Framework for Eco-efficient and Socially Inclusive Urban Water Infrastructure in Indian Context

Nagaraju Ravadi*[1], Vanitha Putta[2]

[1, 2] *Department of Urban and Regional Planning, School of Planning and Architecture, JNAFAU, Opposite Mahavir Hospital, Mahavir Marg, Hyderabad - 500028, Telangana*

Abstract: Water, a critical natural resource, is vital for livelihood of people and human survival and serves as a basic foundation to achieve sustainable development. Rapidly urbanizing economies have resulted in not only population growth but also spatial expansion of urban areas. These in turn emanated the increasing spatial disparities and changes in the location, changes in consumption patterns and nature of the demand for water infrastructure services. On the other hand, due to increase in population the water demand will also continue to increase. Particularly the urban poor and peri-urban areas are the most affected and are deprived of water security. Thus there is an imperative need to give attention to social inclusivity in water infrastructure. The other impacts of urbanization which are otherwise given less attention are the environmental degradation, vulnerability to climate changes and depletion of natural resources. In such circumstances Eco-efficiency for water infrastructure is one more aspect to be addressed critically. According to 'World Business Council on Sustainable Development', Eco-efficiency is defined as 'the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity'. Thus implying the term, 'eco' includes economy as well as ecology. This paper is a research study on urban water infrastructure and classification in India. The paper critically examines the current practices and initiatives in urban water infrastructure. With reference to the specific issues in Indian context, the paper further gives a framework for eco-efficient and social inclusivity in water infrastructure management.

Keywords: Water Management, Eco-efficient, Infrastructure, Socially Inclusive, Ecological efficiency, Economic efficiency

1. INTRODUCTION

Water, a critical and most precious natural resource, is vital for livelihood of people and human survival and serves as a basic foundation to achieve sustainable development. With an accelerated rate of urbanization resulting in continuous increase in population, there has been an increasing pressure on water resources. Thus the requirements of clean water provision and disposal of wastewater have also raised. Nearly three-fourth of over 1.2 billion population of India lives in

water-stressed regions, where per capita availability is less than 2,000 cubic meters per year, of which one-third of the region is in water scarce areas, where per capita water availability is less than 1,000 cubic meters per year. [1]

2. URBAN WATER INFRASTRUCTURE

Urban water infrastructure is essential necessity for management of urban water resources and thus ensuring access of water resources to all. Urban water infrastructure provides water services for the urban population and serves the water demands such as provision of water for drinking and domestic purposes, industrial purposes, commercial, institutional and recreational purposes etc. An efficient facility and installation of water infrastructure makes significant impact in terms of accessibility, sustainable and inclusive development, economic growth and addressing water scarcity.

According to UNESCAP, water infrastructure can be defined as a stock of facilities and installation [2]:

- To develop and manage water resources, including delivery, treatment, supply and distribution of water to its users; and
- For the collection, removal, treatment and disposal of sewage and wastewater.

Table 1 Water Infrastructure Classification by UNESCAP 1996 [2]

Infrastructure for Development of Water	
Infrastructure for Water Use	Drinking water supply and sanitation
	Industrial water supply & effluent treatment
	Irrigation water supply
Infrastructure for Water Management	Environmental Protection
	Disaster Protection
Infrastructure for Climate Change Buffer	

Water Infrastructure – Classification

Water supply system has **stages such as collection from water source, transmission, and treatment of water, storage, and** distribution to the end users, collection of waste water, removal, treatment and disposal. At each stage of the water supply for an efficient and better management of services an efficient water infrastructure is required. Water infrastructure is classified into physical and non-physical components as per the report by "Enhancing Regional Cooperation in

Infrastructure Developement (UNESCAP, 1996)". A sector based classification of water infrastructurue is given below in Table 1. [2]

The three main sectors that are major consumers of water in India are domestic, irrigation and industry. In urban areas the major sectors are domestic and industry. Thus eliminating the infrastructure for irrigation water supply, scenario of urban water infrastructure in India is as follows:

Table 2 Water resources and demand in India in BCM [3]	
Water Resources	**[BCM]**
River basin water resources average potential	1869
Surface water	690
Replenish able ground water	433
Ground water recharge	432
Ground water resources	71
Annual rainfall	3840
Rain water surface runoff	1869
Storage capacity	225
Available water	2301

1. *Infrastructure for development of water resources:* In India urban water resources can be broadly divided into four types: surface sources, groundwater, rainwater and water from wastewater recycling. The total available water from various sources of water shown in Table 2 is 2301 BCM. The total utilizable water is 1123 BCM (Table 3) indicating the mismanagement and underutilization of water resources.

   a) The surface sources include the urban water bodies like lakes, rivers, tanks which are mismanaged, destroyed or underutilized and thus not been given enough attention. These man made water bodies which served the water needs of people during scarcity and controlling floods, are dying due to various reasons such as uncontrolled urbanization, increasing human intervention, encroachment of catchment areas, polluting the water bodies by dumping waste, etc.

   A significant example for development of water sources is the case of source augmentation in Chennai where, rather than **augmenting the source through further extraction, source augmentation is done through a conservation-based approach.** [3]

b) The groundwater sources which are the secondary sources of water supply often become the major source of water supply to the consumers due to inadequate quantity supplied by the local bodies. The depleting ground water table and deteriorating ground water quality are threats to the urban water supply.

Case of Chennai city where introduction of Chennai Metropolitan Area Ground Water (Regulation) Act 27, 1987 to regulate and control extraction, use or transportation of groundwater has controlled and regulated the private water markets and also reduced pressure of ground water reserves from the city. Ground water recharge in the city of Rajkot is an example of people's participation, where 4000 hand pumps were recharged by diverting water from roofs to small tanks and thus reducing impact on groundwater table. **[3]**

c) Rainwater which is considered as a bane rather than boon in urban areas as it results in urban floods due to poor storm water drainage facilities. Average rainfall in India is 117cm with a surface runoff of 1869 BCM (Table 2). Rainwater harvesting is a viable technique for recharging ground water and augmenting the ground water tables.

Indore Municipal Corporation has announced a rebate of 6% on property tax for those who have implemented rainwater harvesting system in their houses. The other Indian cities practicing rainwater harvesting include Chennai, Delhi, Bengaluru and Aizawl, and addressed the issue of demand gap and exploitation of groundwater sources. [4]

d) Wastewater recycling offers immense potential for becoming a viable and practical solution for non-potable water uses. Jamshedpur city has 100% sewage collection and treatment under Jamshedpur Utilities and Services Company (JUSCO) and a portion of the treated wastewater is reused within the industrial units in Jamshedpur and the balance is released into the river downstream. A portion of the solid sludge is sold as fertilizers to serve the adjoining rural and agricultural areas. [5]

2) Infrastructure for Water Use: The urban water demand is categorized based on the water consumers in urban areas. Though the total available water is 2301 BCM the total utilizable water is 1123 BCM out of which 634 BCM is used by people for various purposes (Table 3). The major components of urban water demand are:

Table 3 Urban water requirement in India in BCM [3]	
Urban Water Requirement	
Available water	2301
Total utilizable water	1123

Total used water	634
Per capita average annual availability (m3/year)	1588
Domestic	557
Industries	43

a) *Household Sector:* Urban areas constitute majority of the water demand by the residential population for drinking water, sanitation and other domestic purposes. It is estimated that 8% of worldwide water use is for household purposes and 557 BCM (Table 3) is used for domestic purposes in India every year.

The case of 24x7 uninterrupted water supply initiative in Nagpur Municipal Corporation, Maharashtra ensured the quality and quantity issues in urban water supply. It is one of the good practices in PPP mode in cities like Hubli, Belgaum and Gulbarga. The key benefits are reduction in high amounts of unaccounted for water, better grievance redressal, collection efficiency of user charges, improvement in metered connections and removal of illegal connections and community participation through awareness campaigns. [6]

b) *Industrial Sector:* Apart from contributing to the economy industries also add to water pollution by discharge of waste and scarcity due to worsening of water quality. This leads to environmental degradation and increases private and social costs.

