URBAN WATER SUPPLY AND WASTE WATER

POLICY FRAMEWORK

Smart City
MISSION TRANSFORM-NATION

Ministry of Housing and Urban Affairs
Government of India

National Institute of Urban Affairs

Ministry of Housing and Urban Affairs
Government of India

ABOUT MINISTRY OF HOUSING AND URBAN AFFAIRS (MoHUA)

The Ministry of Housing and Urban Affairs is the apex authority of Government of India to formulate policies, coordinate the activities of various Central Ministries, State Governments and other nodal authorities and monitor programmes related to issues of housing and urban affairs in the country. The Smart Cities Mission was launched by the Ministry in 2015 to promote sustainable and inclusive cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.

National Institute of Urban Affairs

ABOUT NATIONAL INSTITUTE OF URBAN AFFAIRS (NIUA)

National Institute of Urban Affairs (NIUA) is a premier institute for research, capacity building and dissemination of knowledge for the urban sector in India. It conducts research on urbanization, urban policy and planning, municipal finance and governance, land economics, transit oriented development, urban livelihoods, environment & climate change and smart cities.

The institute was set up to bridge the gap between research and practice, and to provide critical and objective analyses of trends and prospects for urban development. NIUA has assisted in policy formulation and programme appraisal and monitoring for the Ministry of Urban Development, state governments, multilateral agencies and other private organizations. It contributed to the National Commission on Urbanisation, participated in drafting the 74th Constitutional Amendment of 1992, prepared the Draft National Urban Policy and other documents for the roll out of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). It also guided the discourse on municipal finance by framing the Model Municipal Law.

URBAN WATER SUPPLY AND WASTE WATER

POLICY FRAMEWORK

Smart City
MISSION TRANSFORM-NATION

सत्यमेव जयते
Ministry of Housing and Urban Affairs
Government of India

National Institute of Urban Affairs

CONTENTS

LIST OF TABLES

LIST OF TABLE

1.	ASP	Activated Sludge Process
2.	AMRUT	Atal Mission for Rejuvenation and Urban Transformation
3.	CEPT	Centre for Environmental Planning and Technology
4.	CPCB	Centre Pollution control board
5.	DEWATs	Decentralized wastewater treatment systems
6.	FSSM	Faecal Sludge and Septage Management
7.	JNNURM	Jawaharlal Nehru National Urban Renewal Mission
8.	KLD	Kilolitres per Day
9.	MBR	Membrane Bio Reactor
10.	MBBR	Moving Bed Biofilm Reactor
11.	MLD	Millions of liter per day or megaliters per day
12.	SBR	Sequential batch Reactor

EXECUTIVE SUMMARY

Increasing urbanization of India is putting significant pressure on the available water resources and the safe disposal of waste water. Most cities are facing increasing water stress and are breaching the limits to accessing drinking water from ground water and rivers and water bodies.

Drinking water requirements of a growing city have to be met along with addressing critical aspects of adequacy and frequency of water supply, affordability and pricing, water quality and the institutional sustainability of the water utilities.

Increasing efficiency in the distribution and supply of drinking water and in the treatment and reuse of waste water is a priority.

A paradigm shift is needed in the urban water and waste water sector, to move away from supply side to demand management and reducing the waste water footprint of cities.

The large volume of waste water generated, if not treated, is a public health hazard and an environmental and bio diversity disaster.

The urban water supply and waste water sector therefore needs a Vision and Policy Commitments to address the challenges of the coming decade.

Vision

Managing water demand and reducing the waste water foot print

Policy Commitments

- Plan for integrated water and waste water management
- Reduce Non-Revenue Water
- Ensure universal access to water supply and sanitation
- Prioritise Operations and aintenance of Water and Sanitation Infrastructure

INTRODUCTION

Urbanisation

Increasing urbanisation is a worldwide trend. "The share of India's population residing in urban areas increased from 20% in 1971 to 31% in 2011, with the urban population of 377 million representing the 2nd largest urban community in the world."[1]

The pace or urbanization is also increasing. "It took nearly 40 years (from 1971 to 2008) for India's urban population to rise by nearly 230 million; it will take only half that time to add the next 250 million. This expansion will affect almost every state. For the first time in India's history, five of its largest states will have more of their population living in cities than in villages."[2]

The Census of India definition of Towns of India is as follows[3];

- All places with a municipality, corporation, cantonment board or notified town area committee, etc.
- All other places which satisfied the following criteria:
  a) A minimum population of 5,000
  b) At least 75 per cent of the male main working population engaged in non-agricultural pursuits; and
  c) A density of population of at least 400 persons per sq. km.

The first category of urban units is known as Statutory Towns. Please refer Table 1 for Urban population across towns,2011 census

India is transitioning from a rural to an urban society and this pace is evident from the nearly fourteen fold increase in urban population since independence. While large cities have grown in number and size, the smaller towns(less than one million) constituted more than 60% urban population as of 2011.

Table 1 Urban population across towns,2011 census.

	Population less than 100,000	Population 100,000 to 1 million	Population 1 to 5 million	Population more than 5 millio	TOTAL
Numbers	112.21	104.71	75.54	85.12	377.58 million
Percentage	29.76	27.62	20.03	22.59	100%

Table 2 Popolatoon in cities and towns of India, 1901-2011

Population (in millions)					
Year	5 million and above	1- 5 million	1 lakh - 1 million	< 1,00,000	Total
1901	0	0	6.8	19.08	25.9
1911	0	2.34	4.85	18.76	26.0
1921	0	3.2	5.22	19.67	28.1
1931	0	3.48	7.06	22.96	33.5
1941	0	5.39	11.66	27.07	44.1
1951	0	11.8	16.36	34.34	62.5
1961	6.08	12.55	22.33	37.95	78.9
1971	14.18	14.51	33.72	46.81	109.2

Population (in millions)					
Year	5 million and above	1- 5 million	1 lakh - 1 million	< 1,00,000	Total
1981	24.88	19.29	53.42	62.03	159.6
1991	37.86	33.95	68.33	77.68	217.8
2001	60.37	47.78	88.12	89.85	286.1
2011	85.18	75.54	104.17	112.21	377.1

Table 3 Share of urban population in cities and towns in India, 1901-2011

Year	Population							
	5 million and above		1- 5 million		1 lakh - 1 million		< 1 lakh	
	Cities	% of urban population	Cities	% of urban population	Cities	% of urban population	Towns	% of urban population
1901	0	0.00	0	0.00	25	26.30	1771	73.80
1911	0	0.00	2	9.00	22	18.70	1768	72.30
1921	0	0.00	2	11.40	28	18.60	1887	70.00
1931	0	0.00	2	10.40	34	21.10	2004	68.60
1941	0	0.00	2	12.20	49	26.40	2087	61.30
1951	0	0.00	5	18.90	72	26.20	2720	55.00
1961	1	7.70	6	15.90	100	28.30	2223	48.10
1971	2	13.00	7	13.30	143	30.90	2405	42.90
1981	3	15.60	9	12.10	207	33.50	3027	38.90
1991	4	17.40	19	15.60	276	31.40	3401	35.70
2001	6	21.10	29	16.70	359	30.80	3984	31.40
2011	8	22.59	45	20.03	415	27.62	5698	29.76

Source: HPEC, 2011 and Census of India, various yers

Drinking water and Sanitation Challenges

There are limits to the extent of supply side solutions to meet the growing demand for water supply to urban India. There is a large dependence on ground water for meeting the urban household water requirements. However continued drilling of groundwater has resulted in not only depletion of urban aquifers but also emergence of Flouride and Arsenic contamination.

The disposal of untreated waste water, septage and sewage, dumping of toxic industrial chemicals and industrial waste, is resulting in pollution of ground water and surface water, with many rivers and water bodies becoming severely contaminated. There are several institutional, financial and systems challenges that have to be met.

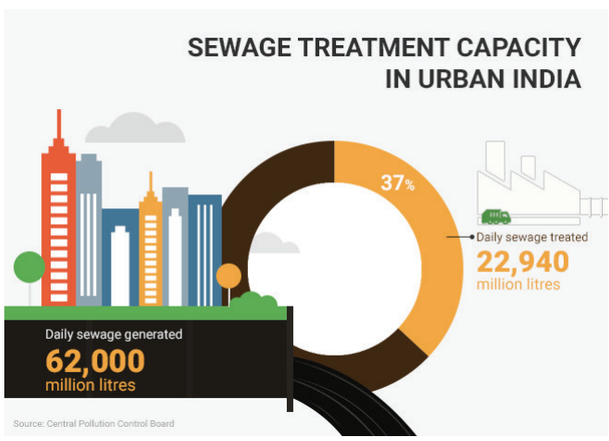


Image Source:Central Pollution Control Board

Treatment capacity is available for only 37 per cent of the 62,000 million litres of sewage generated in urban

India daily, thus creating a wide gap between sewage generated and treated. Untreated sewage is dumped into rivers or lakes, thus polluting the environment even more.

Nodal National Ministries and Missions dealing with urban water supply and waste water issues

- Ministry of Water Resources, River Development & Ganga Rejuvenation[4]
- National Water Mission : National Action Plan for Climate Change[5]
- Ministry of Environment and Forests for the Water Pollution, Coastal Regulatory Zone and Central Pollution Control Board.[6]
- Ministry of Social Justice and Empowerment[7] with Manual Scavenging Act implementation.[8]

- **Swachh Bharat Mission Urban Mission**[9] primarily addressed the aim of achieving Open Defecation Free India by 2019. **The AMRUT Programme Mission**[10] focused on urban infrastructure including water and sanitation systems.

