Efficiency Evaluation of Urban Water Supply Utilities in India

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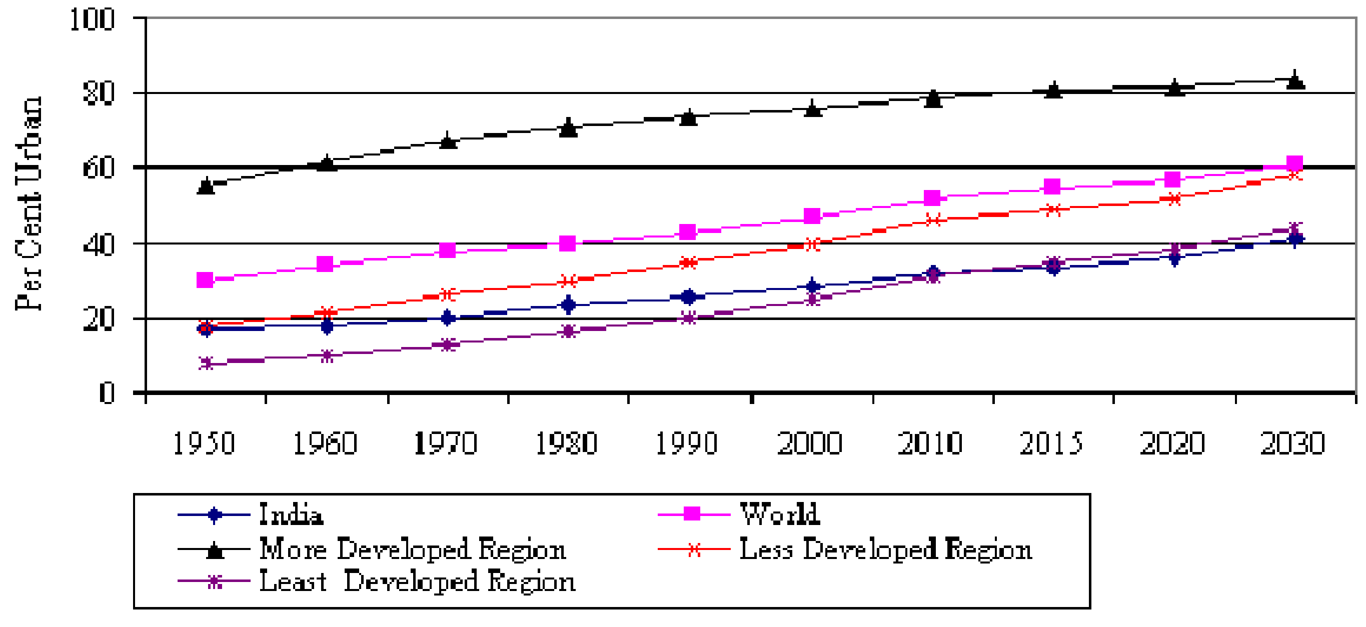
Trends of Urbanization

- The proportion of people in developing countries who live in cities has almost doubled since 1960 (from less than 22 % to more than 40 %), while in more developed regions the urban share has grown from 61 % to 76 %.
- By 2030, it is expected that nearly 5 billion (61 %) of the world's 8.1 billion people will live in cities.
- **India shares this global trend toward urbanization.**



Source :- The State of World Population, 1999 and Population Projections for India 1996-2016

India

TABLE 1
INCREASING URBANISATION

	1951	1991	2001	2021 (projected)
No. of Urban Agglomerations/ Towns	2795	3768	4378	—
Urban Population (In million)	62.0	217.0	285.00	550
As Percentage of Total Population	17.3%	25.72%	27.8%	41%

Source: CPHEEO

It is therefore certain that infrastructure services will have to grow proportionately to make up for the backlog as well as to cater to the future needs, constituting an unenviable task for the urban planners and policy makers

