CHAPTER – 7
MANAGEMENT STRATEGIES

7.1 Introduction

Water is the most precious natural gift for the existence of life on earth. Access to enough water of sufficient quality is fundamental for all human, animal and plant life as well as for most economic activities. At the global level, plenty of water is available. But still, over a billion people, mostly in developing countries, lack adequate access to clean potable water. The demand for fresh water is increasing among the competing users; there has been very serious and intensive thinking at various levels all over the world on its limited availability, possibilities of exploitation and effective management. The world needs sustainable water management. A sustainable water supply which also satisfies people’s need for high quality is an enormous challenge to the governments of many countries, especially in the developing countries because in many countries the existing water shortage is worsened by a large number of problems.

Water is not easily accessible to all. Water scarcity has become a major issue and has invited attention. The drivers of the water crisis are – demographic growth, economic development, urbanisation and pollution. These all factors are putting unprecedented pressure on water resources. But it is only a part of the picture. The curse of water shortage depends on various factors. Most of these factors spring from either socio-economic or politico-administrative arrangements. The ineptness and apathy of the water managers also aggravates scarcity, people lack availability of water, not as much because of natural inadequacies but because of inefficient management. The problem of water scarcity makes it necessary to develop strategies for combating the current situation of shortage.

7.2 The Concept of Water Management

Water resource management is a activity of planning, developing, distributing and managing the optimum use of water resources. The entire gamut of installing and
providing a water supply system, enhancing it and maintaining it to keep up with the increasing demand, ensuring satisfactory quality and also planning long term sustainability of the resources fall under the preview of water management. Three important components of water resource management are given below:

i) **Supply Management:** Supply management includes increased access to conventional water resources through the construction of hydraulic structures aiming at regulating water supply and conveying water to the end user (dams and reservoirs, conveyance system), as well as enhancing supply with treated waste water, desalination and inter-basin transfers.

ii) **Demand management:** Demand management, in contrast, aims to raise the overall economic efficiency of water use or to re-allocate water within and between sectors. The general aim of demand management is to maximize the benefits obtained from a given amount of water available to users, which could also include producing the same benefit from less water. Demand management can suggest alternative water application methods for different purposes and even practices and techniques of water conservation.

iii) **Quality management:** Quality management deals with the preventive and rehabilitative solutions of water contamination and pollution.

According to Zerah (1999)\(^1\) “Management of water in an area is determined by complex interaction among engineering approaches and growth in productivity, stability in production and equability in distribution of water, institutional arrangements and operation and maintenance of resources”. Comprehensive reviews of the water consumption, pattern from each type of water resource, community organization, preparations of people currently having reasonable access of safe water, the proportions of water systems actually working, and the habits of population also form a crucial part of management process.

Water management also includes policy formation. For making public policy on water resources need to be governed by certain basic principles, so that, there is

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some commonality in approaches in dealing with planning, development and management of water resources. These basic principles are as follows:

- Planning, development and management of water resources need to be governed by common integrated perspective considering local, regional, state and national contexts, having an environmentally sound basis, keeping in view the human, social and economic needs.

- Principle of equity and social justice (equity in distribution especially amongst economic classes).

- Good governance through transparent and informed decision making is crucial to the objectives of equity, social justice and sustainability. Meaningful intensive participation, transparency and accountability should guide decision making and regulation of water resources.

- Water needs to be managed as a common pool community resource held by state, under public trust doctrine to achieve food security, support livelihood and ensure equitable and sustainable development for all.

- Water is essential for sustenance of eco-system and therefore, minimum ecological needs should be given due consideration.

- Water security has multiple dimensions. The focus of water management now needs to shift from supply management to demand management.

Water management may be practiced at various levels. Actions dealing with various aspects of water may be initiated at any scale-global to local. The global vision of water management must be reflected at the smallest scales. Policy formations at the global level have to be linked to long-term capacity building at the local level. Institutions and legislation, human resource development and dissemination of information are the three main elements required for capacity building at the local level. The core of water management at the local level is the idea of capacity building, which is linked to the regional development plans and the national policy.
7.3 Issues and Challenges

The issues related to water management are highly complex. Despite the best efforts of the water managers, new challenges crop up every day. The main issues and challenges faced by water managers in managing water resource are as follows.

7.3.1 Water Security

Water security is defined as adequate supply of water of assured and sufficient quality to meet the human needs for drinking and other essential uses. In broader terms, water security means development, protection, management and sustainable use of fresh water resources in such a way to provide equitable access to adequate and safe water at affordable cost to live a healthy and productive life free from the risk of water related hazards. Thus security involves access to adequate quantity and safe quality. According to Human Development Report (2003)\(^1\), “access to water for life is a basic human need and fundamental human right”. Poor access to water, drinking or otherwise is not only be life threatening, but also increases the vulnerability of people by restricting the options available to them towards fully utilizing their potential for human development.

It is unfortunate that despite more than six decades of planned development, we are not able to provide water security to every citizen of the country. Safe drinking water remains a problem for the country. So much so that nearly 45 per cent of India’s rural population does not have access to potable drinking water in adequate quantity\(^2\). Since Independence, there has been sustained effort to provide on priority basis potable water to all inhabitations and this has been seen in urban areas where almost all urban centers have been provided with some public water supply scheme, which is the primary source of potable water for most urban habitants. In the case of Delhi, according to Census 2011, 24.8 per cent of the households were not receiving piped treated water. A population of 32.53 lakh not covered through pipelines, was supplied water through tankers during the year 2011-12 with average per capita supply of 3.82 liters per day against prescribed norms of 172 liters per capita per day for domestic

\(^1\) United Nations Development Programme (UNDP) (2003), op. cit.
use. But official reports tend to give greater weight to physical and financial progress rather than the quality, reliability and sustainability of services. Mere coverage does not reveal the regularity or duration of supply or even whether the supply is made on daily basis or less frequent. Most importantly, the coverage figures say nothing about the equity of distribution, while it is well known that poorer areas are provided with less water whereas the influential rich areas get a more satisfactory service.

