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DRINKING WATER AND WELL-BEING IN INDIA: DATA ENVELOPMENT ANALYSIS

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ABSTRACT

The study examines the use of Data Envelopment Analysis (DEA) for the estimation of the well being from drinking water using 'commodities and capabilities' approach. DEA uses the general purpose linear programme version of the *input oriented multi-input multi-output model* for the estimation taking state as the decision-making unit. The transformation efficiency of the water characteristics into achieved capabilities (free from morbidity rates of water borne diseases) shows that Punjab has the least efficiency while Kerala and Orissa as the Pareto-efficient Peer states. The major reason for the input use efficiency in Kerala may be due to the cultural practice of boiling drinking water before consumption. In the case of Orissa, it can be attributed to better hygienic water handling practices. One such indicator, taking water from the storage containers using vessels with handles, is very high among the households in Orissa.

Keywords: Well-being, Morbidity, Capabilities, Data Envelopment Analysis

JEL Classification : H41, H42, I31, L95

Introduction

The living conditions of poor people free from avoidable morbidity and untimely mortality in the developing world depends to a large extent the provision of drinking water and sanitation along with other basic necessities. This has forced the international community to declare the 1980s as the Development Decade for Safe Water and Sanitation and set the goal of water and sanitation for all by the end of the decade. This paper assesses the performance of the Indian states in achieving the above goal in the case of drinking water. It also provides a methodology for implementing Sen's 'Commodities and Capabilities' approach in the case of drinking water[1] .

The outline of the paper is as follows. In section 1, we take up the estimation of coverage among the rural and urban households. In the same section, we also examine the some major characteristics of the commodity, drinking water, particularly the proximity of the supply source, the sufficiency of the quantity supplied and their quality. The rural-urban gap in the provision of the commodity and its characteristics are also analysed here. Section 2 is concerned with the estimation of the

1 This is stated and elaborated in Sen (1985, 1999)

efficiency of transforming the commodity into capabilities using state as the decision-making unit with data envelopment analysis. The final section gives the summary of the study.

I

1.1 Coverage of Drinking Water

1.1.1 Data

The main source of information for the study is the survey on conditions of drinking water and sanitation conducted by National Sample Survey Organisation (NSSO) in its 54th round during the period January – June 1998. The survey used interview method of data collection from a stratified random sample of households. The sample design adopted for the survey was essentially a stratified multi-stage one for both rural and urban areas. The first stage units for the rural area were the Census villages (Punchayat ward in the case of Kerala) and for urban area, the urban blocks. The selection of villages was from the list of villages from the Census 1991, except for Kerala where the Panchayat wards were used. The urban blocks were based on Urban Frame Survey conducted by NSSO on an ongoing basis. It may be noted that the state-level estimates were based on central sample only.

In the first stage, 5242 villages were allocated from a total of 10,974 villages planned to be surveyed. In the urban sector, the allocation for the central sample was 1788 urban blocks. The actual surveyed were only 5,115 villages and 1,745 urban blocks. In the second stage, a sample of 16 households from every selected village and 18 households from the urban block were surveyed. The total number of households in the sample was 78,990 in the rural sector and 31,323 in the urban sector. The details of the sampling procedure are given in NSSO (1999; Chapter 3). The distribution of samples across the states is given in Table A (NSSO, 1999; p.20).

1.1.2 Coverage of drinking water

The coverage can be measured in two ways; (1) supply side, and (2) from the demand side. In the former case it is based on the capacity of the water supply system and, hence, it measures only the potential coverage. The latter method is based on the actual consumption from potable source. Empirical evidence shows that the two estimates differ substantially. The two estimates of Kerala in 1992 show that supply-based estimate is almost double that of demand-based[2]. The evaluation of the accuracy of the two estimates clearly shows that the demand-based estimates are very close to reality[3]. In the present study, we use only the demand side estimate.

