

# CHAPTER 1

## 1.Introduction

## CHAPTER 1: INTRODUCTION

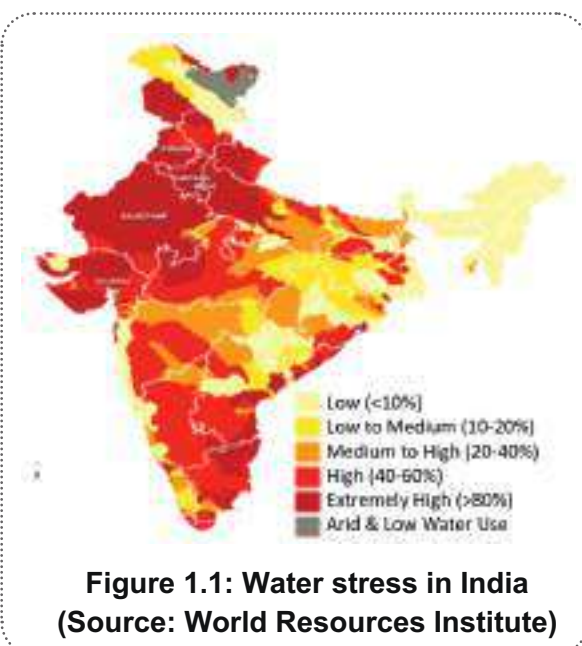
### 1.1 Background

Safe water in adequate quantities is essential to all forms of life on earth. It is the backbone of a healthy economy and greatly contributes to poverty removal. Safe drinking water should be reliable, accessible, and accepted for all the users.

The United Nations (UN) declared access to safe drinking water as a fundamental human right. The UN further stated that drinking water is an essential step towards improving living standards. The UN also declared Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) with the goal of access to water. The SDG's goal 6 states that "Water sustains life, but safe clean drinking water defines civilisation."

National Institution for Transforming India (NITI) Aayog (2019) stated that "India is a home to about 17% of world's population but has 4% of the world's freshwater resources." Every year India gets 4,000 billion cubic metre (BCM) water as annual renewable water resources. India is placed 9<sup>th</sup> in the hierarchy of annual renewable water resource. It receives an average annual precipitation in the range of 750-1,500 mm. From the surface water and replenishable groundwater, 1,869 BCM water is available but only 60 % of it can be beneficially used. Thus, India's total available water resource is 1,122 BCM out of which 690 BCM is surface water and 432 BCM is in the form of ground water. The surface and ground water approximately contribute 61% and 39% of total availability.

Though abundant water is available, the country has great variation of time and space when it comes to rainfall. When the northeast rivers flow in high discharge, rivers in the southern part of India carry low discharge. In India, 90% of flow occurs in the four months of monsoon, and 50% of this occurs in just 15 rainy days.



NITI Aayog (2019) stated that nearly 60 crore people (Figure 1.1) living in India face high to extreme water crisis. It further mentioned that about 40% Indians will have no access to drinking water by 2030. The report finds that the "Water Gap" can be closed by undertaking measures such as boosting water use efficiency and lessening the water intensity of the economy by demand management and good measurement practices. The annual per capita availability of water is expected to reach 1,341 cubic metre per capita per year in 2025 to 1,140 cubic metre per capita per year in the year 2050 thus leading to severe water stress.

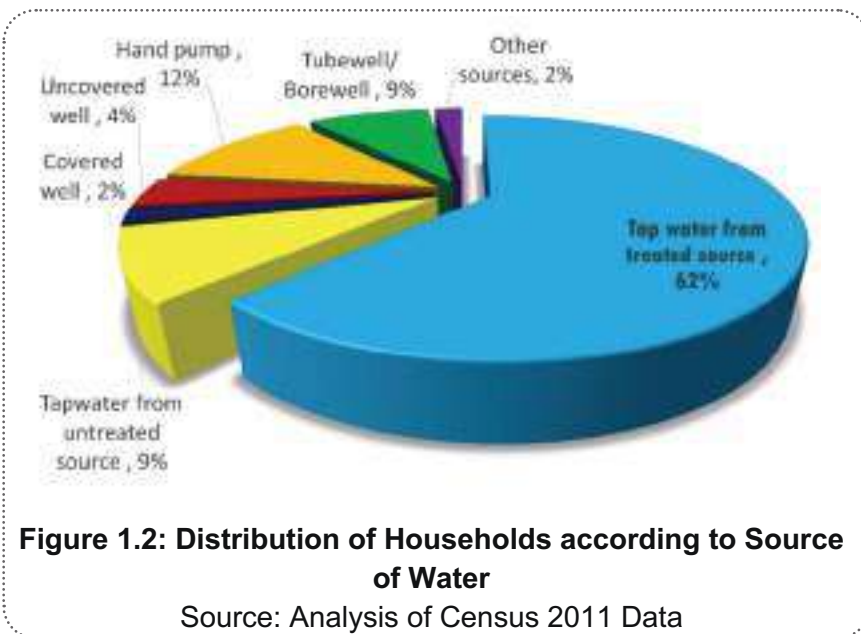
NITI Aayog also estimated that about two lakh Indian persons die yearly due to inadequate and unsafe drinking water. In India, huge quantity of wastewater is generated. Mismanagement of wastewater and that of liquid waste causes contamination of ground water, and poor sanitation conditions. Besides this, poor hygiene habits cause waterborne diseases among the large portion of population, especially among the poor.