The rural-urban interface is also an interesting issue in water management. Water management efforts were mostly directed towards catering the needs of city dwellers. Rural areas either were left to fend for themselves or the development of rural water provision is inadequate. Not just far-flung rural settlements, but also those in city’s hinterland cannot be given a proper supply of water. A large chunk of the city’s rural belt which falls in the water deficient zone is facing acute water scarcity. Though, the coverage of Delhi’s urban area under piped water supply is 100 per cent, even than they are facing water scarcity, particular in summer season.

Government laws usually prevent suppliers from providing water piped networks into illegal, unplanned housing areas. Almost 50 per cent of the city’s population lives in these areas including the poorest, but, for fulfilling their water needs depend on either tankers or community taps. The poor and under privileged in Delhi receive subsidised water, but it comes at a price, in terms of time and cost. Delhi slums are solely dependent on government provisioning for water. The poor in both rural and urban areas bear a disproportionately higher burden of the non-availability of water, as well as its poor quality. Seasonal disruptions of water supply are common, especially during summer months. Fetching of water for domestic use, sometimes from far-flung sources is time consuming as well as physical burden borne by woman and children. Apart from the repercussions on health, this also affects their overall well-being.

Towns and villages are expanding rapidly, new habitations are coming up – all requiring and demanding drinking water for sustenance of life. The distribution system in the city is mostly old and outdated. The population is growing rapidly. Water managers have to ensure adequate supplies for both urban and rural areas. They have to plan their water management in such a manner that the disparity in rural-urban
well-being is minimised. So, meeting the demand of safe drinking water for all or providing water security to all is a challenging task for effective water management in Delhi.

### 7.3.2 Water Pricing

In India, water is priced very low. Water tariffs are absurdly skewed. According to the Bouselly, Gupta and Ghosh (2006)\(^1\), the cost of delivering water to a metro home is 15 rupees per 1000 litres, but the customer pays only 0.5 to 5 rupees. A large amount of clean water is wasted as it is given away almost free. Resource management centre on the proper modes of fixing charges for water. Though the entire municipal water that is supplied, supposed to be accounted and paid for it, in fact, hardly done. The municipal authorities are successful in their endeavor to claim payment for water. First, due to unmetered connection; second, significant number of water meters that are there, are either inaccurate or faulty. A third situation is where a colony (as in some government colonies) has a common measuring system and the charge is divided evenly between users. This amount is nearly a fixed charge for all, regardless of the quantity of water being used (or wasted) by any individual in the group. Unless the price of the water reflects the intrinsic value of the resource, it will continue to be wasted and misused.

The question of affordability is often raised by critics for poor, however, the poor are already paying upto 20 times of what the rich pay to get water from unreliable resources. In contrast, what the rich pay for piped water is a fraction of the actual cost of producing potable water. It is clear that the poor face the brunt of this inequality. On one hand are sizeable number poor who don’t get assured supply and on the other hand, are the rich whose consumption is subsidised by the state. The poor have remained at the end of “pipe dream” of getting water. The benefit of subsidised water delivery system has failed to reach the poor. Since a majority of the poor, for whom the subsidy has primarily been directed, have not been linked to the supply

lines, the benefits have flown to the privilege class. The privilege class pays 2.6 rupees (Annexure IX) per cubic meter of water in Delhi - the lowest in country.

The process of water distribution has continued to encourage inequality. Not only the rich has been served at the cost of the poor, but poor are literally not getting it free. For the poor, the subsidy acts like a double edged sword. First, they don’t seem to get benefit from it and second, the sources of water they depend on, get polluted by untreated sewage that is flushed out by rich. So the benefit of subsidy is rarely reaching the poor. This is a big challenge for water managers to ensure equity in water distribution by reaching out to the unreached. Therefore, there is a need of restructuring water tariff structure to encourage resource conservation as well as to generate more funds for proper operation, maintenance and upkeep of the water supply.

7.3.3 Source Sustainability

Delhi has undergone explosive demographic expansion, which leads increasing pressure on water sources in various river basins in north India as well as on its internal groundwater resources. The small city state is high on consumption (with an insatiable demand), low on internal resource and high on external dependency (mainly dependent on river Yamuna, Ganga, Bhakra-Beas system - all snow fed northern rivers). Despite interstate agreements and regular meetings of Upper Yamuna River Board, there are regular conflicts regarding the sharing of water allocated to each state and particularly to Delhi. Interstate water disputes and bitterness of those disputes would be increasing with passage of time. Delhi has limited options to influence development outside its boundary. With restricted source of surface water, source sustainability is a issue of great concern in Delhi.

The people whose water needs are not being met by Delhi Jal Board (DJB) depends on groundwater. Even DJB draws about 100 MGD of groundwater for its network supply. Thus, there is extensive dependence on groundwater in Delhi and it is increasing rapidly. The people have joined the rush for borewells for water and there is no levy on drawing water and little control over boring wells. Expectedly, the pressure on groundwater has been shown up. Legally, the borewells have to be registered with Central Ground Water Board (CGWB) laws. However, laws are
seldom practiced and the borewells are never registered. People facing acute scarcity rely more on groundwater than on the water supplied by DJB like in south and south-west Delhi, CGWB has forbidden the extraction of groundwater “notified” areas but people still continue to drill borewells and tubewells illegally. Private water tankers also rely heavily on the groundwater for their business. Owning to escalating population without commensurate increase in the availability of raw water, the groundwater in Delhi has been overexploited. This has disturbed the hydrological balance leading to decline in the productivity of wells, increasing pumping costs and more energy requirements. The CGWB assessed the total groundwater potential to be 292 million cubic meters (MCM) in 2003 as compared to 423.07 MCM in 1983. This shows an overdraft and reduction of around 130 MCM over the past 20 years\textsuperscript{1}. Thus, the rapid and accelerated use of groundwater to meet competing demands from various sectors has led to an alarming decline in groundwater level in many areas and consequent stress on groundwater resources.