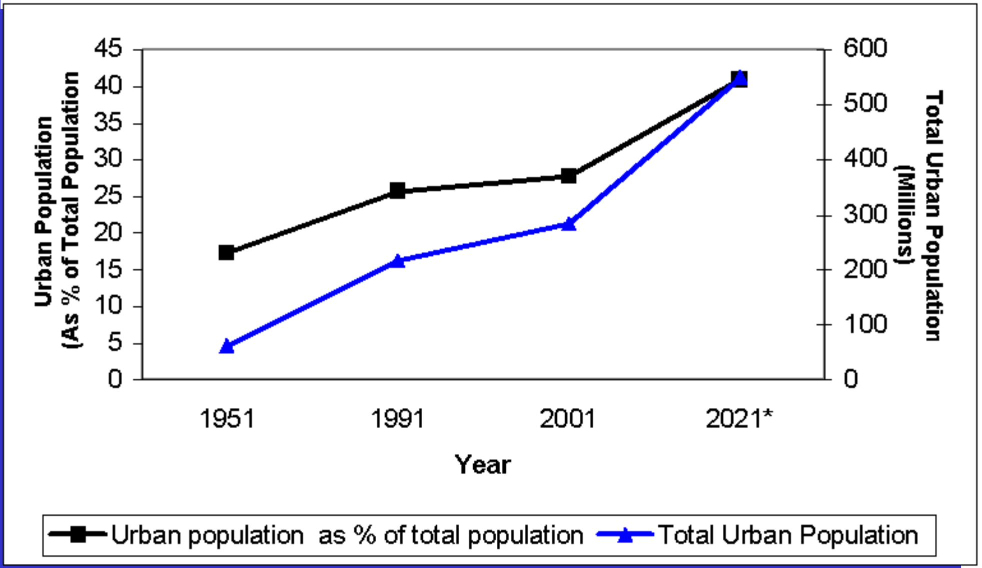
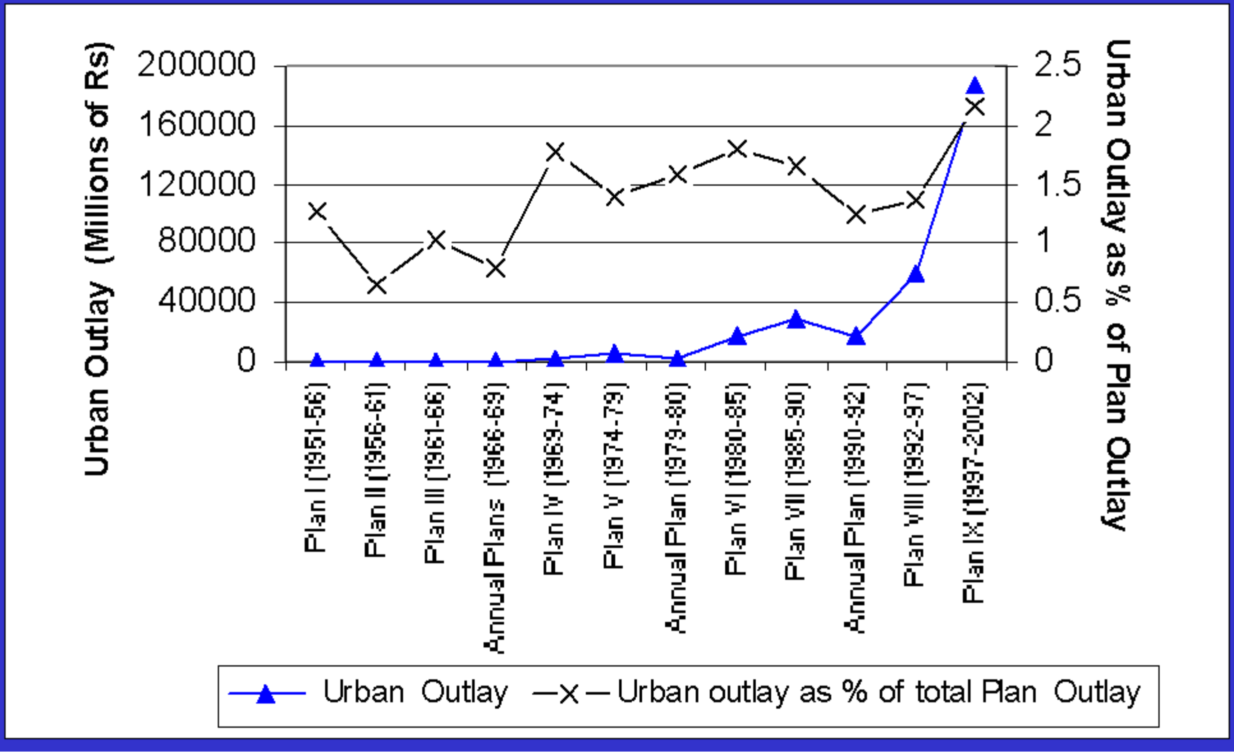