The Smart Cities Mission[11] focused on achieving smart solutions to urbanization through a competitive process. *"The strategic components of area-based development in the Smart Cities Mission are city improvement (retrofitting), city renewal (redevelopment) and city extension (greenfield development) plus a Pan-city initiative in which Smart Solutions are applied covering larger parts of the city."*

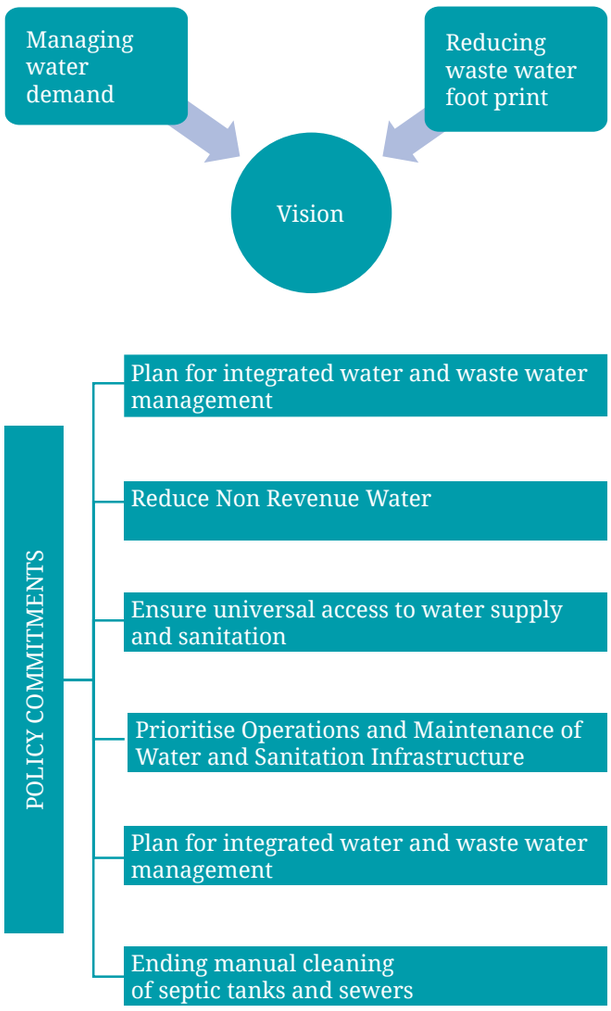
A Manual for District Level Functionaries[12] for achieving the programme guideline aims of Open Defecation Free Cities was released in 2017.

State Level Policies relevant to urban water supply and waste water

Several state level polities and guidelines have come up to promote urban sanitation services. Prominent among them are the State level Faecal Sludge and Septage Management(FSSM) Policies.

- Karnataka Urban Drinking Water and Sanitation Policy 2003[14]
- Odisha Urban Sanitation Strategy 2011[15]
- Delhi Guidelines for MLAs Local Area Development Scheme 2012[16]

Vision and Policy Commitments



A paradigm shift is needed in the urban water and waste water sector, to move away from supply side to demand management and reducing the waste water footprint of cities. This shift is required given the limits to extracting additional water supply from rivers and rural areas and the great volume of waste water generated that if not treated is looming as a public health hazard and an environmental and bio diversity disaster.

Increasing urbanization in India is putting significant pressure on the available water resources and the concomitant waste water generation that is polluting our water bodies.

Drying and polluted aquifers, competing and increasing demand from agriculture is reducing the opportunities for expanding water supply. Dumping

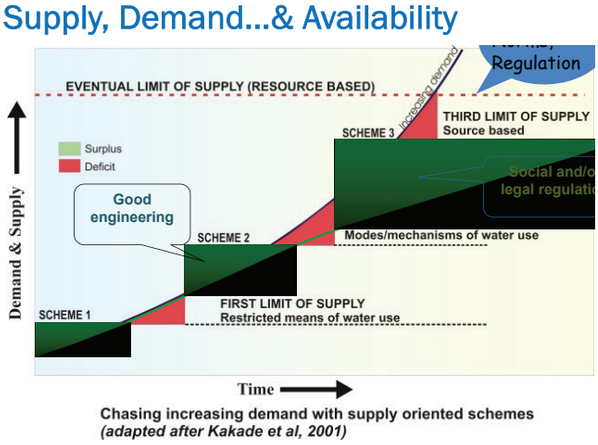
of untreated waste in rivers and water bodies, is creating a public health hazard and great loss to bio diversity. Unequal access to drinking water supply within a city, competing demand with industrial and agriculture needs, is creating conflicts at many levels - urban-rural, agriculture-industry, intra urban conflicts over water supply and disposal of waste water.

City managers and administrators will have to focus on sustainability of water supply for their cities by focusing on demand management and reducing the waste water footprint, instead of exploring options for endlessly increasing water supply. The business as usual case of dumping of untreated sewage, waste water and septage in rivers and water bodies, cannot go on.

Climate change is also going to impact the availability of water supply for Indian cities, due to increasing variability leading to dramatic changes in reservoir levels and water supply

Managing water demand

India's share of world population is 17% while we have only 4% of world's renewable fresh water resources (Ministry of Water Resources, 2012). The World Bank anticipates a 50% increase in urban water demand in the next 30 years. For India, this timeline may be even shorter. Water Demand Projections by the International Water Management Institute show that we have underestimated water withdrawals in India by 3 to 14%. Globally, total domestic water use already exceeds the forecasts for 2025, and water demand for irrigation is much higher than expected.[17]



Chasing increasing demand with supply oriented schemes
(adapted after Kakade et al, 2001)

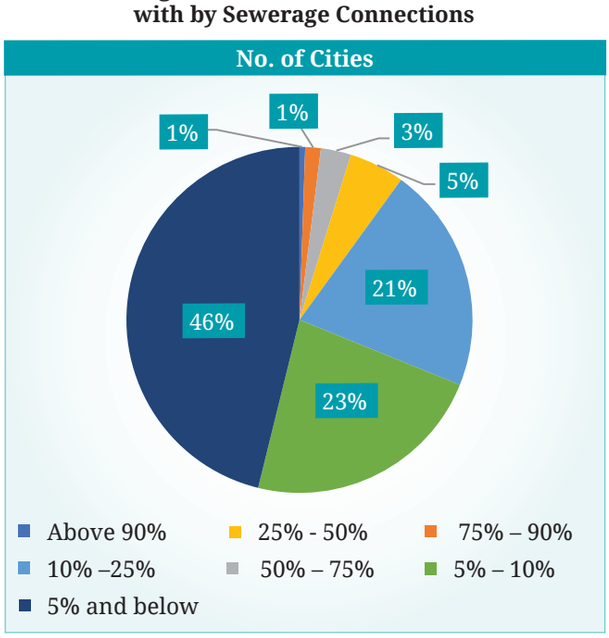
As we reach the limits to ground water withdrawal and exploit all available surface water resources, governance and regulation will be needed to manage water resources. The table below shows limits to water supply

National Water Policy 2012[18] was enacted with the following concerns in mind: *"With a growing population and rising needs of a fast-developing nation as well as the given indications of the impact of climate change, availability of utilizable water will be under further strain in future with the possibility of deepening water conflicts among different user groups. Low consciousness about the scarcity of water and its life sustaining and economic value results in its mismanagement, wastage, and inefficient use, as also pollution and reduction of flows below minimum ecological needs."*

The **Model Bill for Regulation of Groundwater Development 2016**[19] deals with regulation of ground water in both urban and rural areas. Regulation of ground water use is a key element to managing demand for water.

Reducing Waste Water Footprint

Figure 1 Distribution of Cities with by Sewerage Connections

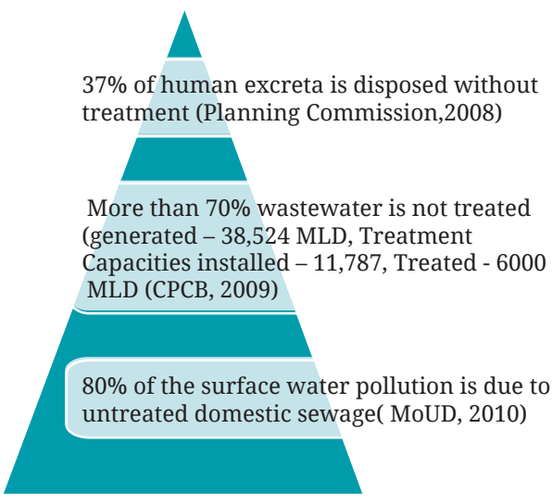


Waste water treatment solutions that are cost effective and sustainable are of utmost priority. Success of Swachh Bharat Mission will require a

renewed focus on addressing the treatment of faecal sludge and waste water.

Sewage generation and its treatment have been prioritized, however as on 2011, only 792 or only 10 per cent of cities have more than 50 per cent of households connected to sewerage systems.

Not all cities having a sewerage system may have functional treatment systems that collecte and treat faecal waste and waste water from all households of the city. Hence even this may be an overestimation[20] as is borne by the reports of the Central Pollution Control Board.



The Central Pollution Control Board Report of 2015 found that the estimated sewage generation in the country was 61,754 MLD as against the developed sewage treatment capacity of 22,963 MLD. Because of the hiatus in sewage treatment capacity, about 38,791 MLD of untreated sewage (62% of the total sewage) is discharged directly into nearby water bodies. There are 920 STPs in different States/UTs out of which, 615 STPs are operational, 80 STPs are non-operational, 154 STPs are under construction and 71 STPs are under planning stage.[21]

Several Legislations have been passed in India addressing water security and sustainability considerations. The implementation of these legislations has however been a challenge.

The Water (Prevention and Control of Pollution) Act was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in the country. The Act was amended in 1988. The Water (Prevention and Control of Pollution) Cess Act was enacted in 1977, to provide for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities. This cess is collected with a view to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Act was last amended in 2003[22].

The Environment (Protection) Act was enacted in 1986 with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities [under section 3(3)] charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country. The Act was last amended in 1991[23].