Sustainable Water Management Initiative by Bajaj Auto Limited, Aurangabad, is at the forefront of conserving water in its industrial processes, through the three principles of reduce, reuse and recycle. It used automation of localized water storage systems wherein a timer is provided for water supply, thus eliminating water wastage. By construction of rainwater ponds for horticulture purposes, changing the sludge pit cleaning frequency from quarterly to yearly, installation of a spot cooling system and drip irrigation system the industry saved about one lakh cubic meters of water per year. [7]

3) *Infrastructure for environmental protection:* Increasing threat to the water resources and their degradation and depletion indicates an increasing attention towards environmental management policies in urban water sector. Observing the recent initiatives in water sector such as waste water treatment, recycling and reuse, it is evident that environmental protection is given priority in the urban areas of India. But such initiatives and policy level water development and management requires to be promoted and implemented at small scale and large scale.

4) *Infrastructure for disaster protection:* Many areas of the country suffer from floods. Due to increase in population and developmental activity, people occupy disaster prone areas like floods plains, low lying areas and nearby lake or river beds. The inadequacy of storm water drainage in such areas results in serious damages and hence needs an urgent attention in the areas such a disaster preparedness, mitigation measure, structural and non-structural infrastructure and improved flood forecasting and warning systems.

5) *Infrastructure for Climate Change Buffer:* Climate change which is a component of the drivers of changes such as increased situations of drought, floods thus effecting the ground water quality, influencing the groundwater recharges, rising sea levels resulting in increased saline intrusion of coastal and island aquifers etc. [7]. In India, micro-climate change is increasingly being recognized as a driver of the changing water scenario in many locations of the country. Climate change variations needs an increased understanding of existing water infrastructure against climate change and inclusion of systems such as rainwater harvesting and efficient utilization of local water resources.

The following table (Table 4) sums up the current practices and initiatives in Urban Water Management in Indian cities in the areas of good practice.

Table 4 Good Practices in urban water management

Initiative	A	B	C	D	E	F	G	H
24x7 Water supply initiative in Nagpur, Malkapur				●	●	●	●	●
Public Private Partnership in Hubli, Belgaum, Gulbarga				●	●	●	●	●
Source Augmentation in Chennai	●	●						
Ground water Recharging in Rajkot		●						
Rainwater harvesting in Indore, Delhi, Chennai		●	●					
Micro-credit for water connections in Tamil Nadu					●	●	●	●
Recycling and Reuse of wastewater in Gujarat	●	●		●				
Microfinance for water and sanitation: A case study from Tiruchirappalli, India						●		
Maharashtra Sujal Nirmal Abhiyan: Incentive based reform program [8]				●	●	●	●	●
Water and Wastewater Management in Jamshedpur – JUSCO Ltd.		●		●	●	●	●	●
Bajaj Auto Limited, Aurangabad	●	●	●					

Note: A-Surface water resources; B-Ground Water resources; C-Rain Water Harvesting; D-Distribution System – Improvement; E-Reduction of UFW/NRW losses; F-Improvement in No. of

Metered Connections; G- Collection efficiency of WS user charges, H- Redressal of consumer grievances

A study of current practices and initiatives in India in urban water sector clearly highlights the efforts of governments at national, state and local level to address the issues and challenges of water sector.

Issues and challenges of Urban Water Infrastructure in India

In spite of such key initiatives, the urban water management has prevalent issues and challenges in terms of economic losses, impact on environment, accessibility to all and people's participation in decision making. Thus here arises an imperative need to ensure that water infrastructure in urban areas benefits to all the people including the urban poor and marginalized while reducing the impact on the environment.

Eco-efficiency is expressed as the creation of more value with fewer resources and less impact, or doing more with less. Eco-efficiency is a management philosophy which encourages municipalities and businesses to seek for environmental improvements that generate consorted social as well as economic benefits. It promotes innovation, growth and competitiveness while protecting our environment. The concept of eco-efficiency has three broad **objectives: Reducing the consumption of resources, reducing the impact on nature and increasing product or service value** [9]. Eco-efficiency thus implies economic and ecological efficiency. Eco-efficiency approach in general is not often given a priority but it is very important for building competitive, sustainable and livable urban areas.