There is another problem of overexploitation of groundwater in Delhi. With enhanced lifestyle and improved water supply systems, water has different uses in study area. In the domestic sector, water use is limited to cooking, cleaning and washing. With increasing awareness of sanitation, health, hygiene and even aesthetic issues, more water is now being consumed by households. Particularly in urban areas, nurturing of lawns, washing cars etc. has led to many fold use of water. Commercial growth of Delhi has put additional pressure on water system. Another problem of groundwater is that people think it is a free public good and they can extract it very easily. Therefore, there is need to regulate the extraction of groundwater.

7.3.4 Quality of Water

Water quality is also a relevant issue in Delhi. As a result of the increasing re-use and re-circulation of water, which is itself a response to water scarcity, water quality tends to deteriorate, thus reducing the availability of water of sufficient quality for given uses. The deterioration of water quality therefore makes scarcity more acute and damage economic growth. The deteriorating quality of surface water and groundwater has for long been an alarming situation in Delhi. Not only the depletion of

\textsuperscript{1} Delhi Development Authority (2007), \textit{Master Plan for Delhi – 2021}, Government of India, New Delhi.
groundwater is raising questions about future availability of water in the capital city but also the quality of water. Chemical quality of groundwater in Delhi varies with depth and space. Brackish groundwater mainly exists at shallow depth in North-West, West and South-West districts with minor patches in North and Central districts. In alluvial formation the quality of groundwater deteriorates with depth, which varies in different areas. The fluoride contamination in groundwater has been noticed in samples of groundwater collected from south-west and west districts. The nitrate concentration in groundwater has been reported mostly from areas where domestic effluent is discharged into open unlined drains. The salinity of groundwater is increasing in south-west and north-west Delhi\(^1\). Salinity of groundwater makes the citizen even more dependent on private suppliers of water.

The poor quality of surface water of the Yamuna, a river traversing a total distance of 48 kilometers in Delhi, has for long troubled the city planners. The Yamuna accounts for about 40 per cent of Delhi’s water supply. However, the stretch of the river running through Delhi is extremely polluted as a result of the uncontrolled flow of untreated sewage and the discharge of industrial effluents. An additional reason is that no fresh water is available for dilution in Yamuna, as the entire fresh water from Wazirabad is used to meet drinking water needs of the citizen of Delhi. It is alarming that the Yamuna has highest bio-chemical oxygen demand (BOD). Therefore, the citizens of Delhi also incur higher costs to procure water that is fit to drink by using systems like RO and Aqua guard, which the poorer segments of population can’t afford. Therefore, providing safe drinking water to all the segments of the society is also a challenge for water management in Delhi.

### 7.4 Management of Water Resources in Delhi

In view of the vital importance for human and animal life, for maintaining ecological balance and for economic and development activities of all kinds and considering its increasing scarcity, the planning and management of water resources and its optimal economic and equitable use has become a matter of utmost urgency in Delhi. Recognising the need for urgent reforms and capacity addition in the water sectors,

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\(^1\) DHDR Anon. (2006), *op. cit.*
Delhi government has undertaken a number of initiatives to manage water resources. These are given below.

### 7.4.1 Managing Supplies

Delhi Jal Board has planned various schemes to increase production and to improve supply of potable drinking water to the inhabitants of Delhi. The major schemes identified are as follows:

#### 7.4.1. (a) Augmentation of raw Water Availability:

The short to medium term availability of surface water is a constraint on the augmentation of water supplies for Delhi. According to Delhi Master Plan 2021, the projected demand in 2021 will be 1380 MGD at the rate of 60 GPCD for 230 Lakh populations. Thus, there will be a shortfall of 440 MGD. To meet this shortfall, the work on the following dams has been expedited. The brief details of the dams are as under:

- **i). Renuka:** Renuka, a 148 meter high rock fill dam on river Giri, a tributary of River Yamuna in Sirmaur district of Himachal Pradesh is established mainly to augment water supply to Delhi. A provision of 275 MGD (about 1.25 million cubic meters per day) has been earmarked for Delhi’s use. Its estimated cost is 3600 crore rupees at 2009 price level. This project has received environmental clearance.

- **ii). Kishau Dam:** This dam is to be constructed on river Tons in Uttrakhand. A provision of 372 MGD (About 1.7 million cubic meters per day) has been earmarked for Delhi’s use in the storage of this dam. The Kishau dam project was cleared in 72nd meeting of the advisory committee on Irrigation Flood Control and Multipurpose Projects. On 18th January 2000, a MOU has been signed with the Tehri Hydro Development Corporation (THDC) for construction of dam.

- **iii). Lakhwar Vyasi Dam:** This project envisages construction of 204 meters high concrete dam on River Yamuna near Lakhwar village in Dehradun in Uttarakhand and another dam downstream at Vyasi for providing drinking water, irrigation and power generation. This dam will provide 330 million cubic metre storage of water and 420 megawatt of power.
With the completion of these storage projects, Delhi shall receive additional availability of about 500 MGD for fulfilling the projected shortage of 440 MGD by 2021\(^1\).

**7.4.1. (b) Augmentation of Groundwater:** Central Ground Water Board (CGWB) has found an ocean of groundwater in the belt around upper Ganga Canal at depths ranging from 200-600 meters. The deep aquifers (underground geological formations that hold water) are located in the Ghaziabad and Meerut districts of Uttar Pradesh. CGWB has proposed to drill 350 tubewells at the depth of 250 meters and expert’s opinion is that each tubewell will draw 2200-3000 litres of water per minute. Running them for 12 hours every day will yield enough water to run Sonia Vihar water treatment plant, often dubbed as the last hope of dry Delhi. This water can simply be put into the existing Upper Ganga Canal and taken to Sonia Vihar water treatment plant through the conduit laid from Muradnagar to the plant. It can fulfill the plant’s need for 50 to 100 years\(^2\).