Coastal Regulatory Zone Notification 2011 defined "the distance upto which development along rivers, creeks and back-waters is to be regulated shall be governed by the distance upto which the tidal effect of sea is experienced in rivers, creeks or back-waters, as the case may be, and should be clearly identified in the Coastal Zone Management Plans"[24] This is being updated and a draft has been shared in April 2018[25]

Core Policy Commitments

Managing demand and reducing waste water foot print will require a conscious attempt by City Managers and Administrators, to plan for water provision and reducing and re using the waste water generated to meet the growing needs of the city.

Following policy commitments should form the core of urban water and sanitation planning and delivery. Performance should be measured for outputs and outcomes against these key commitments.

- Plan for Integrated water and waste water management
- Reduce Non Revenue Water(NRW)
- Ensuring universal access to affordable, safe and adequate water supply
- Prioritise Operations and Management of Water and Sanitation Infrastructure
- Ending manual cleaning of septic tanks and sewers
- Prioritise non networked and decentralised sanitation systems

Plan for Integrated water and waste water management

- GIS based asset mapping & consumer indexing
- Predictive analysis based historic data
- Consolidated view of the water network via schematics
- High volume data analytics using data from across the water network
- Real time monitoring of utility meter readers
- GPRS enabled Mobile Billing devices
- Online bill payment

Drinking water supply receives a priority over sanitation and waste water management. Different projects and schemes are implemented for water and waste water and sewerage systems in the same town, often with little attempt to integrate the choice of technology, the design and planning and peoples engagement.

Figure 2 ICT Initiatives for Waster Water Treatment

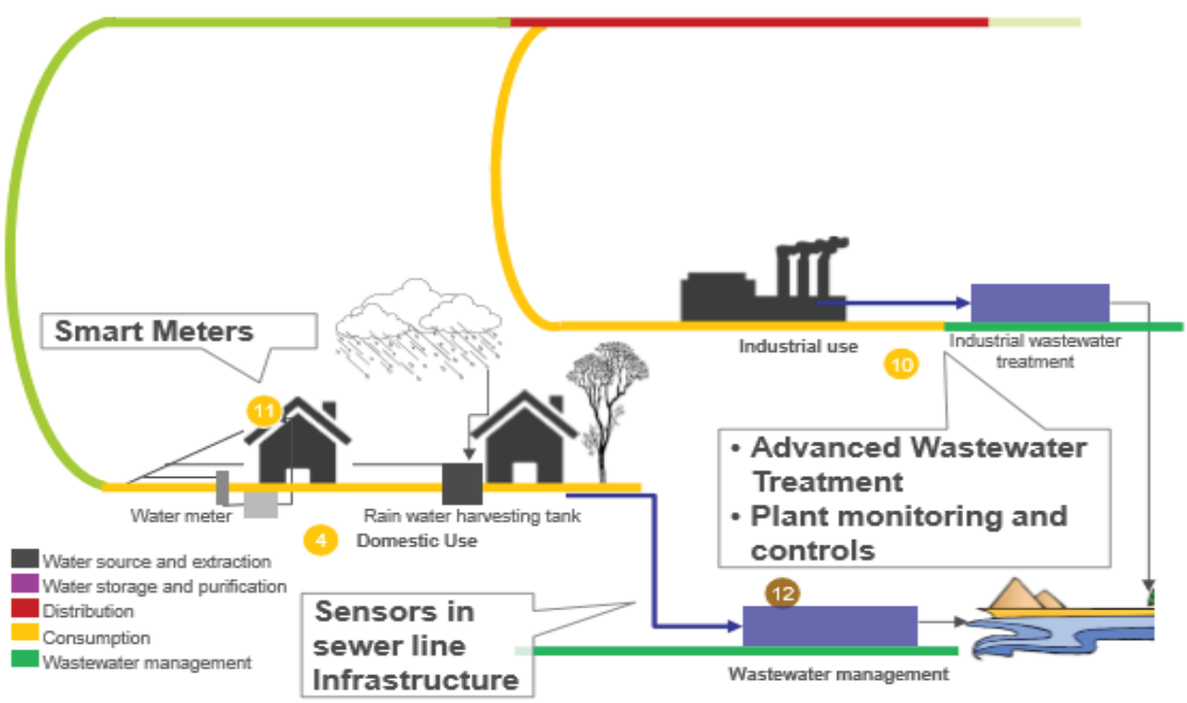


Image Source: smartcity.gov.in

Planning Tools for Urban Sanitation

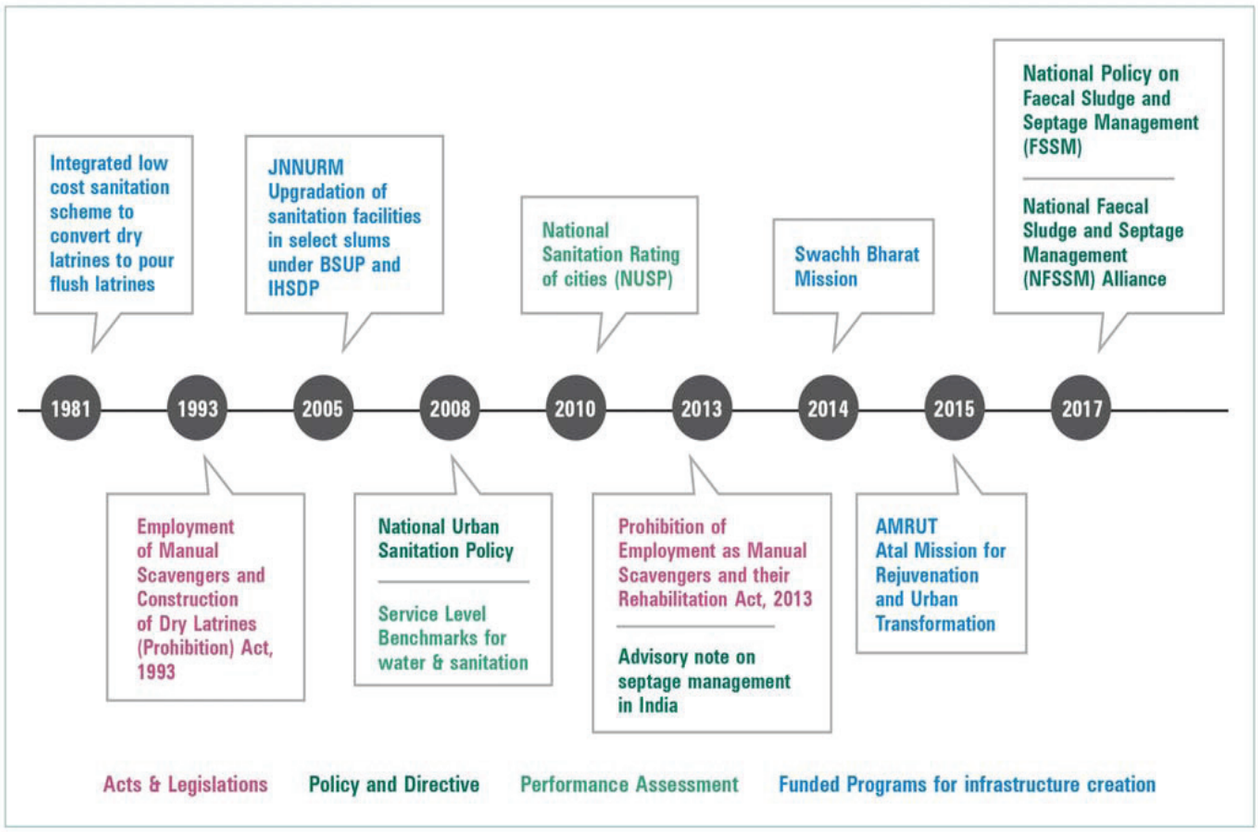


Image Source: An Orientation Module SCBP (NIUA)

National Urban Sanitation policy 2008 envisaged the development of City Sanitation Plans with a holistic perspective of addressing all waste water and sanitation issues and to identify priority interventions. The City Sanitation Plan was to become the basis for cities planning for any urban sanitation infrastructure.

National Urban Sanitation Policy 2008[26] *was brought out with the vision of "All Indian cities and towns become totally sanitized, healthy and liveable and ensure and sustain good public health and environmental outcomes for all their citizens with a special focus on hygienic and affordable sanitation facilities for the urban poor and women. The overall goal of this policy is to transform Urban India into community-driven, totally sanitized, healthy and liveable cities and towns".*

Sani Plan is a tool to assess and plan for city wide sanitation planning that allows for performance assessment of the current and potential status of the town as per the Service Level Benchmarks[27] . It is also a tool for activity planning for a new intervention of centralized or decentralsied sanitation infrastructure and its financial assessment. It uses IT based software to collect information at household level and institutions on their sanitation systems, analyses the information collected for planning, financial and performance assessment of the city.

Image Source: FSSM ToT Module, SCBP

Shit Flow Diagram(SFD) is a tool for assessing the sanitation value chain of a city. SFDs are a new way of visualizing excreta management in cities and towns.[28] It serves the purpose of an learning tool for city officials and also for researchers, to highlight the extent of treated and untreated faecal waste generated in a city on a map. It also serves as an advocacy tool to promote decentralized treatment solutions.