TABLE 2
GROWTH OF METRO CITIES

	1981	1991	2001
No. of Metro Cities (Population: 1 million +)	12	23	35
Population (million)	42	70	108
% of Urban Population	26	32	37.8

Source: CPHEEO

Water Supply Sector in India

- The entire water supply and sanitation programme has so far been government managed, without an active participation of the private sector.
- To the government's credit, progressively larger allocations have been made for water supply and sanitation in the various Five Year Plans .
- 

Water Supply Sector in India

- However, these allocations fall short of what actually is required. The Central Public Health Environmental Engineering Organization (CPHEEO), has estimated the requirement of funds for 100% coverage of the urban population under safe water supply and sanitation services at Rs.1,729,050 Millions (Urban India, 2004) (Indian Rs 48=1US$). (app. $35000 Millions or Euro 25000 Millions)

- Finances of this magnitude are beyond the budgetary resources of Central, State and Local Governments, and it is increasingly being realized that new sources of resources for augmentation and strengthening of services have to be explored. Such challenges have impelled the government of India to initiate institutional, fiscal and financial reforms in the sector (MoUD&PA, 2004).

Reforms

- One of the major thrust areas of this reforms programme is the induction of efficiency enhancement steps in ULBs.

- **Inefficient operational practices and poor maintenance** resulting in large water losses; UFW as high as 40-50% compared to 10-20% for well-managed systems.

- **Excessive and wasteful use of water.**

- **Poor cost recovery and financial problems**

- **High labor costs and low productivity**

The present paper explores the inefficiencies prevalent in the Indian water supply utilities and presents an evaluation of the potential of efficiency improvements possible in urban centres of India.

The study seeks to answer the following specific issues:

- How DEA can be applied for evaluating the performances of water supply services?
- What is the quantum and extent of inefficiencies in water supply operations for major cities in India?
- What is the extent of financial savings possible if inefficiencies are mitigated?
- What is the potential for saving the quantum of water lost hitherto as Unaccounted for Water (UFW)? What are the specific issues that are vital to the reduction of losses?
- What are the policy implications of the findings of the study?

- DEA based efficiency evaluation studies have thus been very rare in the developing countries, primarily because of lack of appropriate database on the performances of water supply services and also because the water supplies are yet to take on the form of an industry that would have needed management on business lines for improvement of operational efficiencies and effect savings.

Efficiency Evaluation By

Data Envelopment Analysis (DEA)

The most common form of measurement of efficiency in case of a single output and single input framework is a ratio like: Output/ Input

In case of multiple outputs and inputs, it is a weighted combination of output to weighted combination of inputs known as virtual outputs and virtual inputs,where the weights are derived from data instead of being fixed in advance.

The following problem is solved to obtain the values of input weights (v_i) and output weights (u_r) as variables:

max

$$\vartheta_o = \frac{\sum_r \{u_r y_{ro}\}}{\sum_i \{v_r x_{ro}\}}$$

s.t.

$$\frac{u_1 y_{1j} + ... + u_s y_{sj}}{v_1 x_{1j} + ... + v_m x_{mj}} \leq 1 \qquad (j=1,\ldots,n) \qquad (1)$$

Efficiency of each of n DMUs is measured and hence n optimization exercises are carried out.

The problem can be considered as an input minimization problem by normalizing the linear combination of inputs consumed by the concerned DMU as:

$$\max_{u\ v} \quad \sum u_r y_{ro}$$

$$\text{s.t.} \quad \sum v_i x_{io} = 1$$

$$\sum_r y_{rj} u_{rj} - \sum v_i x_{ij} \le 0$$

$$\forall j = 1, \ldots.., n \qquad (2)$$

This is also called the multiplier problem as the aim is to derive the optimal multipliers v_i^* s and u_i^* s.