### 1.2 History of Urban Water Supply

Just after independence, water supply in Indian cities was not satisfactory. Only 16 % of the total number of towns in India (Environmental Hygiene Committee, 1949) had protected water supplies which served 6.15 %of total population or 48.5 %of the urban population. Water was supplied at 2 to 40 gallons (10 litres to 180 litres) per capita per day. Only a few waterworks were augmented by 1949. Among these were water supplies of Delhi, Bombay, Kanpur, and Bangalore. In most places, new schemes were shelved. However, the situation has improved since then.

### 1.3 Present scenario of urban water supply

NITI Aayog (2019) also stated that 93% of India’s urban population had access to basic water supply.



Distribution of households according to the primary source of drinking water as reported by Census 2011 is shown in Figure 1.2. It can be seen that 62% of households have access to treated tap water. This means nearly 38%of urban households have no access to treated tap water. They have to depend on other sources of water. As per 2011 Census, urban population was 31.16% and 370 million were inhabiting urban India out of which 65.4 million were slum dwellers. The present

challenge is to provide treated water to the 38% households which are without access to treated tap water. The urban population is expected to grow to 590 million by the year 2030. Thus, there is a great challenge ahead to supply every household with treated water tap.

Universal piped water supply coverage was the objective under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 500 cities of India. The mission was launched by the Ministry of Housing and Urban Affairs (MoHUA). As of November 2023, 1.73 Crore new tap connections have been provided under AMRUT. AMRUT 2.0 was launched by MoHUA in October 2021 with an objective to provide water security and 100% functional tap connections in all cities and towns in the country with the target of 2.68 Crore connections till 2026.

One of the objectives of the AMRUT 2.0 is to provide 24x7 pressurized water supply system (24x7 PWSS with DFT) with the drink from tap facility in at least 1 zone or 2000 connections in 500 AMRUT cities. There lies a great challenge ahead - to offer continuous water supply to every household with functional water tap.

## 1.4 Major Challenges in urban water supply

### 1.4.1 General Challenges

Despite the advancements in water sector, access to piped water supply in urban areas is not yet universal. Thus, there lies a great challenge ahead to supply potable water to every household with functional water tap.

Waterborne diseases is one of the reasons that the infant mortality ratio of India is on higher side, which is 26.7 deaths per 1000 live births in 2022. Thus, low-income group people have to make expenses on health aspect. The economic burden due to this is about USD 600 million (Rs 4,920 crores) per year in India. The waterborne diseases are rampant in drought- and flood-prone areas, which affected a third of India's population in the past couple of years.

Another challenge is the extreme ground water depletion rate (<https://www.unicef.org/india>) in two-thirds of India's 718 districts. Due to rapid increase in the drilling operations since the last two decades, India became the largest user of ground water. Joint Monitoring Programme (JMP) of water supply, sanitation and hygiene of WHO/UNICEF in 2017 stated that through about 30 million access points in India, groundwater supplies drinking water to 85% in rural areas and 48% of water requirements in urban areas.

Besides above, there is another important challenge of supplying pressurised 24×7 continuous water supply to all the people residing in urban areas. 24×7 pressurised water supply system needs information of the existing water infrastructure in the form of maps and database. Unfortunately, maps and databases of existing pipelines laid below ground are not available in most of the urban local bodies (ULBs). Hence, creation of such maps in GIS format is the big task and challenge.

Availability of continuous electricity is important for running the pumps. In many cities/towns, due to daily tripping, there is a breakdown of electricity. As a result, during this period, pipeline becomes empty and require more time to refill with water. This creates pressure-deficient conditions. Hence, providing continuous electricity is a challenge. This manual recommends to use express feeder with bypass arrangement to solve this problem.

#### Engineering and Technical Challenges

There are several technical challenges which are enumerated as follows:

- (i) Highly contaminated raw water sources  
Raw water means the water we get from rainwater, groundwater, surface water, well water, lakes, rivers, etc. One of the major environmental issues in India is that of water pollution. Harmful germs find entry through untreated sewage - the largest source of pollution. Other sources include agricultural runoff and unregulated small-scale industry such as fertilisers, pesticides, industries, sewer overflows, and storm water.
- (ii) Improper planning and design of water supply network which leads to the following problems:
  - a) Shortage of water: If the source is inadequate and undependable (<95% reliable), shortage of water will be experienced. If the supply of water is restricted, then pressure deficiency in the nodal pressures will be formed.
  - b) Haphazard laying: It is normally observed that as and when existing pipeline cannot cope up high demand, parallel pipelines in the covered areas and extension of pipelines in

uncovered areas are provided by ULBs. This gives rise to a clumsy network causing inequitable distribution and insufficiency of pressures, thus making the system uncontrollable from O&M point of view.

- c) Cross connections: The ULB's operating staff generally tends to find temporary solutions to the supply problems and opt for cross connecting distribution network pipelines, without any scientific assessment/study, and on ad hoc basis. No records are generally maintained of these cross connections in most of the cities and towns.
- d) Adding of dwarf and small capacity ESRs: In many cities, ULB chose a way of adding small capacity and dwarf service tanks. As staging height of these reservoirs is less, it is obvious that the norm of minimum residual pressure cannot be achieved from these reservoirs of low staging height.
- e) Exceptionally big zone: In many cities, excessively big operational zones (OZs) are provided with a single service tank to serve large population. This causes dropping of pressures and the system is compelled to operate on intermittent system, resulting in contamination of water in the pipeline during non-supply hours, and high non-revenue water (NRW) leading to unequal water supply.
- f) Low nodal pressures: In some of the cities, the distribution system has been designed for low residual nodal pressure due to which many parts of the city are not getting water with adequate quality and pressure.
- g) A large number of consumers' underground (UG) tanks: In most of the cities, consumers have their UG storage tanks. These UG storage tanks leak and also allow outside contaminants to enter in. Due to unbalanced capacity, high-income residents are using more water and low-income group are starving for water.
- h) Inequitable flow and pressure: The distribution system is laid on high altitude and low-lying areas of the city. Residents in the low-lying areas get excess water and high areas get less with low pressure.