Deep aquifers have never been trapped in India and this water stagnating for thousands of years. Significantly, unless tapped, the quality of water would deteriorate with passage of time. According to CGWB, chemical reactions are already affecting quality of water by making it saline. Tapping this would solve Delhi’s water problem and also stop the ingress of saline water to upper sub-soil areas. CGWB has already presented a “Water-for-Delhi” plan to Ministry of Water Resources, Government of India.

CGWB has also earmarked potential area for 10 MGD from flood plains of River Yamuna in NCT of Delhi along with Okhla barrage, Kalindi Kunj through a battery of 25 tubewells also along Akashardham Mandir and Nizammudin Bridge through a battery of 25 tubewells\(^3\).

**7.4.2 Pollution Control**

Pollution reduces water available for use and increase the cost of water treatment. In order to address water quality issue, Yamuna Action Plan-1 (YAP-1), one of the

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\(^1\) Delhi Development Authority (2007), *op. cit.*

\(^2\) Central Ground Water Board (CGWB) (2009), *op. cit.*

\(^3\) Central Ground Water Board (CGWB) (2008), *Ground Water Potential of the Yamuna Flood Plain: NCT Delhi*, Ministry of Water Resources, Govt. of India, New Delhi.
largest river restoration projects covering Delhi, some other parts of Uttar Pradesh and Haryana was initiated in 1993 as part of joint effort by Government of India and Japan. However, cleaning of Yamuna remained as unfinished agenda under YAP-1 and threw up the need of active people’s participation. YAP-II focused on building new sewage treatment plants and expanding capacity of old plants in order to address the most polluted stretch in Delhi. Now, YAP-III has been approved involving a total cost of about 1657 crore rupees to improve the deteriorating water quality of River Yamuna¹.

7.4.3 Rain Water Harvesting

In Delhi, rainfall generally occurs during short spells with high intensity. Because of short duration of high rain, most of the rainwater tends to flow away rapidly leaving very little to recharge the groundwater level. Most of the harvesting systems in cities have been neglected and have turned into diseases as a result worsening the urban water scenario. One of the solutions to the urban water crisis is Rain Water Harvesting (RWH) by capturing the runoff and promoting the water conservation in big way. Keeping in view the water scarcity in Delhi, its local bodies have been asked to adopt water harvesting through storage of rainwater runoff. In Delhi, building bye-laws (1983) have been modified to incorporate mandatory provisions of roof top RWH in new buildings on plot of size 100 square meters or above. It has also been made mandatory for all non-residential buildings having discharge of 10000 liters per day to incorporate a waste water recycling system for further re-use in horticulture etc. Delhi government has been initiated a financial assistance scheme for implementing rainwater harvesting. This scheme grant in aids (financial assistance of 1,00,000 rupees or 50 per cent of cost, whichever is less) to Registered Resident Welfare Associations (RWA’s), Co-operative Group Housing Societies (CGHS), Government/Private schools, Hospitals, Charitable Institutions and NGO Buildings etc. for adopting rain water harvesting. Under the scheme around 162 rainwater harvesting structures have been completed till 2009-2010².

² Centre for Science and Environment (2012), op. cit.
7.4.4 Recycling of Waste Water

During the course of treatment of raw water at Water Treatment Plant (WTP’s), 8 per cent to 10 per cent water go waste due to backwash of filters and the clarifloculators. In view of scarcity of raw water, DJB has started waste water recycling plant at existing water treatment plants at Haiderpur, Wazirabad and Bhagirathi, thereby adding 37 MGD of water available for further treatment. The fourth water recycling plant at Chandrawal is nearing completion and will be made functional shortly\(^1\).

7.4.5 New Water Treatment Plants

Four new water treatment plants has been constructed and become operational. These are Sonia Vihar (140 MGD), Okhla (20 MGD), Bawana (20 MGD) and Dwaraka (40 MGD). Dwaraka and Bawana water treatment plants are yet to be utilised fully due to non-availability of raw water.

7.4.6 Ground Reservoirs

Construction of ground reservoirs (UGR) and booster pumping stations all over Delhi are planned for rationalisation and better distribution of water. Out of the 53 new proposed UGR’s, 33 UGR’s already commissioned and 3 UGR’s are targeted for completion during 2012-13 financial year and 6 will be commissioned by December, 2013 and for 4 UGR’s, DDA is yet to allocate suitable land\(^2\).

7.4.7 Steps for Infrastructural Betterment

Some important programmes were implemented to reduce the water distribution losses along with lying of new water lines to replace the old water lines, installation of 305 modern bulk meters are installed on all water treatment plants, water distribution mains and UGR’s. Installation of meters on all non-metered consumer connections and replacement of all defective meters by new water meters.


\(^2\) Comptroller Auditor General of India (2013), *op. cit.*
7.4.8 Sewage Interceptors

The project for lying of interceptors sewers along three major drains i.e. Najafgarh drain, Supplementary drain and Shahadra drain has been started. Implementation of this project is expected to ensure discharge of only treated waste water and control of pollution in river Yamuna.

7.5 Role of Civil Society in Water Management

Civil society is an umbrella term which represents all non-governmental voices. The role of civil society is varied and is looked at from viewpoint of providing support, building momentum and supporting movements for democratisation of water resources through research, advocacy and generation of political will, capacity building and supporting ground swell for demanding water rights in favour of those denied the same. Various NGO’s have also taken initiatives to avert Delhi’s imminent water crisis. A brief description of the initiatives taken by NGO’s is as follows.

7.5.1 Pani Morcha

Pani Morcha NGO\(^1\) suggested various suggestions to be taken within Delhi to improve water situation in the city. They suggested creation of five flood plain reservoirs within Delhi. These reservoirs are recommended in areas which normally get waterlogged during monsoon months. Two Reservoirs can be created above the Wazirabad Barrage on either bank of the river Yamuna. The water stored in both the reservoirs would be approximately 39 Million Cubic Meters (MCM). One reservoir could be created below Kalindi Kunj on the right bank of the Yamuna. The storage capacity of this reservoir is estimated to be about 50 MCM. Another reservoir through reviving the Old Horse Lake, by increasing its size and capacity by increasing its area and average depth. Water in reservoir can be filled either through channel from the river or the western Yamuna canal link during the monsoon months. The fifth fresh water storage can be created at Nala Mundela with a storage capacity of about 52 MCM.