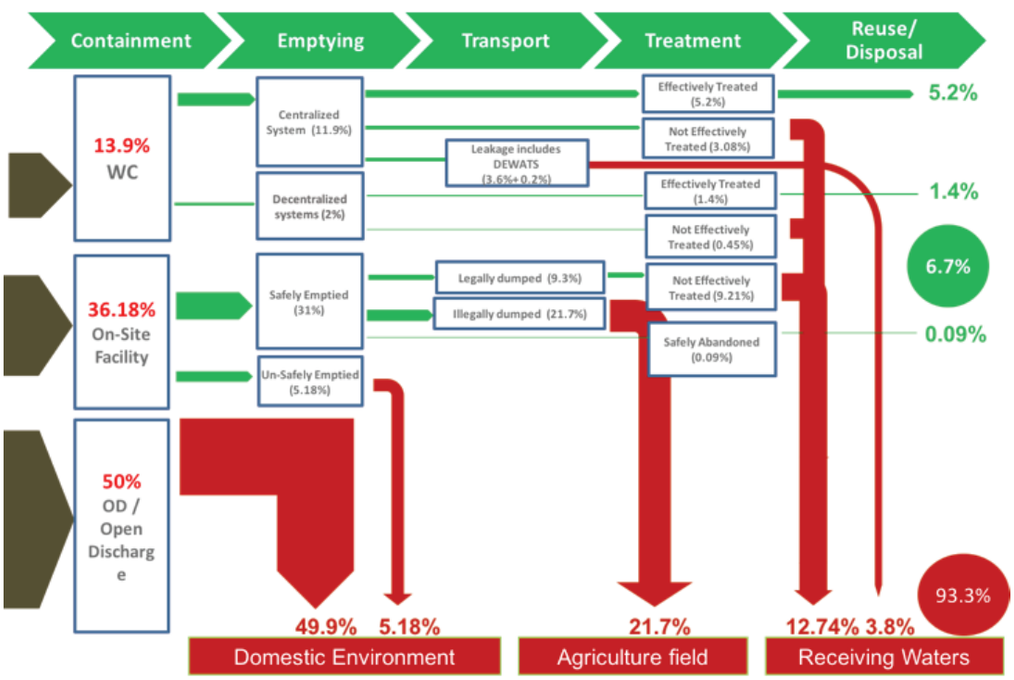
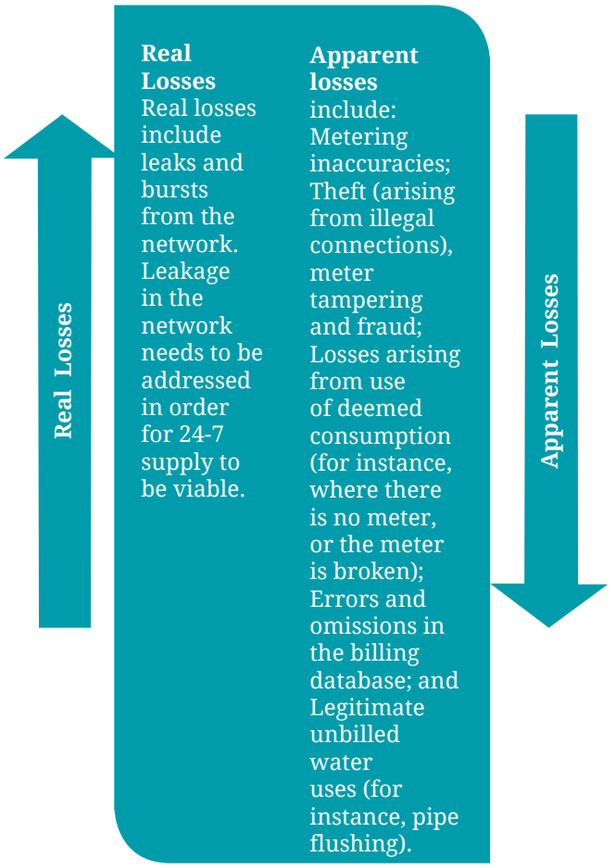


Image Source: Consortium for DEWATS Dissemination Society

Reduce Non-Revenue Water

NRW is made up of real losses and apparent losses.



Extent of Non-Revenue Water (NRW) is an important indicator for assessing the efficiency in service operation of a water supply system as well as for identifying physical loss of water during supply and reducing it to the extent possible.

NRW refers to water that has been produced but is "lost" before it reaches the customer. It refers to the amount of water produced that does not earn any revenues for the ULB. This "lost" water could be due to real losses (through leakages, also referred to as physical losses) or apparent losses (theft, illegal connections, free water etc.). High levels of NRW seriously affect the financial viability of water supply provision due to lost revenues, and increased operational costs adversely impacts the quality of the service provided. It must be recognised that NRW is difficult to estimate in a context where there are no measurements of flow at source of water or at major distribution points and consumer points. Better measurement of NRW can be done by conducting preliminary water audits.[29][30]

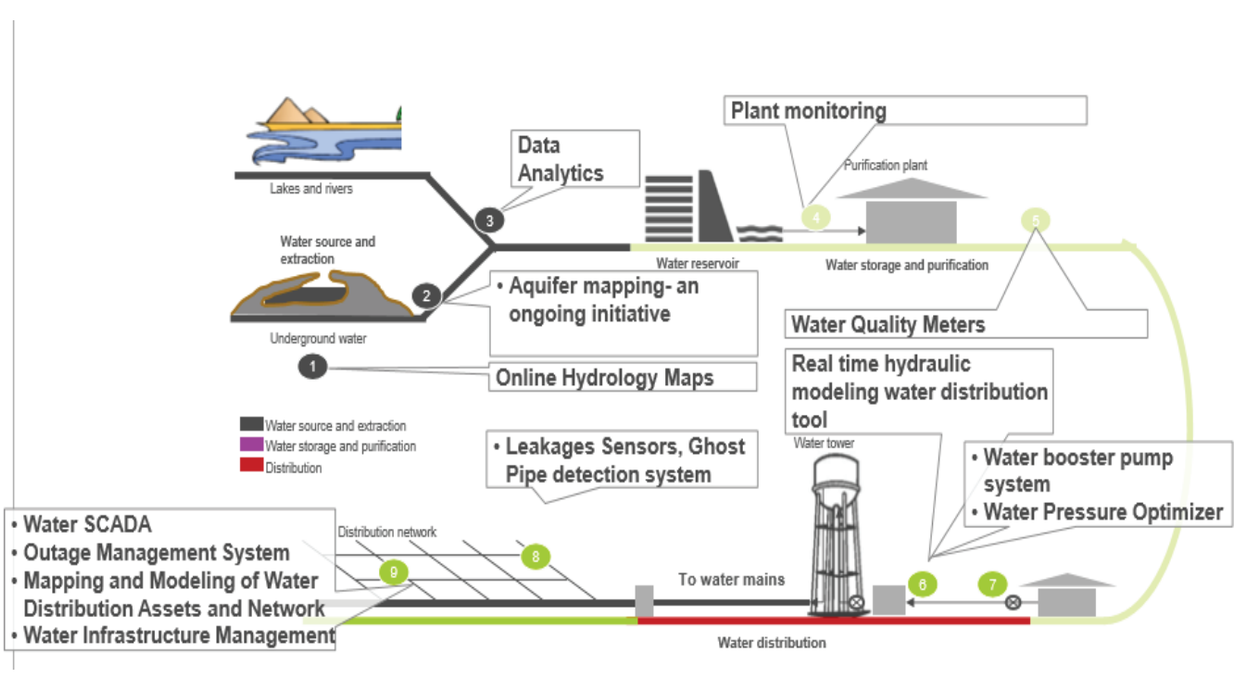
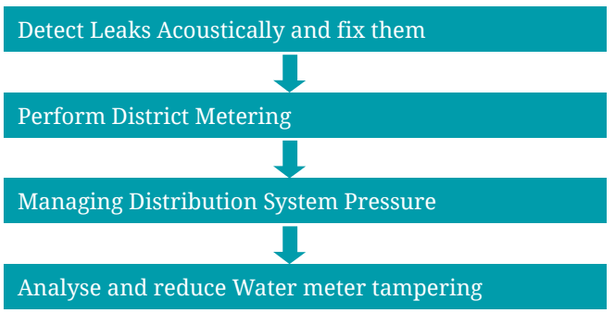


Image Source: smartcity.gov.in

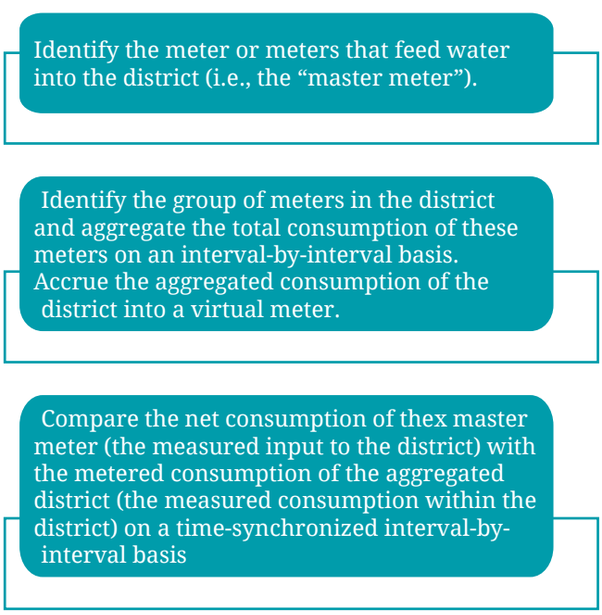
Follwowing Steps are recommended for reducing NRW[31]



Detect Leaks Acoustically and fix them
A dynamic combination of acoustic leak sensors, AMI technology and innovative data analysis software enables proactive leak mitigation. Using a communication module with an integrated acoustic leak sensor, water providers can collect and analyze vibration patterns from anywhere in the distribution system.

Perform District Metering Analysis and Plan for District Metering Supply systems

District metering can be performed via the following steps:



Once the district metering analysis has been conducted and the analytics application has ranked the various districts according to severity, utilities can prioritize where to look for leaks.

Managing Distribution System Pressure
A small reduction in pressure can mean a significant reduction in real losses through leaks. When activated during low-demand periods such as late at night or early in the morning, pressure management will not affect service levels and can reduce consumption in networks with no intermediate storage.

To effectively manage pressure, it is important to comprehensively evaluate a service area and gain an understanding of its background losses before introducing pressure control.