- (iii) Intermittent water supply leading to contamination of drinking water during non-supply hours and formation of THM post chlorination.

Contamination of drinking water in pipeline occurs during non-supply hours. In intermittent water supply system, it occurs during non-supply hours when pipelines are empty.

- (iv) High NRW and inequitable Water Supply:

Generally, NRW is observed in a range of 30%-50%. NRW is the water that has been produced and is "lost" before it reaches the customer. In real loss, water is lost due to physical leaks and in commercial loss, it is due to theft or metering inaccuracies.

As the water in the system is loaded with energy, high value of NRW indicates that energy is poorly managed which is lost.

High value of NRW means a lot of water is lost because of which the water utility gets less income and the system becomes unsustainable.

- (v) Lack of monitoring of drinking water quality and NRW using smart technologies

Water quality monitoring is achieved by the sampling and analysis of water constituents and conditions. It is necessary to know whether water contains pollutants and also pesticides, metals, and oil.

In the absence of water quality monitoring:

- it is difficult to identify whether waters are meeting designated uses;
- it is difficult to identify specific pollutants and sources of pollution;
- it is difficult to determine trends over time;

- early warning "screen" of potential pollution problems is not available.

#### 1.4.2 Challenges in O&M of Water Supply System

The operation and maintenance (O&M) of water supply systems present several challenges, ranging from technical issues to financial constraints. Some of these are as follows:

1. Ageing infrastructure, which requires constant repairs and maintenance to ensure it functions efficiently and effectively.
2. Availability of skilled personnel to operate and maintain the complex water supply systems.
3. Financial sustainability.
4. Control of NRW.
5. Lack of metering to ensure sustainability of O&M.

Addressing these challenges requires a comprehensive approach that involves effective planning, adequate investment, and a skilled workforce, along with the adoption of sustainable practices to ensure long-term climate-resilience of the water supply system.

#### 1.4.3 Management & Financial Challenges

Effective water supply management in Indian urban areas is hindered by several managerial challenges that impact the planning, operation, and maintenance of water systems. Addressing these challenges is crucial to ensure the efficient and sustainable provision of clean water to growing urban populations. These challenges are multifaceted and require comprehensive reforms to address them adequately which are:

- 1) **Fragmented governance structure:** The responsibility for urban water supply management is often fragmented among various government departments and agencies at different levels, including municipal corporations, state water boards, and state governments. Lack of coordination and clear division of roles can lead to inefficiencies and overlapping responsibilities.
- 2) **Outdated legal framework:** Many Indian states have outdated and inadequate water laws and regulations that do not align with the current urban water supply challenges. Reforms are needed to develop comprehensive water laws that address emerging issues and support sustainable water management practices.
- 3) **Limited accountability and transparency:** Transparency and accountability in the urban water sector are often lacking, making it difficult for citizens to understand water service provision, tariff structures, and investment decisions. Improved transparency and accountability mechanisms are necessary to build public trust and ensure efficient resource allocation.
- 4) **Financial viability of utilities:** Many urban water utilities face financial challenges due to high NRW, low tariff collections, and inadequate cost recovery. Ensuring the financial sustainability of water utilities is essential to maintain and upgrade infrastructure and provide reliable services.
- 5) **Limited Community Participation:** Meaningful community participation in decision-making processes related to water supply management is often lacking. Engaging communities can lead to better understanding of local needs and concerns and foster a sense of ownership over water resources.
- 6) **Inadequate Capacity and Skills:** A shortage of skilled professionals and technical expertise in urban water management poses challenges in planning, operation, and maintenance of water supply systems. Building institutional capacity and investing in workforce development are crucial to improve overall water governance.

- 7) Public-Private Partnerships (PPPs): The implementation of PPP models in the water sector has been met with mixed results in India. Balancing private sector efficiency with public interest, equitable access, and affordability remains a challenge.
- 8) Inadequate regulation and enforcement: Regulation of the water sector is often weak, leading to non-compliance, unauthorised connections, and illegal water use. Effective regulation and enforcement mechanisms are essential to ensure adherence to standards and promote responsible water use.
- 9) Inadequate infrastructure planning and asset management:
  - a. Lack of comprehensive infrastructure planning and asset management leads to suboptimal investments, inefficient resource allocation, and difficulties in maintaining and upgrading water infrastructure.
  - b. Data collection and management information systems:
  - c. Accurate data collection, analysis, and management are essential for informed decision-making. However, many water utilities lack robust data collection systems and data-driven management information systems and reporting practices.
- 10) Lack of integrated urban water resource management (IUWRM): There is a disconnect between water supply, wastewater management, storm water management, and groundwater management. The absence of an integrated approach hinders sustainable water resource management and creates challenges in addressing water quality and availability issues holistically.
- 11) Climate change and resilience: Climate change impacts on water availability and extreme weather events pose significant challenges to urban water supply management. Building climate resilience and incorporating climate adaptation measures in water planning are crucial.
- 12) To address these challenges, comprehensive reforms are needed, including revising legal frameworks, strengthening institutions, improving co-ordination between stakeholders, promoting community engagement, and investing in modern technology and infrastructure. A holistic and integrated approach to urban water supply management is essential to ensure sustainable water services and meet the growing demands of India's urban population.