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Besides these five reservoirs, Pani Morcha also suggested creation of two reservoirs in the National Capital Region. One on the Hindon River channel that can use flood water from the Ganga through Ganga canal or of the Yamuna through the Eastern Yamuna canal. Its capacity is expected to be about 280 MCM, which could be shared with Uttar Pradesh, Delhi’s suggested share could be 150 MCM. The second reservoir can be created at the the Najafgarh Jheel by reviving it on a smaller scale to harvest 40 MCM of water. Pani Morcha also suggested revival of old streams of Sahibi, the Tilpat and the Satpula streams originating from Aravallis and draining into Yamuna. Their revival will involve certain essential steps like catchment area development, construction of check dams and creation of tanks and tunneling or use of artificial drains through heavily build-up areas. The combined water yield of all the three streams after revival will be at least 10 MCM. Along with these suggestions, Pani Morcha also suggested that every effort must be made to fill the water tanks, jheels and hauzees with clean monsoon water.

7.5.2 The Centre of Sciences and Environment (CSE)

CSE is one of the India’s leading environmental NGO with a deep interest in sustainable natural resource. The CSE’s work program include awareness rising, policy research, advocacy, education and training and documentation. CSE is also among various NGO’s which initiated Delhi government to start clean Yamuna Project in September 2000. CSE has also taken various projects on water quality testing and monitoring. The CSE has been involved in raising awareness about the need of community based water management. CSE is of the view that unless people are involved from individual households, farmers and industrialists to urban and rural communities, it will be difficult to combat the looming water crisis. A water crisis has come about because rain as a source of water has been ignored. As a technology solution, CSE is therefore promoting the concept of community and household based water harvesting as this technology can be adopted by all concerned and also promote a participatory paradigm of water management.
7.6 Suggestions for Water Management

For meeting the Millennium Development Goal of clean water to all by 2025, it is necessary to adopt efficient management techniques. There is not “a single magic wand” which can solve the complex and interrelated problems of water resource. It is necessary to adopt efficient water management techniques. Till now, for management of water, the focus remains only on physical availability of water whereas the main problem is its efficient distribution and access. The policy makers have to device new strategies so that the basic needs of all can be fulfilled in a manner that works in harmony with nature. Keeping in view the water scarcity scenario of Delhi, the following suggestions are made:

7.6.1 Rain Water Harvesting (RWH)

Rain water is free source. It can be used for potable and non-potable use. But for potable use rain water must be treated to remove disease causing germs. Today, in many parts of the world including Hawaii and the entire continent of Australia promote rain water as the primary means of supplying household water. In Hong Kong, rain water is collected from skyscrapers to supply water for their domestic use. Singapore harvests the rain water that falls on most of its land despite industrialisation. Rain water harvesting is an effective technique that can address water scarcity. It is a simple, economical and eco-friendly technique of preserving water. Considering the increased need for more water in a city like Delhi, it is necessary to tap rain water to augment the water resource. In Delhi, where the ground surface is heavily concretized, the main way to harvest rainwater is to tap the rainwater falling on the terrace of the buildings. The aim is to prevent this water from running off in drains and divert it to borewells that will take it to beneath the ground. Thus, in residential or commercial buildings, the pipes on terrace should be connected to a borewell. This process is termed as “recharging of groundwater”. Delhi has an area of 1483 square kilometers with an average rainfall of 161 centimeters, means that even with 50 per cent efficiency of the rainwater harvesting systems, Delhi still has water harvesting potential of 450 billion liters annually. This equals to about 35 per
cent of the total water demand of the city\(^1\). Realising the importance of RWH, Delhi Government has given financial assistance to Resident Welfare Association’s/Group Housing Societies/ Schools etc. Delhi Jal Board (DJB) has given financial assistance of 51.19 Lakh rupees in 108 cases during February 2003 to March 2007. But, according to Performance Audit of Water Management in Delhi (2008)\(^2\), DJB didn’t enforce the conditions of the agreement, due to which in 90 per cent cases, no maintenance reports were received from the parties concerned and it was found during the inspection of seven sites that all the seven systems either muddy, silted or only partially functional. Therefore, government should get serious and work on water on a war footing. An action plan of what needs to be done must be put under formulation and subsequent implementation.

Government should promote individual rainwater harvesting projects at the colony and household level which improve the local groundwater level. It is also suggested that all the commercial users are required to harvest and it should be strictly ensured by law. Government should provide the necessary technical and financial assistance to communities and households to implement the RWH system and awareness should be created among general public about the concept and benefits of RWH.

### 7.6.2 Groundwater Recharge

There is an urgent need to augment depleting groundwater resources in active recharge zone. This can be augmented through natural or artificial recharge. Rainfall is the main source of both types of recharges. Artificial recharge is the process by which the groundwater reservoir is augmented through increased infiltration by using artificial structures. The dominant method of artificial recharges through the use of civil structures (such as percolation tanks, check dams, recharge shaft etc.), that arrest or slow down surface run off. Some states such as Andhra Pradesh, Gujarat, Karnataka, Tamilnadu, Maharashtra and Madhya Pradesh have implemented few schemes for construction of these structures at scattered locations. Another method involves creation of additional tank storage in flood plains of perennial rivers by

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\(^1\) Centre for Science and Environment (CSE) (2012), *op. cit.*

\(^2\) Comptroller Auditor General of India (CAG) (2008), *op. cit.*
withdrawal of groundwater during non-monsoon season and facilitating recharge/infiltration of a fraction of flood water during rainy season. Artificial recharge can augment groundwater supply and delay the crisis.

Low cost technology such as check dams can be built on flowing streams in rainy season which can be used for recharging the groundwater. Small check dams which take hardly a month to complete can be used to solve the problem of water scarcity to some extent.