With a pressure management program, a utility's distribution system is broken down into pressure zones. Pressure is monitored at the inlet, average zone point and the critical zone point. The average zone point is a location that exhibits the average pressure rate for the zone. The critical zone point is a location where pressure is the lowest, usually the highest elevation in the zone.

Analyse and reduce Water meter tampering
Automated systems are available for monitoring any water meter tampering at consumer level. Through a combination of meter reading and water supply analysis, it is possible to detect tampering and withdrawal of water supply at consumer level. Both tampering and leakages can be analysed over time by comparing data generated by the system.
Best Practices : Surat NRW reduction.[32]

Ensuring universal access to affordable, safe and adequate water supply

Universal supply of water remains a key responsibility of the Urban Local Bodies. Alongwith universal access to water, comes water quality that is drinkable and quantity that is adequate to meet the requirements of different types of city dwellers ranging from slums dwellers and worker colonies to the middle class and higher income colonies.

Universal access of safe drinking water is a fundamental need and human right. One of the most important recent milestones has been the recognition in July 2010 by the United Nations General Assembly of the human right to water and sanitation.[33] "The right to water entitles everyone to have access to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use".[34]

Image Source: ice.org.uk

As a Global Plan of action, the Sustainable Development Goal 6 "Ensure availability and sustainable management of water and sanitation for all" for the access of water.

No city in India receives 24x7 piped water supply. According to CPHEEO 2011 and Census 2011, 70% of Urban Households have the access of piped water supply.[35] According to 2012 United Nations Educational, India is the World Biggest consumer of the ground water extracting on the rate of 251 cubic kilometer (cu km) annually.80 % of Drinking Water and two-third of irrigation needs of India are conveyed by Ground Water. Furthermore, 60% of districts face groundwater over-exploitation and/or serious quality issues.[36]

Most cities do not provide the quantum of water according to existing per capita norms. While Indian cities are supposed to conform to the standards laid down in the Manual on Water Supply and Treatment (CPHEEO, 1999), the cities are rarely able to meet these standards as cities clearly receive only 69 lpcd, as opposed to the norm of 135 lpcd.[10]

Guidelines issued by the Central Public Health and Environmental Engineering Organisation (CPHEEO) defines urban water supply norms for towns with and without sewerage systems as follows:

Table 5 Guidelines issued by CPHEEO defines urban water supply

	Classification of towns/cities	Recommended maximum water supply levels (lpcd)
1	Towns provided with piped water supply but without sewerage system existing/ planned	70+ 15% for leakage
2	Cities provided with piped water supply where sewerage system exists/planned	135+ 15% for leakage
3	Metropolitan and Mega cities provided with piped water supply where sewerage systems existing	150+ 15% for leakage

Source: Ministry of Urban Development, Central Public Health and Environmental Engineering Organisation Manual on Water Supply and Treatment, Third Edition -Revised and Updated (May 1999), New Delhi.

Water supply norms for Indian cities are defined therefore for the purpose of ensuring a certain flow level in the sewerage systems to be able to function. In most cities the norm of 135lpcd is difficult to meet. Thus creating problems of choked sewerage pipes and non functional STPs. This therefore again merits looking a decentralised sanitation solutions that require less water supply.

Table 6 Service Level standard performance parameters as per Ministry of Housing and Urban affairs (MoHUA), Govt. of India

WATER SUPPLY		
S. No.	Indicator	Benchmark
1.	Coverage of Water Supply connections	100%
2.	Per Capita Supply of Water	135 lpcd
3.	Extent of Non-revenue Water	15%
4.	Extent of Metering	100%
5.	Continuity of Water supplied	24 Hours
6.	Efficiency in redressal of customer complaints	80%
7.	Quality of Water Supplied	100%
8.	Cost Recovery	100%
9.	Efficiency in Collection of Water Charges	90%[38]

Best Practices

Performance Benchmarking of Urban Water Supply and Sanitation in Gujarat: Data Book (2008-09)[39]- The Performance Assessment System (PAS) Project developed by the Centre for Environmental Planning and Technology (CEPT) University proposes an assessment system with a set of key performance indicators for urban water and sanitation and links the planning and fund allocation process to performance. Initiated in early 2009, the PAS Project includes three major components of performance measurement, performance monitoring and performance improvement. It covers all the 400+ urban local governments in Gujarat and Maharashtra.

Provision of basic services including water and sanitation, even in unauthorized colonies and slums(notified or non notified) within an Urban Local Body area, remains the responsibility of the Urban Local Body. Provision is made through permanent infrastructure of pipelines and sewers connection or through temporary measures of drinking water tanker supply and mobile or temporary community toilets.

Legislation

The **Slum Areas(improvement and Clearance) Act 1956**[40] was enacted "to provide for the improvement and clearance of slum areas in certain Union territories and for the protection of tenants in such areas from eviction". Several State governments also passed Acts relating to Slum Areas. The Maharashtra Slum Areas Act 1971[41] .The Delhi DUSIB Act 2010[42] as the competent authority to implement the 1956 Act. J&K Property Rights to Slum Dwellers Act 2011[43]. Rajasthan Slums Development Policy(Under PPP) 2012[44]

Model Municipal Law and Building Bye Laws. The Ministry of Housing and Urban Affairs came out with a **" Policy Option Paper for Framing Municipal Law of India, 2016**[45]. This was followed by the **Model Municipal Law**[46].

Several **States and Cities have come up with their Municipal Acts**. Bihar Municipal Act 2007[47]

The **National Housing and Habitat Policy 2007**[48] was intended to promote sustainable habitat in India. This was followed by Guidelines for Projects on Basic Services to the Poor 2009[49] under the JNNURM phase.

Water Quality Norms

Water is defined as safe if it is free from biological contamination (guinea worm, cholera, typhoid etc.) and within permissible limits of chemical contamination (excess fluoride, brackishness, iron, arsenic, nitrates, etc.) as per IS-10500 standard of Bureau of Indian Standards (BIS).

The BIS drinking water specification (IS 10500:1991) was drawn up in 1983 and its most recent revision dates back to July 2010 (Amendment No. 3) with the objective of assessing the quality of water resources and checking the effectiveness of water treatment and supply by the concerned authorities.[50 51]

The qualitative testing of water supply is tested in labs for the presence of contamination is carried out twice a year – Pre Monsoon and Post Monsoon recommended by Uniform Drinking Water quality Monitoring Protocol, 2013.

Central Pollution Control Board has provided **Norms for Water Quality** usage for different purposes, an inventory of Water Treatment Technologies and location of Water Treatment Plants[52].

The Criteria for different class of Water are prescribed by CPCB as Water Quality Standards[53]. **Industrial Effluents Standards** are also prescribed by CPCB[54].

Policy Statement on Abetment of Pollution 1992[55] was one of the earliest policy statement of Ministry of Environment and Forests expressing a "commitment of Government on abatement of pollution for preventing deterioration of the environment". The statement noted that the problem of water pollution is primarily arising from untreated municipal waste water. *"Water is polluted by four kinds of substances : traditional organic waste, waste generated from industrial processes, chemical agents for fertilisers and pesticides for crop protection and silt from degraded catchments. While it is estimated that three-fourths by volume of the waste water generated is from municipal sources, industrial waste, though*

small in volume, contributes over one-half of the total pollutant load, and the major portion of this is coming from large and medium industries. For class-I cities of the Country, less than five per cent of the total waste water generated is collected and less than one-fourth of this is treated."

Prioritise Operations and Management of Water Supply and Waste Water Treatment Infrasructure

Water supply and sanitation are public goods. Hence accountability of the ULBs is paramount. However the financial health of most ULBs is such that their revenue expenditures are not met from revenues. Water utilities are expected to do full cost recovery for O&M cost of service deliver. However dependence of ULBs on state and central finance commissions is high and their capacity to cover O&M cost of water and sanitation infrastructure is low. City Managers face the challenge of high Operations and Maintenance(O&M) of drinking water supply and waste water treatment.

High cost infrastructure may be paid from central government programmes and schemes but its operations and maintenance has to be borne by the Urban Local Bodies. Hence in the selection of technology and infrastructure investment, City Managers must give their input.

Sewage Treatment. The cost of a treatment plant for waste depends on two key factors – the quality of raw influent and the quantity of the receiving medium. Currently, most cities do not have treatment plants, installed or running to treat 100% of the human excreta generated by the city. Furthermore, most sewage treatment plants use basic technologies for cleaning waste. These were built at a time when the characteristic of waste was basic – biological and not chemical – and more importantly, the receiving environment had capacities to assimilate the treated waste. CPCB's last detailed evaluation on sewage technologies in mid-2006 revealed that most cities use waste stabilisation ponds or activated sludge process (ASP), a conventional sewage treatment system, which uses biological processes to settle solids and then a variety of aeration systems to oxidise and clean the waste. According to this report, 60 per cent of the sewage treatment plants were based on some variation of this technology.[56]

Energy charges for running the water pumps or waste water treatment facilities are a major drain on the annual budgets of the Urban Local Bodies(ULBs).

Unless the ULBs and Utilities have the necessary resources, personnel and systems to manage their finances and to undertake regular maintenance works effectively, all costly infrastructure investment will go waste. Hi-tech Technology infrastructure of STPs and Water Treatment Plants, are often difficult to meet and this is one justification for promotion of small sized decentralsied water and waste water treatment systems.