The dual to the above problem is called the envelopment problem, which is easier to solve with lesser number of constraints. The envelopment problem is (CCR formulation):

$$\min \quad \vartheta_o$$

$$\text{s.t.} \quad \sum_j \lambda_j x_{ij} \leq \vartheta_o x_{io}$$

$$\sum \lambda_j y_{ij} \geq y_{io} \qquad (3)$$

$$\lambda_i \geq 0$$

Here θ_o signifies the extent to which the inputs need to be reduced to bring them on the best practice frontier. The λ_j s are the intensity variables to indicate the intensity with which the DMU being scored is related to the DMU in the efficient facet.

To allow for variable returns to scale, the problem becomes:

$$\min \quad \vartheta_o$$

$$\text{s.t.} \quad \sum_j \lambda_j x_{ij} \leq \vartheta_o x_{io}$$

$$\sum \lambda_j y_{ij} \geq y_{io} \qquad \forall j = 1,\ldots\ldots, \; n$$

$$\sum_j \lambda_i = 1,$$

$$\lambda_i \geq 0 \qquad (4)$$

This is called the BCC model after Banker, Charnes and Cooper (1984)

Applications of efficiency analysis

The above methodology finds applications in diverse sectors and industries

- Airports
- Banking
- Transportation
- Gas Industry
- Educational Schools, Institutes and Universities
- Power sector
- Telecommunication
- Hospitals

Efficiency measurement studies have been "relatively scarce" in the water sector (Tupper and Resende, 2004).

Models chosen in the Present Study

List of DEA Inputs and Outputs as Employed in the Current Study

	Inputs	Outputs
Model 1	1.OPEX (Millions of Rs. /year)	1.Number of Connections 2.Length of Distribution Network (Kms) 3.Water Supplied (mld)
Model 2	1.UFW (mld)	1.Number of Connections 2.Length of Distribution Network (Kms) 3.Water Supplied (mld)

- For both the Models, same set of outputs was employed. While the number of connections reflected the reach of the services to the consumers, the network lengths were used as an indicator of the geographical dispersion of the consumer base, and the water supplied reflected the level of service provided to a given population in the city.

- In Model 1, the operating expenditure (OPEX) was chosen as the input variable. The OPEX was adjusted by subtracting a number of items largely outside the control of the water utilities. These items included the depreciation costs, abstraction charges and pumping costs.

DEA Analysis

In all 147 water supply utilities with populations more than 0.1 Million were analysed for calculating the CCR and BCC efficiencies.

