiration and the quantity to meet the field capacity. This surplus is water available for exploitation. Runoff depends on the slope of the terrain, soil type and vegetation. Changes in temperature and rainfall are reflected in the water availability and runoff. Landuse changes has been assessed using GIS techniques. Various issues related to water have been studied from the information collected from different government agencies involved, from the media, non-governmental organizations and from the residents of the city.

3. RESULTS AND DISCUSSIONS

3.1 Rainfall and water resources

The city receives heavy rainfall of around 310cm and lies in a perhumid climate. In extreme years, the rainfall rises up to 450cm and falls to nearly 250cm. Though southwest monsoon (June – September) is the principal rainy season in the area, rainfall from northeast monsoon (October – December) and from the pre-monsoon (March – May) thunderstorms are also significant. The city has 167 rainy days in a year. Annual rainfall intensity is 2.5cm/rainy day and variability 15%. Climatic water balance of the city shows a climatic seasonal water surplus of 170cm, and deficiency of 37cm. Analysis using data of last 100 years shows no decadal trend in rainfall or water balance elements and global anomalies do not show any significant influence on these parameters directly. Anomalies in local climate that do not show a one-to-one correspondence to global anomalies have an impact on this. But, per capita water availability has decreased from 3780 m^3 to 1365m^3 in 100 years, due to rapid increase in population (Table 2). This shows that this area will face acute water shortage in near future. Actual availability of usable water is much less than estimated, due to deterioration of water resources. There exists a considerable annual runoff of 8956Mm^3 in the River Periyar that supplies water to Kochi, as so many small streams contribute to its vast catchment area. This can theoretically vary between 5000 and 13000Mm^3. During 1961-70 there was a record mean annual runoff 10568Mm^3. However, estimates show that there has been a considerable reduction in the runoff from Periyar since the latter half of last century, because of the construction of reservoirs, inter-basin transfer of water and changing rainfall characteristics. Increasing seasonality and intensity of rainfall and large raindrops from the increasing number of convective clouds result in erosion of topsoil in the Western Ghats Mountain where the river originates and sedimentation in the rivers and reservoirs. The mountain area is highly degraded by human interference. Deforestation and removal of topsoil affect groundwater recharge and summer runoff in the river.

Decades	1901-10	11-20	21-30	31-40	51-60	61-70	71-80	81-90	91-00
Per capita Water availability(m^3)	3780	4001	4290	3880	2787	2540	1877	1362	1365

Table 2. Decadal changes in per capita water availability in the city

3.2 Water demand and quality issues

The river Periyar is highly polluted from the toxic effluents from several factories on its banks. Non-point source pollutants like untreated domestic wastes, fertilizers, pesticides and motor oil are also carried into the river through numerous canals. Mudflow in the river during pre-monsoon months has obstructed the domestic water supply on many occasions. Though the rainfall is high, proximity to the sea and pollution from industrial and domestic sources make the surface and groundwater not usable, especially in the western parts of Kochi. Water has to be brought from the River Periyar from a safe point several kilometres away. Public water supply system that was planned long back without properly considering future needs is quite inadequate now. Water need and water availability are not proportional to rise in population. Changing life style necessitates more water. Availability of reliable water sharply decreases with population rise because of the degradation of resources. There are thousands of people travelling daily to the city in daytime for jobs from nearby area and their water use and need are not accounted. Present, against the total water demand of the city is 400 MLD (326 MLD for domestic and agricultural sectors and 74 MLD for industrial use). Even with special augmentation schemes and different projects city still faces a shortage of 120 MLD. Situation can be improved after the implementation of proposed Kochi Metro water supply project and modification of exiting projects. Response from the State Water Authority to public water issues or technical failure in supply is very slow and the inhabitants in certain occasions have to wait for hours and days to get water. The water purification system and delivery pipes are old and without much modifications. Unexpected power

failure always affects pumping and contributes to the water crisis. Daily water supply through public delivery system in the city is only half of the drinking water requirement. Recent studies show that out of the 635Km of pipelines, 190Km is very old and needs immediate replacement. An additional 215Km is required for meeting the present demands. About 34% of the population has domestic water connection and remaining depends on public taps. Many houses have wells attached to it, but the water is contaminated with excessive biological pollutants. Salinity intrusion as a result of proximity to backwater and Sea in the western side and over extraction of groundwater in the eastern side also is reflected in the well water quality. Recent analysis of the pipe water in the city shows that occasionally the quality is far below safety level. The freshwater pipes run through sewerages and highly unsafe areas and when the pipes break, wastewater enters the pipes, resulting in serious health problems. Water-borne and vector-borne diseases have become common.