**1.5 Disadvantages of Intermittent Water Supply**

Intermittent water supply has several disadvantages. Its comparison with 24x7 pressurised water supply system is shown in Table 1.1.

Table 1.1: Comparison of Intermittent water supply with 24x7 pressurised water supply system

<b>S N</b>	<b>Demerits of Intermittent System</b>	<b>Merits of 24x7 System</b>
1	Large doses of chlorine	Required dose of chlorine
2	Capacities underutilised	Otimum utilisation of capacity
3	More wear and tear of infrstructure	Increased life of infrastructures
4	More manpower required	More automation
5	Hapazard laying of pipes	Optimisation of network
6	Supply hours affect poor	Continuous water supply to all
7	Storage is required	Storage not required
8	Pay for pumping	Willingness to pay
9	High health risks	Better health outcomes
10	Meters go out of order	Actual metering of water
11	High non-revenue water	Low non-revenue water

S N	Demerits of Intermittent System	Merits of 24×7 System
12	Wastage of treated water	Attracts industries
13	Water is not easily available to low-income people	Water is supplied to all including low-income people

In an intermittent water supply system, water is supplied only for few hours in a day which causes great inconvenience to consumers, as time of supply does not suit to them. Consumers tend to keep taps open during the no-supply period and this results in wastage of water when the supply starts.

### 1.5.1 Reasons of Intermittent Water Supply

(a) *Haphazard Laying*: It is normally observed that as and when the demand of water increases, pipelines are laid haphazardly by ULBs in expanding areas. One such incident for one city is shown in Figure 1.3(a). This gives rise to clumsy network causing inequitable distribution and insufficiency of pressures, thus making the system uncontrollable from O&M point of view.

In the initial period after commissioning of the scheme, the system operates satisfactorily as shown in Figure 1.3(b).



- ULB laid pipelines haphazardly,
- More than one pipe going in the same direction and same locality.
- No control on distribution
- Due to multiple lines, nodal pressures drop.
- Due to two inlets to DMA, it requires two isolation valve, Bulk meters, PRV and FCV

(a): Haphazard laying of pipes

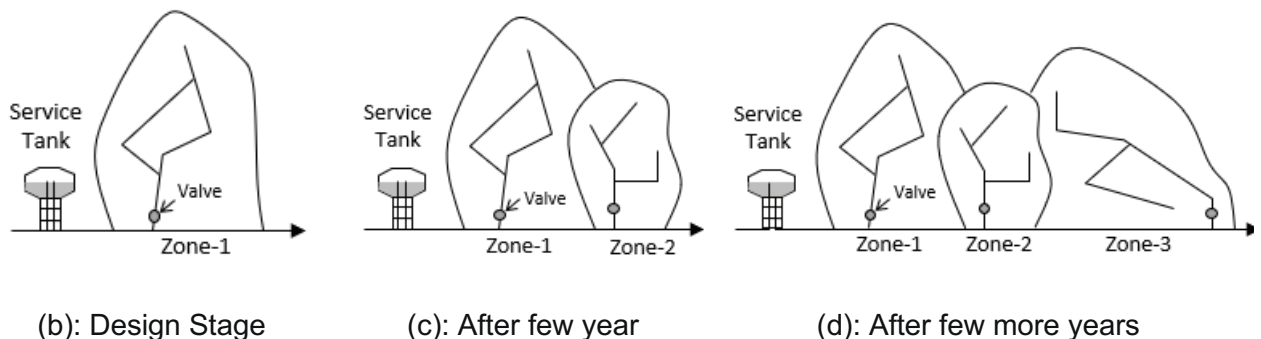


Figure 1.3: Zoning of water distribution system practised.

Later, since ULB added pipelines erratically without proper design check, hydraulics gets vitiated, and pressures drop. Thus, after few years when demand increases, another zone is required to be added as shown in Figure 1.3(c). Again, after few more years with the additional area, a third zone is added as shown in Figure 1.3(d). Subsequently all this finally compels transformation of present system into an intermittent system along with additional transmission lines and storages tanks.

(b)*Adding of Dwarf and Small Capacity ESRs:* In one city, after commissioning of its distribution system around 1990, ULB added 21 ESRs of only 8 to 10 m staging height and a small capacity of 25,000 to 50,000 litres. As the staging height of these tanks was less, it is obvious that the norm of minimum residual nodal pressure cannot be achieved. This is a common scenario observed in many cities.

(c)*Huge Service Area:* In one city, three service tanks have a common huge service area supplying water to 79,790 population. This service area is supplying water for one hour to an area adjacent to the ESRs, but people at farthest boundary of this service area get water supply for just 30 minutes.

(d)*Other major reasons:* for intermittent supply are as follows:

- non-availability of continuous electric supply;
- continuation of water distribution system (WDS) beyond its design life;
- non-availability of adequate quantity of water at source;
- unexpected or unbalanced growth during design period;
- heavy leakage losses;
- improper layout;
- unmetered supply;
- improper planning and design of network and poor O&M.