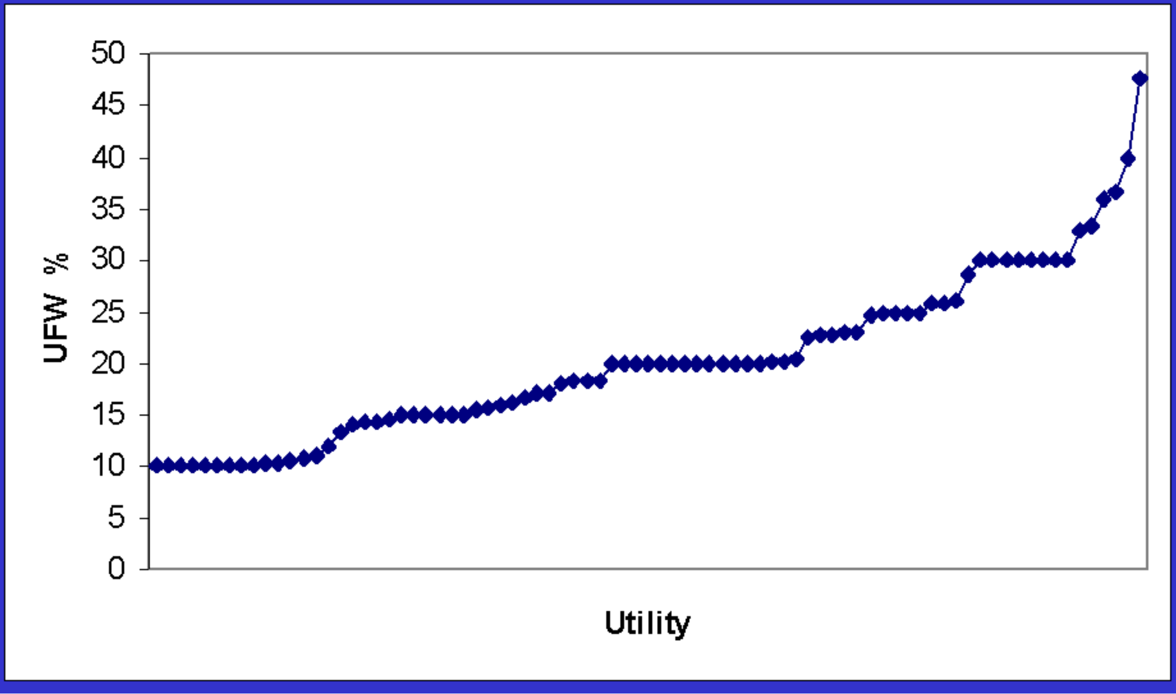
Sample Characteristics

	Average	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
OPEX Rs Millions	78.98	12.48	357.78	0.403	3765.70
Number of water supply connections	51721.01	19800	120837.3	293	1350000
Length of distribution network km	484.59	200	884.9241	6	7906
Total Water Produced mld	123.52	29.55	345.8164	0.68	2978
UFW (mld)*	41.74	7.57	104.43	0.29	675

*Based on data for 82 utilities

A Discussion on UFWs

In the present sample, out of the 147 utilities, only 82 utilities reported UFW estimates. The maximum loss was reported as 47.62%, while none if the utilities reported losses less than 10% . The sample mean for UFW was 20.18%, a value too high when compared with average UFWs of 6% in Singapore, 11% in Japan, 12% in USA and 15% in France



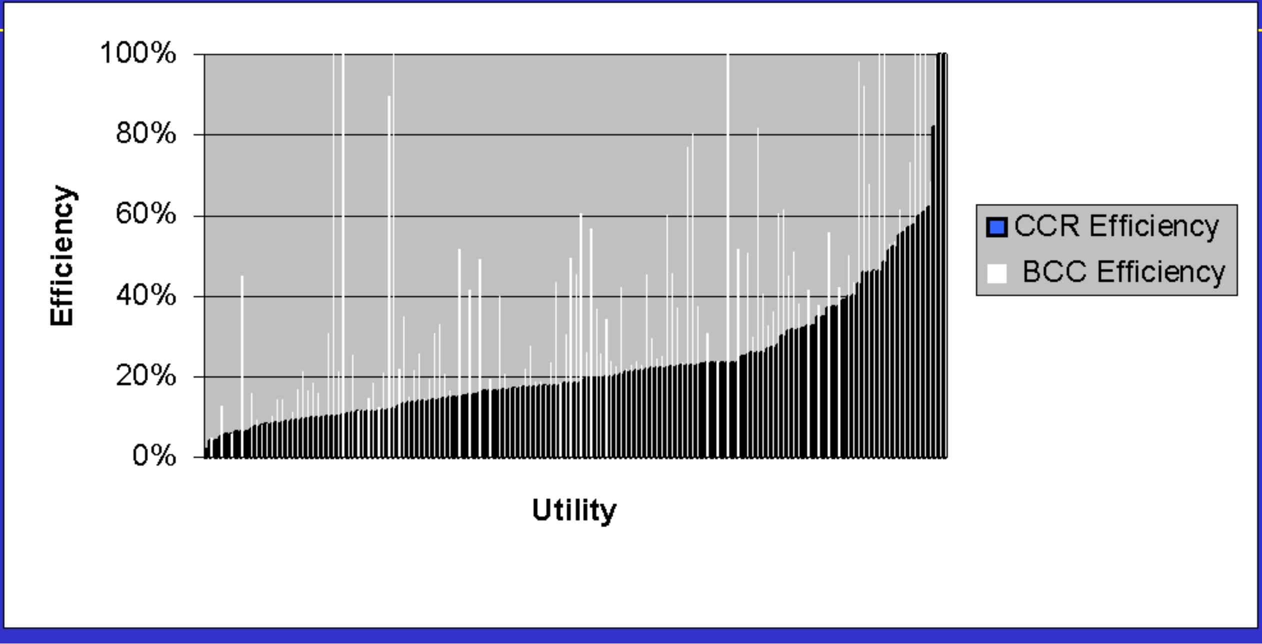
These high levels of reported unaccounted-for waters represent a crude measure of asset maintenance, and indicate poor system management and poor commercial practices as well as inadequate pipeline maintenance.