The survey shows nine major sources being used for drinking water both in the urban and in the rural areas. They are (1) tap, (2) tubewell / handpump, (3) well, (4) tank/pond reserved for drinking, (5) other tank / pond, (6) river/canal/lake, (7) spring, (8) tanker, and (9) others. Among the sources, Government of India considers only tap (TP), tubewell and handpump (TWHP) as potable source. Therefore, drinking water coverage is defined as the percentage of households that use the above sources as their principal source. The estimated coverage is given in Table 1.

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2 See GOI (1995) for the details

3 See GOI (2000)

Table 1: Coverage of Drinking Water by Principal Source and by State, 1998

States	Percentage of Households with potable source							Urban Rural Gap
	Rural			Urban			State Average	
	TP	TWHP	Sub total	TP	TWHP	Sub total		
Andhra Pradesh	26.1	46.9	73.1	75.1	12.8	87.9	77.6	14.8
Assam	7.3	49.5	56.8	42.2	38.4	80.6	60	23.8
Bihar	0.7	70.3	71	35.3	43.1	78.4	71.4	7.4
Gujarat	46.6	31.7	78.3	91.1	7.3	98.4	85.1	20.1
Haryana	31.1	49.9	80.9	80.5	19.4	99.8	87.1	18.9
Karnataka	26.6	53.9	80.5	80.9	11.2	92.1	84	11.6
Kerala	10.6	1.4	12	40.2	0.2	40.4	27	28.4
Madhya Pradesh	5	52.2	57.1	76	13.1	89.2	67.3	32.1
Maharashtra	41.1	24.4	65.5	92	5.3	97.2	80.8	31.7
Orissa	2.9	53.2	56	38.7	32.3	71	58.6	15
Punjab	14.8	82.7	97.5	64.4	35.5	99.9	97.8	2.4
Rajasthan	19.2	36.2	55.4	85.3	10.4	95.7	69.1	40.3
Tamil Nadu	50	31.1	81.1	74	18.7	92.8	82.8	11.7
Uttar Pradesh	5.8	63.5	72.3	43.2	53.2	96.4	73.5	24.1
West Bengal	4.1	75.6	79.8	56	38.2	94.2	73	14.4
India	18.7	50.1	68.7	70.1	21.3	91.4	75.9	22.7

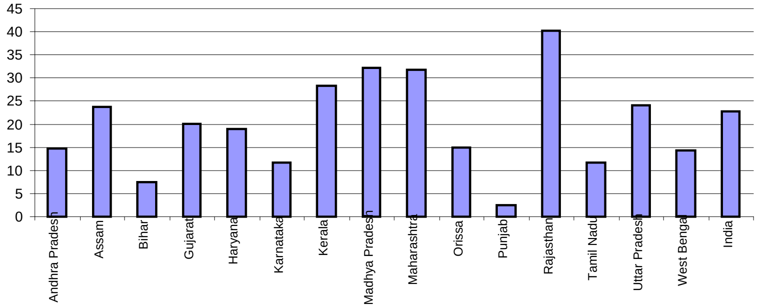
Source: NSSO (1999), 54th round: pp. A114-A115; A124-A125.

Note: TP: Tap Water; TWHP: Tubewell and Handpump

The figure for the state is the weighted average of rural and urban coverage, the weights being the proportion of households in rural and urban area using the same principal source for drinking water.

It may be noted that the coverage is 91.4 % in the urban region and 68.7 % in the rural region at the all India-level. Punjab is the only state that has water for all. However, Haryana and Gujarat have also succeeded in providing drinking water to most of their urban population. Maharashtra, Uttar Pradesh and Rajasthan are very close to the target of water for all in the urban sector. Of the 68.8 % of the rural coverage, about 50 % of the households depend on tube well and hand pump as their main source. In the case of urban region, TWHP contributes only 21.3 % of the total coverage of 91.4 %. This means that the main source of drinking water for rural households is TWHP, while that of urban area is TP. It is well known that there is an urban bias in the distribution of basic services in the developing world. Let us examine this bias in the case of drinking water. A simple measure of the bias is the urban-rural gap in the percentage of households with potable water. If the gap is positive then there is urban bias otherwise not. The gap, urban coverage minus rural coverage, is shown in figure 1.