Though the city has so many inter connected canals, high intensity of rainfall and unscientific design of sewage system and roads block the water, resulting in flash floods. Deposition of mud in the canals and careless disposal of solid wastes worsen the situation. Roads and constructions in the city increase runoff and reduce infiltration, and affect water quantity and quality. Sand filling of paddy fields, ponds and wetlands in and around the city has also reduced the freshwater availability and wastewater outflow. Many residential areas are on reclaimed wetlands. Destruction of the wetlands since the latter half of the last century reduced the natural water purification and added to the flooding during heavy rains. Water demand in this urban area continues to grow because of significant population increase. In addition to the demands of rising population, water consumption in the city has shot up by a huge margin with the rise in development projects and construction activities in the city and its suburbs in the last few decades. As there is no proportionate increase in the supply, this leads to acute drinking water shortage. In addition to all are the theft and misuse of water in the inner parts of the city. Water scarcity is severe in West Kochi and the northern islands. Supply here is much below the requirements of 15 MLD (million litres per day). Violent agitations for water in the Vypeen islands compel the corporation to provide interim additional supply, but this invites protests from people living in other parts. People even resort to illegal tapping as a warning to the corporation. Though agitations for water have become very common, the administration is rarely care about it. If measures for the alternate arrangements for the water supply and efficient use of available water, and stringent measures to reduce water deterioration are not taken urgently, water will soon become a scarce commodity and life will become uncomfortable. Social issues such as disputes over allocation, pricing of water that is unaffordable to thousands of poor and serious health issues will make urban water management more complex.

Recent press reports quoting the international environment group Green Peace say that the industrial belt of the industrial village Eloor in the eastern side of Kochi is one of the world's most toxic spots. Unchecked pollution in the area has led the people in the area to suffer from higher rates of death and disease and an insecticides manufacturing company has been mainly responsible for this. It is afraid that the poisonous material is leaking into the Periyar River. Diseases like cancer, congenital birth defects, bronchitis, asthma, allergic dermatitis and stomach ulcers have become common in the local population. Water at Eloor contained 100 organic compounds that included DDT and its metabolites, endosulfan and several isomers like hexachlorocylcohexane, a persistent pesticide. Some of these products were banned long time back, but still they appear in different forms. The study reveals that the chances of the residents of Eloor inhabitants contracting cancer are 2.85 times higher than similar toxic areas in India. Terrifying findings include 2.63 times higher risk of malformation due to congenital and chromosomal aberrations in children, 2.7 times higher chances of death due to an accident, 3.8 times chances that children may die due to birth defects, 3.4 times chances of death due to bronchitis and 2.2 times that of asthma. Though the water related problems in the city are increasing with time, so far an appropriate urban water policy and implementation measures is not formulated.

3.3 Urban water policy

Urban development in India had been neglected for a long period because of multiple problems. However, Government has recently introduced several schemes for integrated urban development. A serious attempt to formulate policies for integrated urban development in India began in the 1980s with the appointment of the National Commission on Urbanisation. The main objectives of Urban Development Policy were - saving cities and reviving their economies, development of fast growing intermediary level urban centres and development of stagnating towns by providing gainful employment opportunities. The National Commission suggested that strategy should be a part of the major strategy of generating economic growth and urbanisation and should be visualized as a major instrument for promoting agricultural and industrial development as well as implementing antipoverty

programme in backward areas. Water naturally becomes an integral part of any such development strategies.

Though increased urbanisation is an important aspect of the process of economic and social development, it is closely connected with many other problems, such as migration from villages, relative costs of providing economic and social services, provision of housing for different classes, provision of facilities like water supply, sanitation, transport and power, location and dispersal of industries, civil administration etc. Kochi generates employment for thousands of people from rural areas. Though not in a large scale, migrants, mostly poor and illiterate from other states also come here in search of job and they create slums. The associated problems like sanitation, health, law and order, lack of basic necessities and so on that lead to unrest in society. Unemployment and overcrowding are also becoming an issue in the city.