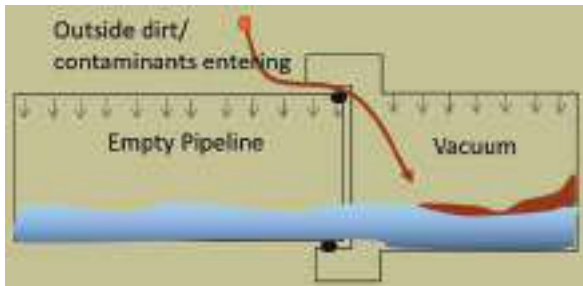
### 1.5.2 Sustainability of Water Sources

Water source is the soul of any water supply project. The source should be such that it will supply water incessantly for all the seasons. City water supply requires 95% dependable source. Sustainability of the water source is achieved by adopting IUWRM which is defined as a technique that encourages co-ordinated land and water development and management in order to maximise economic and social welfare in an equitable manner and is needed for comprehensive planning of river sub-basin and groundwater sources. Details of IWRM and IUWRM including City Water Balance Plan are discussed in sections 4.13 and 4.14 of Part A Manual.

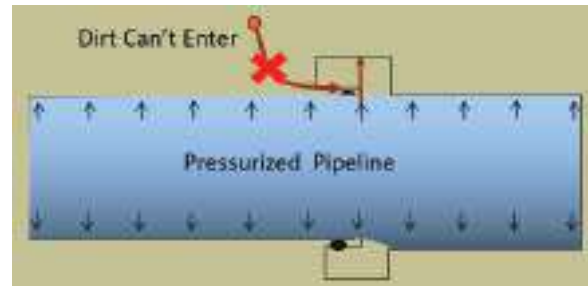
### 1.5.3 Necessity of Shifting from Intermittent to 24×7 Water Supply

Urban water sector is facing the challenges of poor quality of water. Intermittent water supply often results in contaminated drinking water and is one of the reasons of considerable mortality ratio of 27.6 in year 2022 in India. The mechanism of water contamination is shown in Figure 1.4. During non-supply hours, there is a vacuum inside pipelines due to which outside dirt/contaminants find entry into the pipelines, thus, water is contaminated. When supply of water starts, the contaminants are mixed with the treated water, thus, contamination takes place.

Unlike in intermittent supply, in 24×7 water supply system, by definition, pipelines are pressurised and hence outside dirt cannot find entry (Figure 1.5), hence water retains its quality. Because of contamination in supply, people tend to purchase small reverse osmosis (RO) machines in their homes. Thus, coping costs such as developing storage facility, pumping water to roof-level storage, household treatment facility and their maintenance are on the rise (Amit and Sasidharan 2019) about Rs 558 to 658 per month for piped and non-piped households respectively. In addition, power is required and about two-third water from RO is wasted as reject water.



**Figure 1.4: Intermittent System**



**Figure 1.5: 24x7 Pressurised Water Supply System**

In developed countries, water is provided on a 24x7 basis. Some of the countries in Africa also provide 24x7 pressurised water supply system. Intermittent water supply system is practised only in South-Asian countries like India. Hence, it is the most important challenge ahead of India to convert its intermittent water supply to 24x7 system.

## 1.6 Sector Organisation

### 1.6.1 Government of India (GoI)

In India water is a state subject, but the provisions are quite complicated. The primary entry in the Constitution relating to water is at 17 in the State list. It brings water including water supplies, irrigation and canals, drainage and embankments, water storage and waterpower under state list.

Though water is in the State list, there was a need to have a centralised organisation to guide the state's water supply projects. Therefore, the Environmental Hygiene Committee, in its 1949 report, recommended to form a centralised agency of Central Public Health and Environmental Engineering Organisation (CPHEEO).

#### (i) CPHEEO

CPHEEO has been in existence for more than 67 years since its raising under the Ministry of Health in 1954. It has participated in all important sanitation programmes for the country. CPHEEO is affiliated to the Ministry of Housing and Urban (MoHUA).

The organisation not only supports the Ministry in policy formulation but also handholds States by way of technical advice, guidelines, scrutiny, and appraisal of schemes and propagation of new technologies in the field of water supply and sanitation including municipal solid waste management. CPHEEO deals with the matters related to urban water supply and sanitation including solid waste management in the country. CPHEEO plays a vital role in processing the schemes posed for Bilateral and Multilateral funding agencies such as World Bank/JICA/ADB/KFW/AFD and other external fund agencies.

#### (ii) Formation of Jal Shakti Ministry

GoI formed Jal Shakti Ministry in 2019 by merging two ministries - Ministry of Water Resources, River Development and Ganga Rejuvenation and Ministry of Drinking Water and Sanitation (Rural).

#### (iii) AMRUT

AMRUT was launched in June 2015. In 2019, AMRUT 2.0 was established. Some of the salient features of AMRUT 2.0 are as below:

- total outlay of Rs. 299,000 Cr.;

- securing tap and sewer connection of estimated 2.67 crores urban connections;
- 500 AMRUT cities are mandated to implement 24×7 water supply project in at least one ward, or one district metered area (DMA) with 2000 household;
- reform incentives and additional funding extended for performance based 24×7 water supply projects;
- water balance and NRW reduction to 20% is mandated;
- outcome based financing and innovative contract structure like PPP, HAM, etc.

### 1.6.2 State Governments

As water is a State subject, the States have set up water-related departments such as Water Resource Department, State Water Supply Boards, Zilla Parishads, etc. These departments prepare water supply schemes for urban and rural sector of the states.

### 1.6.3 Urban Local Body (ULB)

India Infrastructure Report (2011) further states that “the 74<sup>th</sup> Amendment to the Constitution of India recognises local self-governance as an enforceable ideal and helps the state governments to constitute ULBs. The 74<sup>th</sup> Amendment also requires that the Legislature of a State may, by law, endow the Municipalities with such powers and authority as may be necessary to enable them to function as institutions of self-government.” Thus, the issues that may be entrusted to the Municipalities include water supply for domestic, industrial, and commercial purposes. With such mandate, ULBs started executing water supply schemes with financial assistance from the State as well as from the Central Government.