7.6.3 Groundwater Management

Sustainable use of groundwater is possible only when users restrict average extraction to long term recharge. Even when recharge is augmented artificially, restraint on use will be required in water scarce regions. In a common property resource, individual will restrict their use only if there is a credible agreement among all users to limit their use. Cooperative management of groundwater by the users is thus necessary. The CGWB should monitor groundwater situations through scientific methods and make their findings public. They should access the average annual recharge that takes place in the aquifers and be responsible for preparing a suitable plan and guidelines for aquifer water management. The effectiveness of groundwater management could be substantially improved through the application of advanced tools such as Remote Sensing, Geographical Information System etc. integrated with information technology systems. The use of these tools can help in making the groundwater management plan more accurate, holistic and efficient. In order to provide incentives to communities to use water sustainably, a “Pani Puraskar” may be given to the localities where the groundwater table has been maintained or improved over the past 5 years.

7.6.4 Conjunctive Use of Water

Though, surface water and groundwater resources typically defer significantly in their availability, quality, management needs, development and use costs. Even then managing both resources together, rather than in isolation, allow water managers to use the advantage of both resource for maximum benefits. Conjunctive use involves the efficient use of both resources through the planned and managed operations as
groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Well planned conjunctive use can’t increase the reliability and the overall amount of water supply in region, but also provide other benefits such as flood management, environmental water use and water quality improvement. Through the conjunctive use efficiency and equity in water management can be achieved.

7.6.5 Demand Management

“More water syndrome”- Delhi Jal Board’s main focus is to augment its water supply capacity. It is now accepted worldwide that for smooth running of a water utility, demand management is equally important as supply management. Mahatma Gandhi Ji rightly said, “There is enough of everybody’s need, but not enough for anybody’s greed”. Therefore, efficient management of water for overcoming scarcity must include demand management. Demand for water is increasing gradually with increasing awareness of hygiene and sanitation issues both in rural and urban areas. Non-domestic water supplies for parks, recreation places, public utilisation, commercial and industrial purposes also stake a claim in the overall demand. The increasing demand can be managed with alternative water application with its multiple uses. Increasing scientific research in developing new technologies and methods whereby domestic, commercial and industrial functions can be served with the use of lesser amount of water. Along with this, demand management has another important aspects that of water conservation. Wasteful and profligate use of this precious resource must be discouraged by the water managers. Consumers outside the domestic sector must be encouraged to work constantly to meet their requirements with lesser water use. A conservation movement needs to be generated so that presently un-informed consumers would adopt attitudinal changes to use water resources wisely.

7.6.6 Development of Water Bodies

Water bodies in the NCT of Delhi have been affected with the rapid urbanisation process. According to a report, there are 700-1000 ponds in city crying for attention.\(^1\)

These water bodies form gateways to the aquifer and hence part of groundwater recharge strategy. Maintaining water levels and water quality in water bodies is thus essential for raising water table and groundwater quality. Water bodies have been under threat from reclamation and waste disposal. Each water body needs to have conservation plan and maintenance of its water balance and health of water status. The lost water bodies spread in Delhi needs to be recovered to the extent possible. Along with this, at the time of preparation of Zonal Developmental Plans, water bodies, large depressions and other groundwater recharging areas should be identified and protected from filling and encroachment.

7.6.7 Pollution Control

Pollution reduced water available for use and increases the costing of water treatment. The cost of not addressing pollution is high and some impacts may be irreversible (contamination of groundwater, drinking water, ecosystem losses). Though, Delhi has introduced legislation to protect their water resources but implementation often legs behind. “The principle of the polluter pays” can stimulate changes in the attitude towards pollution and led to increased recycling of waste water.

7.6.8 Dual Pipeline Systems

About 40 per cent of the water supplied by Delhi Jal Board is never used for drinking instead it is used for domestic chorus including flushing of toilets. This wastage is continuing from years even as city’s demand for drinking water is rising every year. There is no reason why water meant for drinking should be used for washing or flushing. In dual pipe line system, two separate pipelines may be provided to each dwelling unit. One is for potable water that leads to the kitchen for drinking and cooking. The other is for domestic water supply for toilets, bathrooms etc. The domestic water doesn’t need much treatment as it is not meant for drinking. Even tubewells with water unfit for consumption can be used to augment supply. In the dual supply system, less potable water is used and civic agencies can divert the saved amount where needed. Though such a system is existing in some parts of the Lutyen’s Delhi for years and recently this system is introduced in Dwaraka by Delhi
Development Authority (DDA). But it is never meant to be a solution for water shortage. Dual water system should cover the whole Delhi. Though this system require a higher investment in infrastructure like two parallel water lines and additional overhead tanks, even then once the infrastructure is in place, vast amount will be saved on treatment costs.

7.6.9 Full Pipeline Coverage

The government of Delhi is mandated to provide water, sewage and sanitation facilities to the entire population of Delhi. Though there is 100 per cent piped water coverage in urban areas but villages, J. J. colonies and designated slums, regularised unauthorised colonies are partially covered with piped water supply. Therefore, steps should be taken by government for 100 per cent piped water supply coverage. Only 100 per cent coverage is not enough, inequality in water supply should be removed in different parts of Delhi by redistribution of water supply across the city to ensure equity. Due to this unequal distribution of water, certain areas (New Delhi and Cantonment etc.) get over 400–500 litres per capita per day, others not get even 30 litres per capita per day. The NDMC and Contentment areas should get the same amount of per capita drinking water as other parts of Delhi. The government must make public disclosures on monthly per capita supplies in all areas of Delhi.