Cost of Waste Water Treatment Plants : Power costs a high component

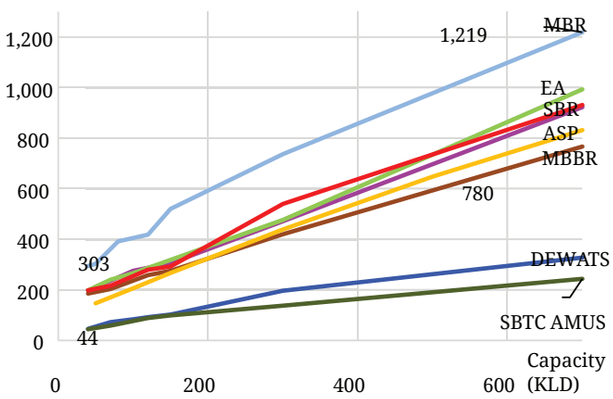
Sewerage systems are not likely to cover even 50% of the towns in the coming 20 years. Growing urban population will always lead to sewerage systems not being able to handle the septic tanks based sanitation systems that will be installed in all towns. **Life cycle cost of waste water treatment** technologies shows a significantly lower cost per Kilo Liters Day(KLD) treatment for non mechanical DEWATS technology versus the other technologies of Moving Bed Biofilm Reactor(MBBR), Membrane Bio Reactor(MBR), Sequential batch Reactor(SBR), Activated Sludge Process(ASP)[56] and others.

Table 7 Cost of Waste Water Treatment Plants

Plant	Technology	Capacity (mld)	Capital cost (Rs/ crore)	Capital cost (Crore/ mld)	O&M costs (Rs/kl)	Power costs (Rs/ kl)	Total O&M costs (Rs/ kl)
Sonia Vihar, Delhi	Presettler-Pulsator+ Aquazur (Degremont)	635	189	0.30	0.38	1.04	1.43
Chembarambakkam	Pulsator Aquazur (Degremont)	530	135	0.25	0.39	0.82	1.21
TK Halli-1	Pulsator+ Aquazur (Degremont)	300	45	0.15	0.22	0.10	0.32
Nagpur	Pulsator+ Aquazur (Degremont)	120	15	0.13	0.39	1.04	1.43
TK Halli-II	Aquadaf+ Aquzur (Degremont)	550	190	0.34	0.32	0.10	0.42
Minjur, Chennai	Desalination plant	100	473	4.73	48.66	10-12	59-61
Nemmeli	Desalination plant	100	1034	10***	--	--	21

Source: Planning Commission (2011)

Life Cycle Cost of Sanitation Treatment Technologies[57]



Advisory Note: Recent Trends in Technologies for Sewerage Systems 2012[58] were introduced to supplement the older technology options.

"The Manual on Sewerage and Sewage Treatment published by the Ministry in 1993 emphasises conventional sewage treatment technologies such as Activated Sludge Process (ASP), Waste Stabilization pond (WSP), Upflow anaerobic Sludge Blanket (UASB) Reactor etc. Over the last two decades, many new technologies for sewerage and sewage treatment have emerged. These technologies which are being used in other parts of the world have not been deployed in India on a large scale".

Ending manual cleaning of septic tanks and sewers

Manually cleaning of septic tanks and of blocked sewers by workers is now a punishable offence. City Managers will have to find out mechanized emptying equipment to empty the toilets built under Swachh Bharat Mission as well as the routine cleaning of sewers.

Prohibition of Manual Scavenging Act 201359 was enacted by the Ministry of Social Empowerment and Justice.

The Act to provides for the prohibition of employment of manual scavengers as well as construction or continuance of dry latrines and for the regulation of construction and maintenance of water-seal latrines and for matters connected therewith or incidental thereto.

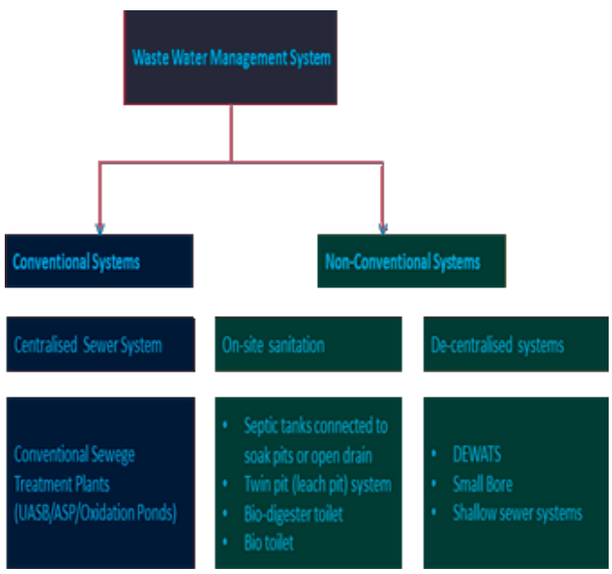
This has implications including jail term and fine for violations by anyone including Urban Local Bodies

for manually cleaning of sewers and septic tanks.

Prioritise non sewered and decentralised sanitation systems

Septage Treatment. Considering majority of toilets in urban India are not connected to sewerage systems(only 32% are connected as per 2011 census), there is need for septage treatment systems that can be set up and operated with minimal treatment costs. Since the characterisation of faecal sludge in septic tanks is less complicated and than sewage that may be mixed with industrial contaminants, its treatment technology can be determined based on a combination of cost, climatic and geographical considerations.

Decentralised sewerage or Non Networked Sanitation Systems that treat sewerage or septage in decentralised locations within a city or within a housing colony or for the whole town – are needed, instead of more large capacity centralised sewage treatment plants(STPs). Co treatment of septic tank waste with existing under utilised STPs will also have to be prioritised.



Source SCBP Orientation Trainng Module scbp.niua.org

Centralized waste water treatment plant is a conventional STP which could be set up in a city and all waste water can be transported to the STP via sewer lines. A centralized sewerage is perceived as an underground sewer system to collect the sewage from all over the settlement. While the conventional sewerage may be a comprehensive system for sewage collection and transport, it also remains as a highly resource-intensive technology. Consequently, high capital cost and significant O&M cost of this system inhibits its widespread adoption in all sizes of urban areas.

In decentralized method, more than one, small capacity of treatment plant can be set up across the city. It could be in the cluster of residential areas, in commercial areas, at the individual scale or in the industrial areas. A decentralized treatment plant is also able to provide treatment facilities close to the areas served and is also able to serve areas which are situated below the sewerage network and cannot be served by a gravity drainage network. It will also obviate the need for pumping stations, thus saving on energy costs.

Decentralized systems offer the opportunity of wastewater recycling and reuse thus reducing water demand substantially. Such systems in peri-urban areas could provide treated wastewater for agricultural use and can thus improve agricultural productivity.

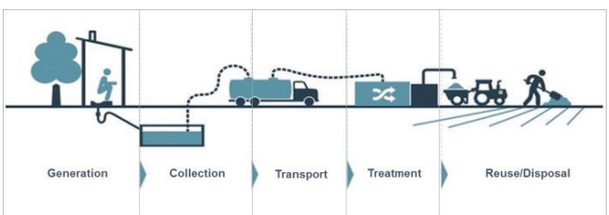
Usually centralized systems are adopted when there are limited challenges in terms of cost, land resources and operative finances in place. There are 2 stages in case of centralized systems. Stage -1 involves building of underground sewer network and stage 2 involves building of a STP. In both the stages there are several intrinsic challenges. Generally, sewer network is built by the ULB/parastatal organization while the STP can be either built and operated by the government or may be commissioned on a public private partnership (PPP) basis.

Most of our faecal waste is ending up untreated in our water bodies and polluting the ground water. A similar condition exists for solid waste. Nearly two thirds of India is semi arid and arid country. Water is scarce and we cannot afford to use excessive water for sewer based sanitation systems. Larger Municipal Towns and Corporations may develop expensive sewerage based treatment systems in the coming decade(but water availability is still a barrier and the poor) but may find it very difficult to operate and attain a break even operations, and serve the vast majority of their city populations living in slums and peri urban informal settlements. Small and medium

scale towns may not even be in a position to invest in and develop centralized hi tech treatment systems and sewer mains and subsidiary networks.

Most para state agencies, that decide technology options and install infrastructure of waste treatment facilities for ULBs, see the Faecal Sludge Treatment Plants(FSTPs) as intermediary solutions. Smaller towns lack decision making power and sufficient knowledge and capacity to develop, implement and operate alternative decentralised sanitation solutions.

Addressing septage management implies intervening at all critical stages of the service value chain from generation of faecal sludge to its collection, transport, treatment and disposal.



Source: Bill and Melinda Gates Foundation

The problem of septage management was attended to through the **National Policy on Faecal Sludge and Septage Management(FSSM) 2017**[60] . The National Policy addressed the need for not just toilets and safe containment of human faeces but also its safe conveyance, treatment and re use of treated waste and waste water. This was preceded by the Ministry of Urban development adopting the **Primer on FSSM in 2016.**[61]

Several state governments have either adopted the national policy or come up with their own state level FSSM policies. State FSSM Policies have been drafted by Tamil Nadu, Odisha, Bihar, J&K, Jharkhand and Andhra Pradesh, Karnataka, Rajasthan, UP and Chattisgarh[62].

Following the adoption of the National Faecal Sludge and Septage Management Policy 2017, several states have come forward to take up Faecal Sludge and Septage Treatment. Odisha is setting up of FSTPs in many towns of the state, Andhra Pradesh has contracted for 33 Faecal Sludge Treatment Plants(FSTPs), UP has invited bids for 37 FSTPs, Maharashtra for 51 towns, and several other states are getting ready to put decentralized septage treatment plants in many more towns. Rajasthan has 8 towns ready for implementation of FSTPs.

Different technology options ranging from DEWATS to Thermal and Membrane based technologies are being tried out.

The Sanitation Capacity building Platform : https://scbp.niua.org/ has an online learning portal on non networked sanitation systems including Polciies, Research, Publications, Technology guidance and Training Modules.

Training and Capacity Building Plan

Capacity is "the ability of people, organisatiaons and society as a shole to manage their affairs successfully". Capacity development is the "process of unleashing, strengthening and maintaining of such capacity"(OECD/DAC)[63]

Capacity Building is more than just development of training modules and providing trainings and exposure visits. In a UNDP symposium in 1991 on A Strategy for Water Sector Capacity Building, following were identified as components of capacity building[64]**:**

- The creation of an enabling environment with appropriate policy and legal frameworks;
- Institutional development, including community participation (of women in particular);
- Human resources development and strengthening of managerial systems.