## 1.7 Initiatives of GoI

### Service Level Benchmarking

Considering importance, the Ministry of Housing & Urban Affairs (MoHUA), GoI, has launched the Service Level Benchmarking (SLB). As part of the ongoing endeavour to facilitate critical reforms in the urban sector, the MoHUA has adopted national benchmarks in four key sectors of water supply, wastewater, solid waste management (SWM), and storm water drainage. Therefore, there is, a need for a shift in focus towards service delivery. These service level benchmarks have been developed for assessing performance of ULBs in providing water supply services. Such performance indicators, targeted benchmarks, and baseline performance figures are shown in Table 1.2.

**Table 1.2: Performance indicator and benchmark for water supply services**

S. N.	Performance indicator	Targeted Benchmark	Average values in India
1	Coverage of water supply connections	100%	70%
2	Per capita supply of water (LPCD)	135*	114
3	Extent of metering of water connections	100%	22%
4	Extent of NRW	15%	31%
5	Continuity of water supply	24 hours	2.7 hours
6	Quality of water supplied	100%	95%
7	Efficiency in redressal of customer complaints	80%	89%
8	Cost recovery in water supply services	100%	72%
9	Efficiency in collection of water supply-related charges	90%	60%

Source: PAS-SLB data from [www.pas.org.in](http://www.pas.org.in) covering 900 cities in five States

For cities having population more than 10 lakhs, the target benchmark is 150 LPCD. The breakup of water requirement (IS 1172:1993), is shown in Table 1.3.

**Table 1.3: Average water use per person per day in urban area**

SN	Purpose	Quantity (LPCD)
1	Drinking	5
2	Cooking	5
3	Bathing	50
4	Toilet flushing	30
5	Washing utensils	15
6	Washing the house	10
7	Washing of clothes	20
	<b>Total</b>	<b>135</b>

## **1.8 Emerging Trends and Technologies**

### **1.8.1 Climate Change**

Climate change alters hydraulic cycle and has considerable impact on water. It changes the timing and intensity of the rainfall. Monsoon vagaries has impacts on water supply and sanitation of many cities whose population and demand of drinking water is ever increasing. It directly affects the quantity and quality of water resources.

In India, it is believed that impacts of climate change on water supply and sanitation may affect the achievement of the MDGs and that of SDG number 6.

### **1.8.2 Impact of Climate Change on Piped Water Supply:**

Piped water supply system of a city is vulnerable to extreme rainfall events. On 26th of July, 2005, Mumbai Metropolitan Area (having 20 ULBs) had witnessed such extreme rainfall (955mm in 24 hours). It had affected all the 20 water supply systems in the region. Subsequently, the Government of Maharashtra created an interlink grid joining different sources of water supply as a resilient measure. This arrangement is working efficiently.

Heavy rainfall events increase loads of suspended solids (turbidity) in reservoirs that are built as source of water supply. Increased turbidity increases load on water treatment plant consuming more coagulant doses and requires increased doses of chlorine disinfectants.

### **1.8.3 Response to Droughts**

Many cities have to curtail water supply in the event of low rainfall. In such situations, pressure-deficient conditions are formed affecting service delivery. City administrations have to rationalise water distribution. For avoiding such situation, water needs to be reserved in the dams.

### 1.8.4 Integrated Urban Water Resources Management (IUWRM)

IUWRM is a participatory planning and implementation process. It is based on scientific approach in which the stakeholders decide how to meet society's long-term needs for water while maintaining essential ecological services and economic benefits.

The main elements of an IUWRM system are:

- supply optimisation;
- demand management including cost-recovery policies;
- equitable access to water resources through participatory and transparent management;
- improved policy, regulatory and institutional frameworks;
- inter-sectoral approach to decision-making, combining authority with responsibility for managing the water resource.

### 1.9 Revision of Manual

Way back in 1949, the report of Environmental Hygiene Committee was accepted by the GoI, which stated, "Intermittent water supplies should be discouraged as far as possible. It results only in dissatisfaction, waste of water, inequitable distribution, and risk of contamination of water by back siphonage or in suction during hours of low pressure. Intermittent supplies are also open to the objection that the flushing of closets is interrupted, and the fighting of fires is impossible during the hours of interruption. It has been demonstrated at Lucknow that the water-works authorities can successfully supply water all the 24 hours, educate a community used only to intermittent supply to adapt themselves to continuous supply and reduce consumption."

This recommendation shows the long-lasting aim of improving service delivery of water supply to provide pressurised continuous water on a 24×7 basis. Even though the present progress in that direction is not tangible, it is the time to work to achieve the above goal ultimately throughout the country. The AMRUT 2.0 programme envisaged to provide 24×7 pressurised water supply system with drink from tap facility, GIS based master plans of towns and target for reduction of NRW to 20%. AMRUT 2.0 programme envisioned incentive-based reforms planning and implementation of projects in PPP mode in water sector, especially in cities with population below ten lakhs. All the urban water supply schemes are designed and operated as per the earlier CPHEEO (1999) norms and Service Level Benchmarks (SLBs).

#### 1.9.1 24×7 Pressurised Water supply

Though the earlier manual (1999) recommends continuous a 24×7 pressurised water supply system with a minimum peak factor, important topics such as methodology of OZs, DMAs, water loss reduction programme, which are the essential building blocks of a 24×7 system are not mentioned. If the OZ is not sized, designed, and maintained properly, it leads to malfunctioning of storage reservoirs like emptying and overflowing. Moreover, if the DMAs are not properly created (hydraulically discrete and with 100% consumer metering), it is not possible to compute the level of NRW which is required as first step in the programme of water losses reduction. All these require Decentralised Planning.