7.6.10 Co-Operative Use of Groundwater

Groundwater is too valuable as a natural resource to be left unmanaged. Groundwater conservation and recharge is an essential backup for Delhi, being it’s only internal resource. In the absence of well-defined property right to it and with growing water markets and wide spread use of modern water extraction technologies, groundwater has been overexploited in Delhi. For avoiding its overexploitation and depletion, it is necessary to change the status of groundwater from a common pool resource to a co-operative or the joint property of the users through creation of co-operative usufructuary rights and vesting them in water user’s co-operative societies. Implementation of this model of co-operative management of groundwater would require among other things, enactment of a groundwater law for governing the use of
groundwater, creation of groundwater management zones/districts/subdivisions, organising water users in some sort of formal associations and helping the water user bodies with technical information, funds and management advices.

7.6.11 Water Conservation

With increased awareness and integration of water saving technology, the per capita demand of water can be steadily brought down. In Delhi, each individual should start water conservation. If, the people in Rajasthan can conserve rain water, Delhities can also do so. In Rajasthan, even poor households conserve water without government intervention. In Delhi, unnecessary cementing and tiling of pavements, courtyard and storm water drains has precipitated in the water crisis. It is necessary that Delhi residents keep their front and backyards “Kachcha”. It will also reduce water logging. Even the storm water drains should not be cemented. There are several options which converge in this direction.

- Conservation of fresh water through use of water saving devices (shower heads, taps, sprinklers etc.), this should be reinforced by a retrofitting program and also by rebates on efficient devices and disincentive applied to less efficient devices.

- The retrofitting of homes with pressure reduces devices in faucets and showerheads, pull handle taps, two volume flush toilets and cisterns with double quantity dispensers should be promoted in Delhi to encourage efficient water use within home. In fact, all new buildings are required to install such water saving devices. Citizens should also encourage to repair leaking faucets and to report leaks.

- There should be prohibition against washing cars in paved areas with hoses. Violations of these restrictions and prohibitions should be subjected to fines.

- Parks should be included in the water conservation strategy. Parks must use native plants; minimize water use through efficient garden irrigation and only water at nights in private and public gardens. Private garden must be watered through sprinklers only.
7.6.12 Grey Water Reclamation

Grey water is water coming out of bathrooms after use from washing machines, bathtubs and showers and can be effectively employed in mitigating water crisis privileging in Delhi. This grey water can be put back in low fresh water uses. Grey water treatment in top soil is highly effective. It is less energy consuming, contains fewer chemicals, help in groundwater recharge as well as plant growth. Most importantly it brings back the fresh water which otherwise will join waste water. Grey water is different from black water, which is contributed by faseses and urine. In the contemporary times of water crisis, deepening every year, it is high time that awareness among common masses be generated about grey water and people should be encouraged to establish grey water plants at colony level on Public-Private partnership. Residents Welfare Associations can play vital role in this scheme.

7.6.13 Political and Government Commitment

Traditionally, water can be perceived to be a free good available from the nature. Existing institutional, legal and governmental framework relating to acquisition, distribution and utilisation of water has not helped in changing this perception. The role of the state in sustainable management of water resource is and will continue to be quite critical. The sovereign right of the state in any natural resource like water is undisputed. The augmentation and development of water infrastructure at any scale, involves expenditure, which is provided by government and other agencies. The role of the state as planner and manager of present and future demand can be assessed by water policy, water laws and water administration machinery. The objectives and goals of water policy can’t be achieved without proper water laws and efficient implementation mechanisms. System dealing with water resource management must take into account the principles of access, justice and social equity.

The experience of the Phnom Penh water supply authority (in Cambodia) is a valuable example for other urban centers of the world. From a near bankrupt, demoralised and corrupt institution, it has transformed itself into a viable institution that can be placed in same league as the best water utilisation of the world. Within just one decade (1993-2003), it developed into a new mindset and team spirit. It
continuously expended its network, improved its management and operating efficiency, became financial self-sufficient and progressively increased its net annual profit. It’s incredible progress within such a short time frame shows that providing a clean and drinking water supply is possible with political will, dynamic leadership and non-interference in the policies and management of utilities\(^1\).

Strong political and government commitment is essential for a country as city to be sustainable in water. The government should give high priority to water issue. Only with high commitment a city will be able to invest in the infrastructure and technology needed to achieve sustainability in water supply.

### 7.6.14 Private Sector Participation

Private sector participation should be encouraged in various aspects of planning, investigation, design, construction, development and on the water resource projects. For diverse uses wherever feasible, private sector participation will help introducing corporate management in improving service efficiency and accountability to users depending upon specific situation, various combinations of private sector participation in building, owning, operation, leasing and transferring of water resource facilities will be considered.

### 7.6.15 Education

State environmental and water agencies need to understand that their role is not only to regualarise water, but also to educate citizens about water usages and water problems. For example, Singapore’s Public Utilities Board (PUB) has raise conservation campaigns since the early 1970’s. PUB initiates meter reading contests, organises public water fairs and established a water conservation center with interactive exhibitions. Such initiatives are an integral part of Singapore’s effort to improve water management. Such tactics and awareness campaign has pastured long

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lasting behavior changes in Singapore and per capita water consumption has dropped from 172 lpcd to 153 lpcd in 2011\(^1\).

Government should create mass awareness programs on water and environment issues as part of its commitment to social and environmental sustainability. Public exhibits, water theme marches on world water day, quiz and science shows on water in schools and seminars and workshops on water conservation and rain water harvesting should be organised under the awareness program.

**7.6.16 Non-Revenue Water (NRW)**

About half of the water that is treated and distributed at public expenses is non-revenue water in Delhi. This is due to leakages and illegal connection. Delhi may not be allowed to continue this, otherwise DJB may not find enough resources to meet the cost of water infrastructure required for growing population of Delhi and its present financial position can affect its operational efficiency. Reducing water losses is cheaper than augmenting water capacity for such losses.

NRW reduction in a large water supply system needs sustained commitment and investment for example, Metropolitan Water Works Authority of Bangkok has been able to reduce NRW due to its commitment to address it and the subsequent allocation of a sizeable amount of investment for the implementation of suitable measures.