Capacity building of Staff and officials of Urban Local Bodies and Para State Technical Agencies, including administrative and executive staff engaged in the designing, implementation and maintenance of

water supply and waste water treatment systems, is a necessity for ensuring sustainable and equitable water and sanitation services. Capacity Building of Elected Representatives of Urban Local Bodies is also important to build political will and ownership.

AMRUT Mission has Individual and Institutional Capacity Building Components [65].

"The purpose of individual training is to enhance the functional knowledge, improve the job related skills and change the attitude of municipal functionaries. The one-year training will be imparted to municipal functionaries in training institutes (classroom) followed by its application at their work place. Additionally, they will be mentored and provided coaching services at their work place during the one-year training period. The aim of Institutional Capacity Building is to improve institutional outcomes, as set out in the AMRUT Reform Agenda."

"The aim of the Institutional Capacity Building is to improve institutional outcomes (e.g. accountability and transparency, service delivery, citizen empowerment, resource mobilization) by bringing in external experts and professionals. The external resources can be brought in two ways: (i) outsourcing of functions, and (ii) outsourcing of functionaries."

An Integrated Capacity Building Plan[66] covering Swachh Bharat Mission, AMRUT and SMART Cities programmes has been approved by the Ministry of Housing and Urban Affairs. A list of 35 Training Entities have been empaneled.

Sewerage design modules are available with most para state technical agencies and AMRUT nodal agencies. IIT Madras has compiled a module.[67]

Advanced training module for storm water management[68]

Capacity Building for Decentralised Faecal Sludge and Septage Management has been undertaken by **National Institute of Urban Affairs since 2016** in partnership with credible national level expert agencies.

A Training Needs Assessment[69] for decentralized sanitation identified the priorities for capacity building. Six Training Modules for staff of Urban Local Bodies have been produced and delivered in partnership with state level Nodal AMRUT agencies in and a four phase state level capacity building programme implemented in Rajasthan. All resources placed on the portal of **Sanitation Capacity Building Platform(SCBP)**[70].

Sustainable Water and Wastewater Management Policy papers/Tool kits/Practitioners guides[71] of Centre for Science and Environment are also available as reference guides and training modules

List of Massive Online Open Courses (MOOC) on water, sanitation and waste water

Water and Waste water Engineering by IIT Madras
https://freevideolectures.com/course/3434/water-and-waste-water-engineering

Online courses offered by IHE Delft, Netherlands
https://sanitationeducation.org/online-courses/

Water supply and Sanitation Policy for Developing Countries
https://www.mooc-list.com/course/water-supply-and-sanitation-policy-developing-countries-part-1-understanding-complex-problems

https://www.eawag.ch/en/department/sandec/e-learning/moocs/

Urban Sewage Treatment course
https://online-learning.tudelft.nl/courses/introduction-to-treatment-of-urban-sewage/

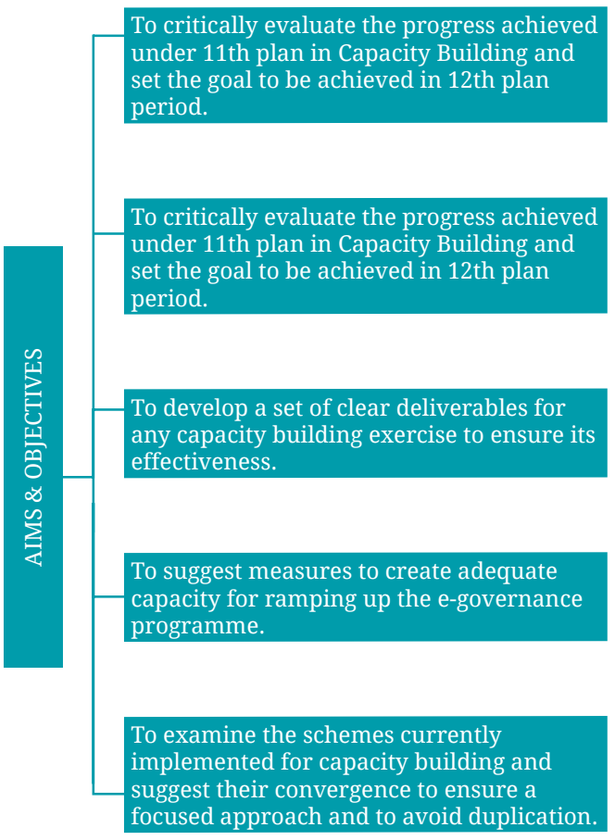
Osmosis Water Treatment Course
https://online-learning.tudelft.nl/courses/nanofiltration-and-reverse-osmosis-in-water-tment/?tds=ga-%2Bwater%20%2Btreatment%2s&gclid=CjwKCAiA45njBRBwEiwASnZT54GHn0kEU1_ayW2VdpgLO8Rp3N4E1z4D-mgjV-l-hgV4NJpTCzEs4hoCkqgQAvD_BwE

Faecal Sludge management course

https://www.mooc-list.com/course/introduction-faecal-sludge-management-coursera

Earlier initiatives for urban water supply and waste water capacity building

The **12th Five Year Plan formulation, a Report of Working Group**[72] on Capacity Building for was prepared with the following aims and objectives:



A **National Training Policy 2012**[73] relooked at the "existing capacity building measures for civil servants and to further strengthen institutional mechanism".

As a follow up to the National Policy, the **National Training Guideline**[74] outlined a 'Competency Framework' for training of government staff. The implementation of this concept by the Ministries/ Departments would "bring to light the various 'Competency gaps' of employees that need to be bridged through a range of 'Training interventions' to enhance their performance. Competencies encompass knowledge" skills and behaviour, which are required in an individual for effectively performing the functions of a post".

The JNNURM programme in 2013 produced a **Toolkit for Comprehensive Capacity Building Programme**[75]

A **Training Needs Assessment** study was conducted under the **Capacity Building for Urban Development (CBUD)**[76] in 2014 to assess training needs of the ULB officials, both elected and appointed.

A strategic training plan was prepared containing priority capacity building topics; training modules, and target groups. It also recommended study visits and visits to the best practices in urban governance and management of service delivery in India and abroad.

Capacity Building Strategy for Urban Water Supply and Waste Water

A. Sensitization/ orientation Trainings

1. Orientation Training on Urban Water Supply and Waste Water

Target audience: Mixed group of officials (Commissioner/ EO, Elected Representatives, Engineers).

Training to be conducted in more participatory format rather than class room/ lecture format. The aim of the training is to enable the participants to discuss and gauge the sanitation situation in their city and draft a strategy for effective service delivery. It will also facilitate peer learning – officials learn how other ULBs are addressing similar challenge.

Components/Modules of Orientation Training :

- Urbanisation trends in different towns, Water Availability, Climate Change
- National water supply challenges, availability and urban context
- National Legislation, Acts, Policies and Current Programmes
- Centralised and Decentralised Water Supply and Waste Water Systems and their Operations and Maintenance challenges: Advantages, merits and limitations. Ground water, Water Harvesting, small decentralised treatment systems including decentralsied Septage treatment plants.
- Cast Studies and Best Practices : Urban water supply and waste water in towns in different typographies of India – Hills, Coastal areas, flood plains, desert and water stress areas, different category of Towns and Cities.
- Municipal Financing, Raising Public & Market based Financing.
- Procurement and Contracting/Tendering
- Public Private Partnership.
- Monitoring Service Standards and Outcomes

- Role of ULB in ensuring effective service delivery – stakeholder analysis, Social and Individual Behaviour Change, Participatory Planning and Monitoring frameworks, etc.

2. Training on health and safety of sanitary workers

Components/Modules :

- their role in effective service delivery
- Health and safety standards/ norms under various national and state level polices pertaining to health and safety of sanitation workers
- Benefits for them under various national/ state level programmes and how to avail them

3. Training on design of Citizen engagement strategy

Target Audience – community workers, official incharge of IEC and BCC initiatives and community engagement under different programmes like SBM, SMART City, etc

- The training will provide an overview of need for IEC, BCC and citizen engagement under various national/ state missions
- It will help them understand the various approaches for community engagement
- Introduce them to good practices on IEC and BCC – what worked, why and how, key messages/ IEC BCC materials developed by other cities – posters, jingles etc

B. Thematic Trainings

1. Training on emerging issues and innovative solutions exposure visit (two day)

Target audience – decision makers (Commissioners and Executive Officers), Senior Engineers and Town planners

- The training will help in understanding emerging issues of in wat san sector and introduce the innovative solutions/ good practices available in the sector.
- Resilience (climate change and disaster) – urban flooding, water scarcity etc
- Resource recovery (3R) concept – rain water harvesting, revival of water bodies, concept of recycle and reuse etc
- water sensitive urban planning – convergence of city sanitation plan with the master plan/ zonal plan, approaches for holistic management of water and waste water
- Issues of equity and inclusiveness – effective service delivery for the urban poor, gender issues, social issues- manual scavenging, health and safety of sanitary workers etc

2. Training on planning and management of wat-san projects (three day)

Target Audience – sector specific training for engineers of different divisions – water supply and waste water management

- The training can be specifically designed as per the need of the city for planning and implementation of specific project - 24*7 water supply, NRW reduction, faecal sludge and septage management etc. The training will cover aspects like -
- Project planning – methods and tools for assessment/ data collection, stakeholder analysis
- Technology – available options and criteria for selection of appropriate technology
- Funding – methods/ tools for estimating capex and opex, identifying sources of revenue for cost recovery, Private sector participation
- O & M - understanding the O&M process, defining the role and responsibilities of various stakeholders – ULB, technology provider, operator, end users etc, understanding the regulatory framework to be implemented for successful running of the project
- DPR process – key components of DPR, checklist for review of DPR

3. Training on integrated water resource management (three days)

Target Audience – Engineers and town planners

The training will help them the process for formulating the wat-san strategy for the city. The participants will come to the training with the baseline data for their city and through various handson practice sessions will design an integrated water resource management plan/ strategy for their city:

- Analysis of baseline data for understanding and mapping of wat-san sector of the City
- Identification of key issues and problem areas, prioritizing the issues

- Understanding technology options and analysis of Municipal Finance to draw the rationale for the strategy
- Developing action plan – defining the vision, strategy development, technology selection
- Financial analysis of the action plan and investment plan for specific projects identified

C. Exposure visits:

1. **One day exposure visit- to a champion city/ proactive and well performing city within the same division/ state**

Target Audience – Elected representatives

The visit will help them understand how the particular city ensures effective wat-san service delivery through effective management. The visit will include an interaction with Mayor and Commissioner and other key officials and site visit to few good practices within the city. Eg visit to the top three cities under Swachh Sarvekshan – Indore/ Mysore etc. Visit to Surat which is part of the 100 resilient cities.