Figure 1. Urban-Rural Gap in Coverage by State



Source: Same as in Table 1

The urban-rural gap is highest in Rajastan followed by Madhya Pradesh and Maharashtra. The least is in Punjab followed by Bihar. One plausible reason for the bias is the inability to transport the equipments required for creating the potable source in rural areas because of the lack of and/the poor quality of road networks. Another reason would be the difficulty of finding source in certain hydro-geological zones. This requires further investigation.

The coverage of water supply estimated here only shows the availability of water for drinking purposes. But the actual consumption depends on the characteristics of the water supply. For example, the frequency of use of a source within dwelling units is usually higher than that of a source away, say one kilometer, from it. Empirical analysis of the user rates of public taps in rural Kerala shows higher the frequency of use lower its distance from the households[4]. Hence 'proximity' of the source is an important factor affecting consumption of drinking water. Another characteristic that is very influential in the use of potable source is the adequacy of the source in the sense of getting enough water throughout the year. If the source were unable to provide sufficient quantity of drinking water for the households, then the chances of households substituting inferior sources would be higher. This would mean that 'sufficiency' of water is yet another desirable characteristic of good water supply system. A third characteristic of drinking water is the quality of water from the source. If the quality is poor, then it may not be consumed even if coverage is very high. Since the characteristics vary across the states, the coverage in terms of the characteristics may also vary form region to region. Let us examine the variation in each of them in turn. For analyzing the sufficient characteristic, a household with adequate water supply is defined as fully covered, otherwise partially covered. The estimate of the percentage of households with full coverage is given in Table 2.

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4. Pushpangadan et al. (1996)

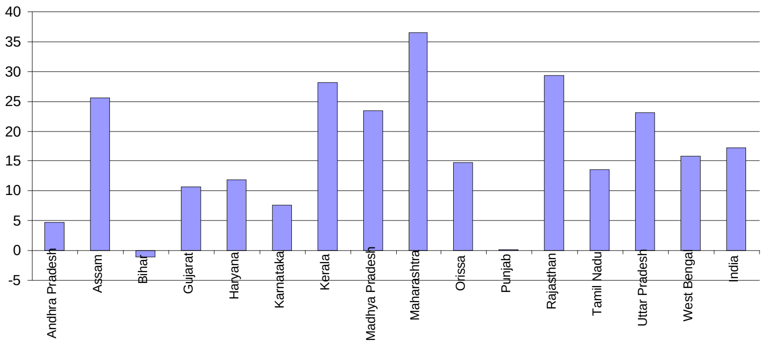
Table 2. Distribution of Fully Covered Households by Potable Source and by State

States	Percentage of Households with potable source							Urban Rural Gap
	Rural			Urban			State Average	
	TP	TWHP	Sub total	TP	TWHP	Sub total		
Andhra Pradesh	19.4	38.5	57.9	52.3	10.3	62.6	59.3	4.7
Assam	6.7	46.8	53.5	40.6	38.4	79	57.6	25.5
Bihar	0.7	68.7	69.4	26.3	42	68.3	68.6	-1.1
Gujarat	40.9	29.2	70.1	75.5	5.3	80.8	73.5	10.7
Haryana	23.6	41.2	64.8	59.3	17.3	76.6	68.6	11.8
Karnataka	21.3	47.3	68.6	65.4	10.8	76.2	70.9	7.6
Kerala	7.6	1.2	8.8	36.8	0.2	37	25.4	28.2
Madhya Pradesh	3.9	46.9	50.8	52.5	11.8	74.3	58.1	23.5
Maharashtra	27.4	20.5	47.9	80.2	4.2	84.4	66.9	36.5
Orissa	2.6	49.4	52	36	30.8	66.8	54.5	14.8
Punjab	12.9	81.1	94	61.6	32.5	94.1	94	0.1
Rajasthan	17.7	34	51.7	70.4	10.7	81.1	61.1	29.4
Tamil Nadu	40.9	26.4	67.3	63.4	17.5	80.9	72.8	13.6
Uttar Pradesh	4.9	61.5	66.4	37.8	51.8	89.6	72.2	23.2
West Bengal	3.6	72.3	75.9	53.8	37.9	91.7	80.6	15.8
India	14.8	46.5	61.3	58.5	20	78.5	66.7	17.2

Source: Same as in Table 1.