### 1.9.2 The Concept of Decentralised Urban Water Supply System

Decentralised planning system solves the complex problem by breaking it into smaller sub problems (Figure 1.6) which are then initially solved. Finally, by combining the solutions of small problems together, the original complex problem can be resolved.

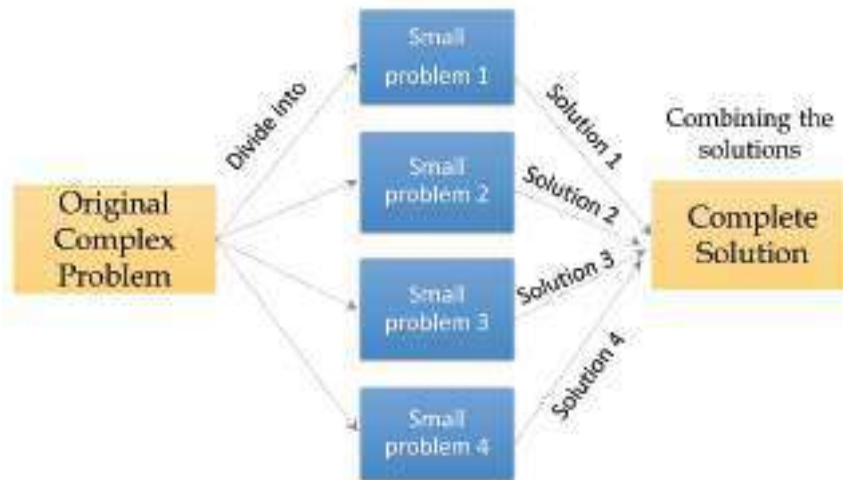


Figure 1.6: Principle of Decentralised Planning

Keeping this principle in mind, and considering the best practices adopted in the developed countries, thrust is given in this manual to the concepts of OZs. Converting water supply in each of them finally helps to switch city's intermittent water supply to a 24x7 water system. For this purpose, a city is divided into manageable zones called OZs (Figure 1.7), which are further divided into subzones called as DMAs.

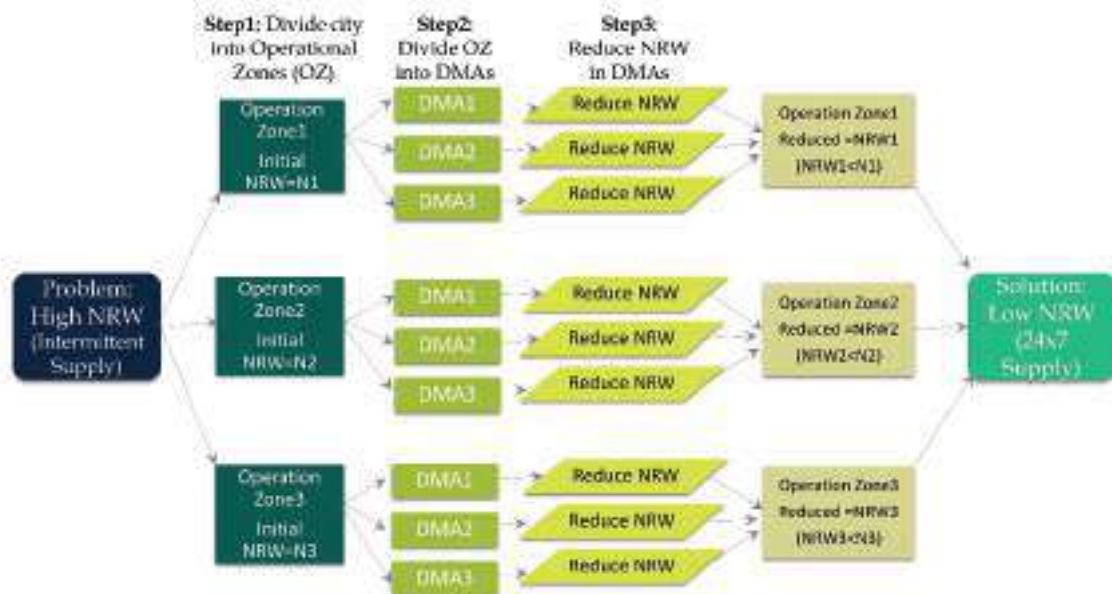


Figure 1.7: Application of Decentralised Planning in Water Supply

DMAs are progressively chosen for providing 100% consumer metering and with bulk meter at entry of DMA. Leakages in chosen DMAs are identified, gets quantified, and are removed. The leakages in all the DMAs should be stopped, and water, that otherwise would be lost, is saved which helps in increasing hours of supply. This is the basic principle of converting intermittent systems in to 24x7

systems. Each individual DMA is tackled in this way and their combined success in increasing water supply duration finally converts the intermittent system of a city to a 24×7 water system.

### 1.10 Uniqueness of this Manual

This manual provides the detailed procedure for conversion of an intermittent system to a pressurised continuous 24×7 system. This includes a procedure for determining optimum boundary of OZ, establishing DMAs with various tests required for making it hydraulic discrete, comprehensive design of transmission main, rational design capacity of service tanks for a 24×7 system, retrofitting and rehabilitation of water distribution networks, proper material selection, and control valves for 24×7 system.

It is well known fact that there are several problems in supplying water through distribution system giving rise to inequitable distribution, lack of pressures in higher elevation areas, high rate of NRW and problems related to quality of water. Most of the cities have clumsy and complicated distribution system. Because such situations were in existence before advent of DMAs, leakages were tackled in a passive way, i.e., leaks were repaired only when they were visible.