Socially Inclusiveness refers to treating all people in a city equally in their access to services and resources. "Inclusive" generally refers to planning and decision-making processes that include a broad range of people from across a city, ranging from experts to ordinary residents, with the aim of considering their inputs and reaching mutual agreement [9]. Socially Inclusive urban water infrastructure must be demand driven and affordable for both communities and local bodies. The approach towards provision of facilities for urban water must be participatory and people-centered, trans-disciplinary, gender sensitive and focus on aspects of poverty reduction. Creating employment opportunities and increasing quality of life.

The following table (Table **5) highlights some of the issues in urban water sector in terms of economic, ecological and social inclusiveness:**

Table 5 Key issues in urban water management related to Economic, Ecological and Social inclusiveness

Economic Issues	Ecological Issues	Socially Inclusive related issues
The high amounts of unaccounted for water which is usually 40 to 60 percent of water supplied. Unmetered connections, high tariff and poor collection efficiency of user charges. Lack of technical know-how, poor redressal of complaints indicates a need for capacity building in the urban water sector.	Exhaustion of groundwater resources, Depletion of urban water bodies or polluting the existing ones by dumping solid waste, Discharging untreated or partially treated wastewater into surface water resources. Mismanagement, under-utilization or over-exploitation of water resources Neglecting the potential of existing local sources of water in urban areas Unreliable supply leading to sewage infiltration in water supply system	Unreliable water supply which is restricted at best to a few hours per day. Inadequate quantity due to supply on selected number of days even for households with in-house connections. Inadequate water to urban poor leading to unsanitary living conditions. Gender related issues such as time spent in carrying water from community water sources to households. Due to spatial expansion of urban areas, the peri-urban areas are deprived of water security due to lack of water infrastructure facilities.

Framework

In order to have a clear approach towards assessment of eco-efficiency and social inclusiveness of urban water infrastructure, the following framework is conceptualized based on the study of water related initiatives in urban areas, eco-efficiency and social inclusive studies by various institutions like MoUD, MoWR, UNESCAP, Agenda 21, TERI etc. The framework is divided into three broad overlapping stages (Table 6) (Figure 1):

Table 6 Framework for eco-efficient and socially inclusive urban water infrastructure

I. Understanding the existing system	II. Identification of indicators for each parameter	III. Overlapping of parameters in each stage
The urban water infrastructure which includes water supply system and waste water management has various stages in each of them. To get a holistic understanding of the existing water network is necessary to assess the performance in terms of eco-efficiency and socially inclusiveness.	The infrastructure classification types are taken as parameters and in each parameter the various indicators related to economic, ecological efficiency and socially inclusive will be evolved.	Each stage of water supply system and waste water management will be assessed based on the indicators identified in each parameter with respect to the stages.