Obviously, the coverage in Table 1 should be higher than that of in Table 2 since the former includes both fully and partially covered households. More precisely, the sufficiency characteristic reduces the coverage in rural area by 7.4% and in urban area by 12.9 %. This suggests that water shortage is more among urban households than among rural households. This insufficiency also creates water markets during the summer months. For example, the percentage of households that resort to water purchase during scarcity is 5.8 % in the urban and 1.7 % in the rural region. The percentage of fully covered households in the total coverage (sum of fully and partially covered) is about 89 % in rural areas and 86 % in urban area at the all India level. At the state-level, it is lowest in Maharashtra (73.1 %) followed by Kerala (73.3 %) and Andhra Pradesh (79.1%). However, the same ranking does not follow in the urban region. It is the lowest in Andhra Pradesh (71.2 %) followed by Haryana (76.8 %), Karnataka (82.7 %) and Gujarat (82.1 %). How the scarcity is distributed across rural and urban households among states is examined by the gap - in- coverage of the characteristics as shown in figure 2.

Figure 2. Urban-Rural Gap in Fully Covered Households by State



Source: Same as in Table 1

Obviously, the gap is least in Bihar (negative) and in Punjab. This would suggest that availability of drinking water is more in the rural region in Bihar and almost equal in Punjab than in the urban region unlike in other states. The bias is largest in Maharashtra followed by Rajastan and Kerala. The reasons for the inadequate supply need further enquiry. Next we examine the proximity, the location, of the sources. A household is included in this category if the source is located within the dwelling units or within the premises. The proximity of source thus obtained is reported in Table 3.

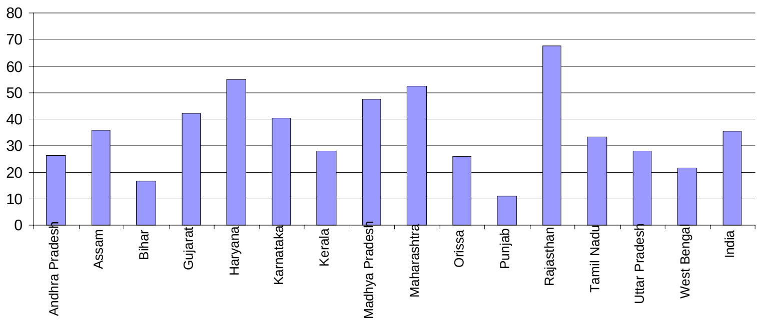
Table 3. Distribution of Households with Source Proximity by State

States	Percentage of Households with Source Proximity			Urban-Rural Gap
	Rural	Urban	State Average	
Andhra Pradesh	15	41.3	28.7	26.3
Assam	31.7	67.3	38.5	35.6
Bihar	37.1	53.8	40.1	16.7
Gujarat	37.4	79.4	56.7	42
Haryana	28.3	83.1	55.1	54.8
Karnataka	13	53.2	39.2	40.2
Kerala	4.1	32.1	23.4	28
Madhya Pradesh	7.8	55.3	40.1	47.5
Maharashtra	24.3	76.7	58.4	52.4
Orissa	5.2	30.9	17	25.7
Punjab	82.9	93.7	87.6	10.8
Rajasthan	13	80.5	58.7	67.5
Tamil Nadu	15.3	48.5	36.5	33.2
Uttar Pradesh	47.6	75.7	55.1	28.1
West Bengal	22.5	44	30.8	21.5
India	27.2	62.6	42.5	35.4

Source: Same as in Table 1

By proximity, the coverage comes down to 27.2 % in the rural region and 62.6 % in the urban region in India. This means that time spent by rural people for meeting their water requirements is more than that of their counterparts in the urban region. Most of the households in Punjab have the source of water supply very close to it. The source is far away in majority of the households in Orissa, Kerala, Andhra Pradesh and West Bengal. The rural-urban disparity at the state level is examined in figure 3.