It is therefore appropriate that in countries like India, UFW be regarded as a critical indicator to reflect the productivity levels of a utility

Table 5.14. Distribution of efficiency scores: Model 1

Efficiency Range	Number of CCR utilities	Number of BCC utilities
0-25%	106	60
25-50%	29	46
50-75%	9	21
75-100%	1	7
100%	2	13

- The sample mean was only 28.3% and 40% under the two formulations (Constant return to scale & Variable RTS), indicating that the utilities are largely quite inefficient. The majority of utilities (92% and 72% respectively) had efficiencies of less than 50%.

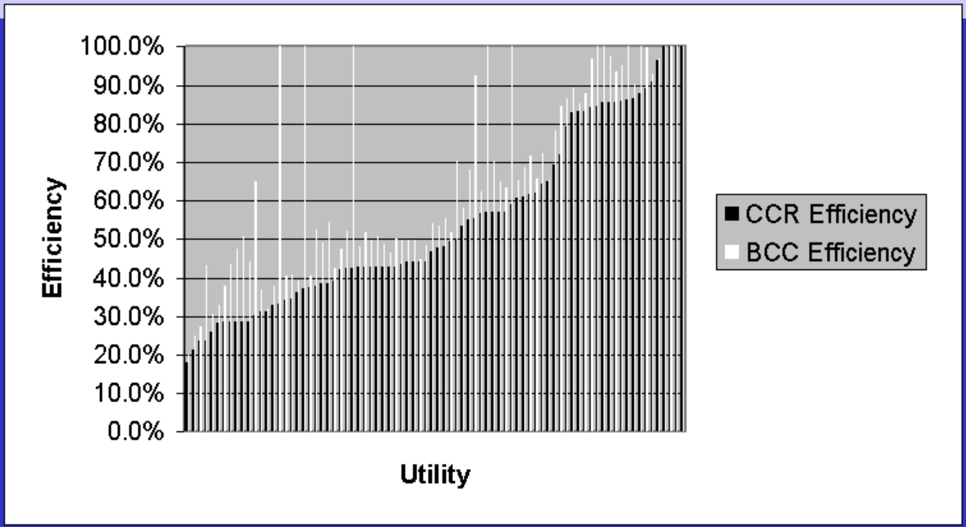


Break-up of efficiency scores: Model 2

Efficiency Range	Number of CCR utilities	Number of BCC utilities
0-25%	4	2
25-50%	41	28
50-75%	17	24
75-100%	16	15
100%	4	13

The majority of utilities had efficiencies of less than 50%

This implies that a very large number of utilities are relatively very inefficient, there exists significant scope for improving water supply operations with regard to curtailment of losses.



This also implies need for greater investments into O&M of infrastructure.

Potential savings in the water supply sector summed over all the sample utilities

- The Table demonstrates the necessity for induction of efficiency in the urban water supply services in India

	Input	CCR formulation	BCC formulation
Model 1	OPEX, Millions of Rs.	10481	3393
	Estimated % Savings	90.3%	29.2%
Model 2	UFW mld	2107.58	887.48
	Estimated %Savings	66.8%	28.1%
	Savings as % of water produced	13.9%	5.9%

In model 1, it is theoretically possible to save nearly Rs. 3393 Million in the short run, and this constitutes as much as 29.2% of the total cost. Analysis of Model 2 indicates that it is possible to theoretically save 28.1% of the total quantum of water currently being wasted as UFW. **Microanalysis of individual utilities would be required to identify the potential areas that would need to be addressed in order to realize these potential savings**

Policy Implications

- Case for Restructuring/Privatization/ Commercialization
- Case for unbundling of Water Supply utilities
- Cost savings: Analysis of Potential areas
- UFW reductions –examination of possible reduction strategies; Case for O&M of Infrastructure
- Examining the financial viabilities of the utilities:A case for tariff resetting
- universal metering-the need for investments

Thank You