All the above mentioned problems can be solved by scientifically designing OZs and DMAs so that the main problems of high NRW and inequitable distribution can be effectively solved in decentralised manner. The demand management is most important. For demand management, 100% consumer metering with telescopic rate of tariff is required which helps in computation of NRW and subsequent water loss reduction. Elimination of illegal connections and volumetric telescopic tariff will further save water. The saved water is used for extending supply hours and finally converting the scheme in to 24×7.

Geographic Information System (GIS) and network technology for hydraulic modelling are also discussed in this manual. Hydraulic model, which simulates an entire distribution pipe network, has been discussed at length in this manual. Using the planning tool of GIS, the methodology such as forecasting ward-wise population and demand allocation using forecasted population density have been discussed. Additionally, the scientific art of making equitable distribution of water has been discussed. Thus, this Manual helps to improve service delivery of water supply system and would help to finally transform existing water supply systems into a 24×7 system.

The following missing new design procedures are discussed in this Manual:

- 1) Design of OZs and DMAs is included in this Manual. Distinctiveness of the present decentralised approach is to consider one OZ for each service reservoir. This is achieved by grouping the reservoirs as per characteristics of terrain which becomes easily possible by use of powerful GIS tool.
- 2) If the OZ is not sized properly, it leads to malfunctioning of reservoirs like *emptying* and *overflowing*.
- 3) There are many inappropriate practices existing in distribution systems of the cities in India. For example, in existing distribution system of many cities, it is observed that two or three existing reservoirs are observed to combinedly serve a single excessively large operation zone. This manual discusses how to correct such snags.
- 4) If DMAs within OZs are not properly established, water audit is not possible. Prioritisation of the leak repair programme is also not possible in absence of DMAs in the existing distribution system.

- 5) The technique of optimisation of diameters of pipes has been addressed in this document by introducing a new method. Uniqueness of this method is that it does not require any costly specialised software except the hydraulic model created by any easily available software.
- 6) One of the neglected areas in water supply is the equitable distribution of water in the distribution systems. Equitable distribution of water with designed pressure is an important aspect of 24×7 water supply. It is achieved by *Whole-to-Part* approach, in which two stages are involved: (a) equitable distribution from Master Balancing Reservoir (MBR) to service reservoirs and (b) equitable distribution from service reservoir to DMAs.
- 7) Equalisation of pressures (residual heads) at Full Supply Level (FSL) of service tanks is also a *grey* area. Equalisation of heads helps in effective and equitable supply of water to various service reservoirs in city by the transmission mains.
- 8) Currently, many cities are being transformed into *Smart Cities*. This manual describes the procedure to economically design pipelines on both sides of the roads by utilising these roads as boundaries for OZs and DMAs.
- 9) Pressure management strategies in Water Distribution Network is important. The methods of pressure management are discussed.
- 10) NRW computation is an important parameter in 24×7 systems. Estimating physical and commercial losses in the distribution system is an essential component of water balance in NRW reduction programme. This Manual discusses the procedure to compute such losses. For this purpose, importance of connecting the meters and flow control valves to the Supervisory Control and Data Acquisition (SCADA) system is also discussed.

### **1.11 Composition of this Manual**

The Manual intends to provide support so that all state governments and UTs to upgrade their water supply system to 24×7. The Manual is divided in three Parts: Part A, Part B, and Part C.

#### **Part A: Engineering - Planning, Design and Implementation**

Executive Summary

- Chapter 1: Introduction
- Chapter 2: Planning, Investigation, Design and Implementation
- Chapter 3: Project Reports
- Chapter 4: Planning and Development of Water Sources
- Chapter 5: Pumping Stations and Pumping Machinery
- Chapter 6: Transmission of Water
- Chapter 7: Water Quality Testing and Laboratory Facilities
- Chapter 8: Conventional Water Treatment
- Chapter 9: Disinfection
- Chapter 10: Specific Treatment Processes
- Chapter 11: Pipes and Pipe Appurtenances
- Chapter 12: Service Reservoir and Distribution System
- Chapter 13: Water Meters
- Chapter 14: Automation of Water Supply Systems
- Chapter 15: Water Efficient Plumbing Fixtures
- Chapter 16: Planning and Design of Regional Water Supply Systems

#### **Part B: Operation & Maintenance**

Executive Summary

## Part A- Engineering

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- Chapter 1: Introduction
- Chapter 2: Operational Strategy
- Chapter 3: Sources of Water Supply
- Chapter 4: Transmission of Water
- Chapter 5: Water Treatment Plant
- Chapter 6: Raw Water and Clear Water Reservoirs
- Chapter 7: Distribution System
- Chapter 8: Drinking Water Quality Monitoring and Surveillance
- Chapter 9: Pumping Stations and Machinery
- Chapter 10: Automation of Water Supply System
- Chapter 11: Water Audit, Monitoring and Control of NRW
- Chapter 12: Energy Audit & Conservation of Energy
- Chapter 13: Safety Practices

## Part C: Management

### Executive Summary

- Chapter 1: Introduction
- Chapter 2: Legal and Institutional Framework
- Chapter 3: Institutional Strengthening and Capacity Building
- Chapter 4: Financial Management
- Chapter 5: Stakeholder Engagement
- Chapter 6: Asset Management
- Chapter 7: Management Information Systems
- Chapter 8: Public-Private Partnerships
- Chapter 9: Building resilience for Climate Change and Disaster Management