Figure 3. Urban-Rural Gap in Proximity of Water Source by State



Source: NSSO (1999)

It may be noted that the bias is highest in Rajastan followed by Haryana and Maharashtra. This is least in Punjab and, then, in Bihar. The urban bias is partially explained in terms of the concentration of settlements in the urban centres than in the rural areas. The third and the last characteristics with which we are concerned here is the quality of the drinking water available to them as judged by the users. If the households report that the quality of the water from their source is satisfactory, the household is classified as getting quality drinking water otherwise not. The distribution of households according to the quality of water is given in Table 4.

From Table 4, the rural coverage with satisfactory quality is the lowest in Kerala (10.1 %), followed by Assam (37.6 %) and Orissa (48.3%). Punjab tops the rank in the rural coverage followed by Karnataka (78.9 %) and Haryana (78.5 %). In the urban sector, Haryana tops in coverage followed by Punjab, Maharashtra and Uttar Pradesh with more or less same coverage. The quality problem may be due to the poor repair and maintenance of the system arising from the severe financial crunch experienced by the public utilities in general and water supply in particular. The recovery rates in the non-merit part of the water supply, urban water supply, substantiate this point.

Table 4. Distribution of Households with Quality of Drinking Water by State

States	Percentage of Households with Satisfactory Quality of Water			Urban-Rural Gap
	Rural	Urban	State Average	
Andhra Pradesh	67.2	80.0	63.8	12.8
Assam	37.6	47.7	38.9	10.1
Bihar	54.4	65.6	56.1	11.2
Gujarat	73.1	80.3	75.3	7.2
Haryana	78.5	96.4	84.4	17.9
Karnataka	78.9	88.4	81.1	9.5
Kerala	10.1	41.6	28.8	31.5
Madhya Pradesh	55.0	84.3	64.3	29.3
Maharashtra	61.3	92.8	71.7	31.5
Orissa	48.3	67.5	50.3	19.2
Punjab	83.7	92.9	86.8	9.2
Rajasthan	52.7	90.1	60.2	37.4
Tamil Nadu	75.8	86.5	80.1	10.7
Uttar Pradesh	61.1	92.3	67.0	31.2
West Bengal	54.7	79.2	60.1	24.5
India	59.6	83.3	65.1	23.7

Source: Same as in Table 1

The subsidy given to this sector is an indicator of the resource crunch. Srivastava and Sen (1997) provide estimates for the year 1994-95. According to their estimate, the total subsidy of the Central Government on the non-merit part of water supply for the year 1994/95 is Rs. 87.92 crore. The recovery rate is only 0.43 % implying the supply is almost free of cost[5]. Direct estimate for the urban water supply is not given for the states. But the classification of the government services show that urban water supply is same as the non-merit services in water supply and sanitation[6]. The total cost incurred by all states for urban water supply in 1994/95 is Rs. 5304.8 crore and the total receipts is only Rs. 169.4 crore, implying an average recovery rate of 3.2 % for the states[7]. The recovery rates vary widely among the states. For example, Punjab (10.5 %) tops among the states followed Haryana (9 %). The lowest rate is for Assam (.02%) followed by UP (.04 %) and Gujarat (.33 %). It is worth mentioning that the rate of recovery is not even 1% of the cost of production in a state like Tamilnadu where the urban water supply has already put a break on the urbanization and industrial growth. It may be noted that Assam has the highest estimated number of households reporting quality problem, which has lowest rate of cost recovery. It is estimated that the financial resources needed for the operation and maintenance (O & M) of water supply is about 10 % of the total cost. By this criterion, the revenue collected is not enough to meet this requirement for most of the states either. The shortage of funds can affect only the maintenance but not the operation of the system. The neglect of the maintenance of the system would eventually lead to poor quality of water supply. This explains the poor quality of water-supplied from the potable source. In order to get the bias in comparative

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5 Srivastava and Sen (1997), Annexure 4, p.140.