2. **Exposure visit (national and international) on emerging issues and innovative solutions exposure visit (two days for national/ three days for international)**

Target audience – decision makers (Commissioners and Executive Officers) and senior engineers

The visit will help in understanding emerging issues of in wat san sector and introduce the innovative solutions/ good practices available in the sector.

3. **Exposure visit (national) on technology options for wat-san sector (two/three days)**

Target Audience – sector specific field visits for engineers of different divisions – water supply and waste water management

The visits will enable the officials to actually see the live projects, interact with the key stake holders to understand the complexities and innovative approaches adopted. The visit will consist of a package of good practices - inter sector/ intra sector depending on their priority/ need:

Package 1: good practices which address a range of issues for the particular sector/ theme Eg an exposure visit package for wat-san sector which covers good practices on 24*7 supply, NRW reduction through smart metering and SCADA. An exposure visit package on recycling and reuse of water, recourse recovery – energy from waste water etc

Package 2: good practices which cover a range of technology options for a specific issue of Eg an exposure visit package on decentralized sanitation which covers various technology options for decentralized waste water treatment – Bioremediation methods - DEWATS, wet lands, Soil Bio Technology, mechanized solutions -pyrolysis, MBBR, Co-treatment septage at STP etc. This will help the participants in understanding the rationale for selection of the particular option by the concerned ULB, the enabling regulatory framework pertaining to each option and pros-cons of each technology option.

ENDNOTES

1. India Policy Forum : http://www.ncaer.org/Events/IPF-2017/IPF-2017-Hasan-Yiang-Kundu-Conf-version.pdf
2. Mckinsey report 2010: https://www.mckinsey.com/featured-insights/urbanization/indias-urbanization-a-closer-look
3. http://censusindia.gov.in/2011-prov-results/paper2/data_files/India2/1.%20Data%20Highlight.pdf
4. http://mowr.gov.in/about-us/history
5. http://nwm.gov.in/?q=objectives-national-water-mission-0
6. http://envfor.nic.in/division/introduction-20
7. http://socialjustice.nic.in/
8. http://socialjustice.nic.in/
9. http://164.100.228.143:8080/sbm/content/writereaddata/SBM_Guideline.pdf
10. https://amrut.gov.in/writereaddata/AMRUT%20Guidelines%20.pdf
11. http://smartcities.gov.in/content/
12. https://darpg.gov.in/sites/default/files/Swachh%20Bharat%20Mission%20%28Urban%29.pdf
13. http://www.siudmysore.gov.in/pdf/readingmaterial/W&WWM/RM.pdf
14. http://www.indiaenvironmentportal.org.in/files/file/Odisha_Urban_Sanitation_Strategy.pdf
15. http://delhi.gov.in/wps/wcm/connect/a61120004ea387f2b5c3f78cde80066d/mlalad%2Bguidelines.html?MOD=AJPERES&lmod=228286823
16. http://www.worldbank.org/en/news/feature/2017/05/15/water-scarce-cities-initiative
17. http://www.iwmi.cgiar.org/2014/08/water-demand-projections-off-need-more-local-insight/
18. http://mowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf
19. http://mowr.gov.in/sites/default/files/Model_Bill_Groundwater_May_2016_0.pdf
20. http://iihs.co.in/knowledge-gateway/wp-content/uploads/2015/08/RF-WATSAN_reduced_sized.pdf
21. https://nrcd.nic.in/writereaddata/FileUpload/NewItem_210_Inventorization_of_Sewage-Treatment_Plant.pdf
22. http://cpcb.nic.in/water-pollution/
23. http://envfor.nic.in/legis/env/env1.html
24. http://envfor.nic.in/legis/crz/crznew.html
25. http://pib.nic.in/newsite/PrintRelease.aspx?relid=178791
26. http://mohua.gov.in/upload/uploadfiles/files/NUSP_0.pdf
27. https://www.pas.org.in/Portal/document/UrbanSanitation/uploads/SaniPlan_CEPT_AIT.pdf
28. https://www.eawag.ch/en/department/sandec/projects/faecal-sludge-quantification-and-characterisation/sandec/
29. http://cpheeo.gov.in/upload/uploadfiles/files/Guidance%20Note%20for%20Continuous%20Water%20Supply.pdf
30.
31. https://pas.org.in/Portal/document/PIP%20Application/Urban-drinking_water_Gujarat%20-%20Final.pdf
32. https://www.wwdmag.com/how/four-steps-reducing-non-revenue-water
33. http://mohua.gov.in/upload/uploadfiles/files/NRW_Reduction_Mgmt_Surat_0.pdf
34. http://www.un.org/en/sections/issues-depth/water/
35. http://www.unwater.org/water-facts/human-rights/
36. http://wateraidindia.in/wp-content/uploads/2018/06/State-of-Urban-water-supply_2018_WEB.pdf
37. http://wateraidindia.in/faq/drinking-water-problems-india/
38. http://iihs.co.in/knowledge-gateway/wp-content/uploads/2015/08/RF-WATSAN_reduced_sized.pdf
39. http://mohua.gov.in/upload/uploadfiles/files/Indicators%26Benchmarks.pdf
40. https://indiacode.nic.in/bitstream/123456789/1709/1/195696.pdf
41. http://www.sra.gov.in/upload/Maharashtra_Slum_Areas_Improvement_Clearance.pdf

42. http://delhishelterboard.in/main/wp-content/uploads/2012/02/DUSIB-ACT-2010.pdf
43. http://jkhudd.gov.in/pdfs/J&K%20Property%20Rights%20to%20Slum%20Dwellers%20Bill,%202011.pdf
44. http://www.informagerealty.com/upload/policy_subcategory/1364551324_Rajasthan%20Slum%20Development%20Policy%202012.pdf
45. http://mohua.gov.in/cms/Municipal-Law-in-India.php
46. http://mohua.gov.in/cms/mml.php
47. http://urban.bih.nic.in/Acts/AR-01-29-03-2007.pdf
48. http://www.indiawaterportal.org/sites/indiawaterportal.org/files/National%20Urban%20Housing%20and%20Habitat%20Policy_Ministry%20of%20Housing%20and%20Urban%20Poverty%20Alleviation_2007.pdf
49. https://smcsite.org/bsup[1].pdf
50. http://www.indiawaterportal.org/articles/indian-standard-drinking-water-bis-specifications-10500-1991
51. http://cgwb.gov.in/Documents/WQ-standards.pdf
52. http://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvTmV3SXRlbV8xMDNfc3RhdHVzb2Z3YXRlcnF1YWxpdHlwYWNrYWdlLnBkZg
53. http://cpcb.nic.in/water-quality-criteria/
54. http://cpcb.nic.in/industry-effluent-standards/
55. http://www.envfor.nic.in/divisions/cpoll/psap.pdf
56. http://icrier.org/pdf/Working_Paper_323.pdf
57. http://sanitation.indiawaterportal.org/english/node/2419
58. CDD Society Analysis
59. http://cpheeo.gov.in/upload/uploadfiles/files/Recent%20Trends%20in%20Technologies%20in%20Sewerage%20System.pdf
60. http://ncsk.nic.in/sites/default/files/manualsca-act199136357385163824444610.pdf
61. https://amrut.gov.in/writereaddata/FSSM_Policy_Report_23Feb.pdf
62. https://scbp.niua.org/content/fssm-primer
63. https://scbp.niua.org/govt-state-reports
64. http://www.fao.org/capacity-development/our-vision/en/
65. https://www.gdrc.org/uem/capacity-define.html
66. http://amrut.gov.in/writereaddata/Institutional%20Capacity%20Building.pdf
67. https://smartnet.niua.org/content/4f9c5e1c-755d-40d6-8a8d-8720fe77d897
68. https://nptel.ac.in/courses/105105048/1#
69. (https://smartnet.niua.org/sites/default/files/br1522930005gian_brochure_himanshu_stormwater_management_july_2018.pdf)
70. https://scbp.niua.org/content/capacity-needs-assessment-addressing-urban-fssm
71. https://scbp.niua.org/
72. https://www.cseindia.org/cse-has-prepared-the-following-practitioners-guide-and-policy-papers-in-the-area-of-sustainable-water-and-wastewater-management-6950
73. http://planningcommission.gov.in/aboutus/committee/wrkgrp12/hud/wg_capacity_%20building.pdf
74. http://persmin.gov.in/otraining/NationalPolicy.pdf - National training policy by DoPT
75. http://www.nicf.gov.in/pdf/dopt-circular-dated-04-07-2012.pdf
76. http://amrut.gov.in/writereaddata/Toolkit-for-CCBP.pdf -
77. http://smartcities.gov.in/upload/oms/5821b0833e2b0TNA-Strategic-Training-Plan_Vol-I.pdf