		Stage 1	Stage 2
Parameter	A_1		
	A_2		
	A_3		
	A_4		

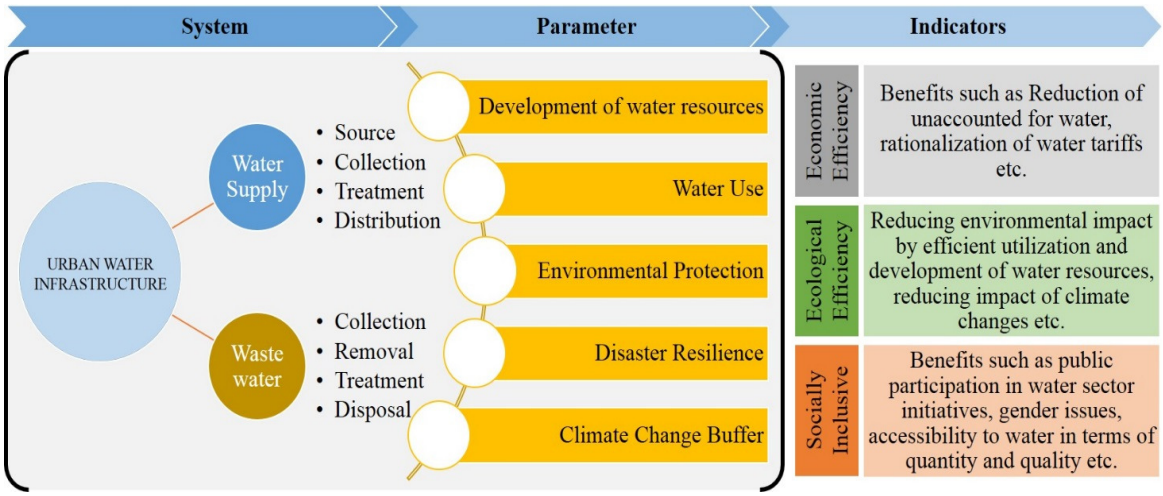

Figure 10 Framework for assessing eco-efficiency and social inclusiveness in urban water infrastructure

3. CONCLUSION AND WAY FORWARD

Though the national, state and local level governments are making efforts towards developing an efficient water supply system and waste water management the urban water infrastructure needs to achieve efficiency in terms of reducing the environmental impact, accessibility of services to all and involvement of citizens in decision making.

The given framework is to be further developed into calculative indices which would be useful in rating the performance of urban areas in India in terms of ecological efficiency, economic efficiency and social inclusiveness in the water infrastructure. The indices would not only reflect the areas of improvement in management of water infrastructure with lesser impact on environment and inclusive to all but also increase the awareness and competitiveness among urban areas in relation to the prominence and need for eco-efficiency and social inclusivity. These indicators can also help in making better management and investment decisions and also indicates the areas of improvement in the existing urban water infrastructure. Thus it would contribute to sustainable development of the region.

REFERENCES

[1] P. Tiwari and A. Pandey, "Overview," in *India Infrastructure Report 2011, Water: Policy and Performance for Sustainable Development*, New Delhi, Oxford University Press, 2011, p. xxix.

[2] B. Sinha and T. H. Kim, "Status and Challenges in Water Infrastructure in Asia and Pacific," United Nations Publication, Thailand, 2011.

[3] Teri, Sustainable Urbanism International and Arghyam, "http://www.teriin.org/," 2009. [Online]. Available: http://www.teriin.org/files/Sus_Cities_Report_20090424151451.pdf. [Accessed 6 June 2014].

[4] CSE, "http://www.rainwaterharvesting.org/," Centre for Science and Environment, [Online]. Available: http://www.rainwaterharvesting.org/urban/Practices-and-practitioners.htm. [Accessed 6 June 2014].

[5] A. Chiplunkar, S. Kallidaikurichi and C. K. Tan, "http://www.indiaenvironmentportal.org.in/," 01 July 2012. [Online]. Available: http://www.indiaenvironmentportal.org.in/files/file/good-practices-urban-water-management.pdf. [Accessed 08 June 2014].

[6] H. SS, "http://moud.gov.in/," Ministry of Urban Development, Govt. of India., 6 June 2011. [Online]. Available: http://moud.gov.in/sites/upload_files/moud/files/pdf/Nagpur_Water_PPT.pdf. [Accessed 8 June 2014].

[7] UNICEF, FAO and SaciWATERs, "http://www.unicef.org," 2013. [Online]. Available: http://www.unicef.org/india/Final_Report.pdf. [Accessed 6 June 2014].

[8] M. o. W. Resources, "http://www.performance.gov.in," Febraury 2011. [Online]. Available: http://www.performance.gov.in/sites/default/files/document/strategy/Water.pdf. [Accessed 6 June 2014].

[9] G. Ministry of Urban Development, "http://moud.gov.in/advisory," July 2012. [Online]. Available: http://moud.gov.in/sites/upload_files/moud/files/Advisory_Note_uwss_2.pdf. [Accessed 6 June 2014].

[10] "Are we building competitive and liveable cities? Guidelines for developing eco-effi cient and socially inclusive infrastructure," 6 December 2013. [Online]. Available: http://www.unescap.org/sites/default/files/Guides%20for%20developing%20eco%20efficient%20infra_full.pdf. [Accessed 9 June 2014].