The Jamshedpur Utilities and Services Company (JUSCO) has significantly reduces its NRW from 36 per cent to 9.9 per cent during 2005 to 2009. Firstly, through by leakage identification through leakage detection equipment’s, which helps to detect the exact location of leakage and identifies ground leakages. Proactive leak detection is carried out regularly by way of “walk through surveys” along the network using leakage detection equipments and secondly by initiating a major disconnection

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drive to reduce illegal connections. Illegal connections were disconnected and consumers were forced to pay a fine and get authorized connections. If the entire area is taking water illegally, then new networks are laid down to provide authorized consumption under the Public-Private Partnership Program\(^1\).

In Delhi also, wastage and theft of water should be curbed mercilessly. Suitable amendments are necessary in Delhi Water Board Act to provide for stringent measures for enforcing curbs on theft/wastage of water. Simultaneously, it would be necessary to evolve more intelligent system of leak detection and control. Severe penalties should be levied on those found responsible for leakage and wastage of water. Delhi Jal Board (DJB) should start NRW reduction programme - this should include metering at the consumer levels and convert them to authorized connections, eliminating illegal connections and convert them to authorized connections, replacing old pipelines with new ones and monitoring leakages on monthly basis. Water saved from leakages could be redistributed to areas not receiving sufficient water supplies, thereby improving water access and revenue.

7.6.17 Metering

To ensure that a fair and transparent system exists, it is essential that all the connections be measured in terms of their water consumption. Only after each connection is metered, consumers can be sent an accurate bill that directly reflects the amount of water they consumed during a specific period. When meters are faulty or non-functional or in governmental residential buildings where average bill is provided, often didn’t reflect the actual quantity of water consumed. So, steps should be taken for faulty meters replacement.

7.6.18 Effective Institutional Management

NCT may be a small city state but it is blessed with several layers and levels of authorities. All have their areas /domain of jurisdiction and thus adds to the complexity of policy formation and implementation. Issue of water quality and health often go entirely unaddressed because they don’t fit within mandate of any single government agency. At the same time, there is little stakeholder’s involvement and community participation in setting water policies and regulating use, so projects don’t meet peoples need. Delhi needs a strong leadership with a political will that work towards the vision of making water services in the city sustainable and efficient. Politicians should limit themselves in policy matters and not intervene in day to day operations of Delhi Jal Board (DJB) by clearly separating policies and delivery. Delhi Jal Board (DJB) should become the nodal agency for all works related to water and sewage services. Shenzhen (China) has set up an excellent integrated urban water management system. Shenzhen adopted the type of organization in which water and waste water services are overseen by the same Water Affairs Parent Bureau (SZMWAB). SZMWAB is in-charge of integrated water affairs throughout Shenzhen. As a result the city can avoid possible conflicts among government agencies due to overlapping function and making function of each bureau clear. Although some government departments retain several functions related to water management, the functions are unambiguous and the coordinating mechanism is good enough to allow them to resolve water management problems co-operatively and quickly. Shenzhen’s water management reform has met with considerable success\(^1\). Besides resolving the problems of authority overlap and conflicts among government departments, integrated water management has also led to other positive results. It has promoted the development of urban water infrastructure and raised management standards. It has been beneficial to the unified planning and implementation of water resources development. It is also conducive for greater coordination in the development of water sector and water conservation and use of water sources in a sustainable manner.

7.6.19 Water Recycling and Reuse

Investment in water supply, sanitation and water management tends to be planned, designed and managed separately and with different time horizons. The creation of environmentally sound system that takes into account the whole water cycle for various users calls for coherent approach to overcome sectoral boundaries and the rural urban divide. Managing waste water is essential for several reasons. First, waste water is often discharged in places where it can’t be reused thus losing an opportunity for beneficial use. Secondly, waste water is often rich in plant nutrients and these and the residual water can both be put into beneficial use through irrigation. Re-use for agriculture following primary or secondary stage treatment with low cost ecological technologies, can be cost effective and win-win solution in these circumstances. With the expansion of urbanisation process, the water requirement of construction industry in Delhi is increasing. It is estimated that maximum unauthorised exploration of groundwater is made by construction industry. Supply treated waste water at reasonable rates to the construction industry. Delhi Metro, Railways, DTC, major auto workshops in Delhi may prove as a better check on unauthorised exploration of groundwater.

Reuse of treated sewage must be given priority in view of fact that water is going to become scarcer in near future. With tertiary treatment, water from treated sewage can be used even for air conditioning, industrial cooling and other non-potable uses. This should be made a thrust area. Singapore collects and treats all its waste water, which meets more than 30 per cent of its water demand. Singapore’s example shows that high quality reclaimed water can be produced economically for human consumption and non-domestic use. Used water need not be wasted; it could be treated, reclaimed and reuse on an extensive scale to multiply water supply and enhance self-sufficiency in water.

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7.7 Conclusion

Rapid increase in water demand, degradation of water quality, depletion of groundwater and inter-sectoral competition for water, bottlenecks in the system are putting extreme pressure on water resources in Delhi. The solution to the problem in water largely lies in areas of effective mechanism for conservation, distribution and efficient use and management of water resources. The management of water involves two strategies i.e. Demand Management and Supply Management. The government has taken various steps for the management of water resources in Delhi like measures for augmenting water supply, pollution control and for conservation of water resources. Concerted efforts of all the stakeholders in water sector are needed to resolve the problem of water scarcity. Some techniques for effective water management have been suggested in this chapter. An effective technique that can address water scarcity is rain water harvesting. There is an urgent need to trap this rain water through new artificial water harvesting structures as well as reviving older natural structures. Water scarcity can also be countered by the charging groundwater and through conjunctive use of surface and groundwater. Water scarcity can also be overcome by stressing on demand management by effective pricing, redistribution of water and through efficient use of water. The importance of three R’s - reduce, recycle and reuse is very important technique for resolving the problem of water scarcity. Improvements in operation and maintenance can also overcome water scarcity. As people’s participation is a prerequisite for successful water conservation programs, there is a need to spread awareness among masses regarding different techniques of water conservation.