Coming to the problem resolution, Certain minimum requirements related to urban water problem which need to be fulfilled include — (i) Designing housing societies so as to minimise water supply and drainage problems (ii) efficient land use and (iii) strong administration to maintain water supply, street lighting, drainage, roads and streets; and treatment of waste water and safe disposal of wastes. Traditional technologies for natural resources protection and management are more environment friendly and of low expenditure. This can be encouraged in cities also.

More investment is needed in basic infrastructure to cope with increasing demands and changing environmental conditions. Private sector involvement becomes necessary, as the government funds are limited and the government machinery is slow. But, any more taxation will invite strong protests. So, a government control should be there in pricing for any commodities. Water should be highly subsidised or provided totally free to the poor. From the past experience, timely completion of projects and efficiency of implementation are possible only in non-government sectors. Involvement of non-governmental organizations may function better. An Urban Regulatory Authority is necessary to ensure efficient private sector participation in water and power in municipal services, to maintain quality of services, and to make sure that the cost of services to the public is reasonable. This authority may be given statutory powers to enforce these objectives.

Kochi city region has already attracted substantial industrial activity supported by well-developed trade and commerce. The port, the newly developed airport and railway linkages have contributed to the development of Kochi region as the prime economic node of the state. The National Commission on Urbanisation has identified this region as the Spatial Priority Urbanisation Region. So there can be a considerable increase in water demand in industrial sector in coming years. Without proper management practice, there can be a reduction in domestic water supply, leading to severe environmental, administrative and legal issues.

Inadequate drainage pattern is a curse to the city. Plastic and other solid wastes from domestic sector often block the drainages and during summer monsoon flash flood occur in the city. In addition, indiscriminate conversion of low lying paddy fields, water bodies, ponds etc., has resulted in surface drainage problems. Land zoning and new land developments have to be viewed with regard to urban drainage aspects and the required measures are to be strictly enforced.
Urban Drainage being a specialized technical subject, adequate expertise has to be developed and required institutional assistance for urban drainage is to be found. Involvement of residents' association in urban projects may be considered favourably wherever feasible. Government should promote setting up of underground sewerage system and liquid waste treatment plants.

To make the urban structure an effective tool of catering to people's needs, administrative reformation is necessary and all the outdated laws are to be rewritten. Policy implementation needs strong political will also. The Government shall make available modern technological facilities and equipment to personnel engaged in Planning and Development. Government shall insist on all developers including public sector agencies to attach Environmental Impact Assessment (E.I.A.) statements to all applications seeking approval for major development projects. The Government shall issue necessary guidelines in this regard.

Indiscriminate conversion of low lying urban areas shall be regulated using policies arrived at based on scientific studies. Such conversion not only affects water availability, but also the drainage outflow from city area. As the drainage is becoming a major water quality related issue, urban drainage expertise may be developed and required institutional assistance for urban drainage may be found. Private sector participation may be explored in this area also. Government may give top priority to keep the cities and towns clean - establish scientifically designed solid waste management system including improved methods of collection and transportation, recycling etc. without causing

environmental pollution. Hygienic sanitation facilities for public use made compulsory with eateries, hotels, restaurants, petrol pumps, supermarkets, malls public buildings etc. Public Crematoria and. modern slaughterhouses are to be established in the city. Modern water treatment system is to be established and the wastewater is to be cleaned before empty to backwater and the Sea, as the urban water problem is leading to transboundary issues.

4. CONCLUSIONS

The study reveals that water shortage is increasingly becoming a serious issue in the city. Demand has been growing fast with population, and the availability is fast decreasing due to pollution, landuse changes and climate change. Both surface and groundwater in the city have been polluted far above permissible limits. Present amount of water supply and the maintenance of the delivery system are quite inadequate. Suggestions for the better management includes: - Proper and timely maintenance of the public water system, sewerages and canals, Control of unauthorized use of public water, Provision of convenient local disposal sites for domestic wastes and its timely removal, discourage use of chemicals and fertilizers before heavy rainfall to prevent its transportation through water, minimising river pollution from industries, Proper filtering of tanks, Reducing water loss in distribution system and starting water conservation measures from domestic level, Increased public awareness on the needs of water conservation and pollution control and advanced training for the engineers and technicians. Public participation and involvement of NGOs for implementing and supervising urban sanitation programmes may help lot in solving social problems related to water. After all, there should be a strong government policy for urban water management and pollution control, an appropriate adaptation strategy and a political will to implement them.

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