6 Srivastava and Rao (2002), Appendix 1.

7 The estimates are based on Srivastava and Rao (1997), Annexure 5 – 25.

perspective, rural-urban gaps together across states is given in Figure 4. The urban-rural gap is the lowest in Gujarat followed by Punjab and Karnataka. The quality problem is highest in Rajastan, followed by Maharashtra, Uttar Pradesh and Kerala. The comparative provision in the characteristics is examined in figure 5.

Figure 4. Urban-Rural Gap in the Quality of Drinking Water by State

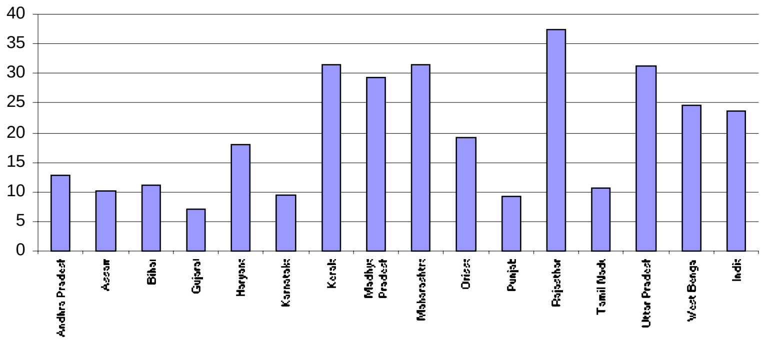

Figure 5. Urban-Rural Gap in Drinking water Characteristics by State

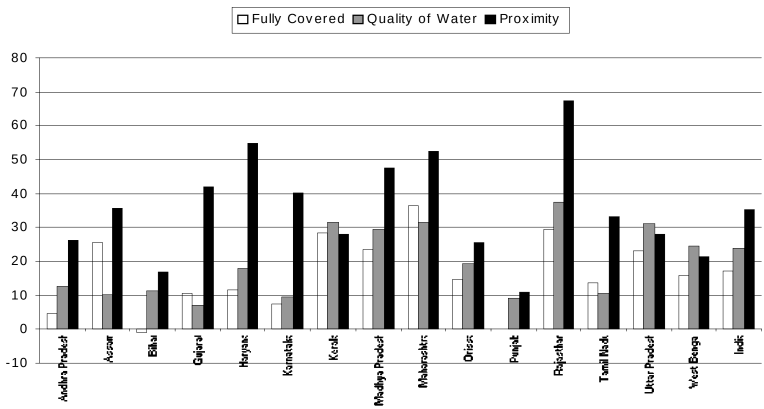

Figure 5 shows that urban bias is least in Punjab followed by Bihar in the three characteristics combined. Highest bias is in Rajastan followed by Maharashtra. This also suggests that considerable variation exists among the states if one is concerned with the desirable characteristics rather than the commodity itself.

Thus far we have been concerned with the availability of drinking water and its desirable characteristics among rural and urban households of the major fifteen states in India. Our task is to measure the welfare implications of the commodity/characteristics among the people. In other words, we have to develop a methodology for measuring the impact of drinking water among people. Although, Sen's 'commodities and capabilities' approach provides such a framework, its empirical implementation especially in drinking water has not been undertaken in the literature. This is taken up in the next section.

II

2.1 Commodities- Capabilities Approach (CCA): Drinking Water

In the CCA, the major task would be the identification of the capabilities arising from drinking water. For our analysis, we consider only the achieved capabilities arising from the characteristics. The achieved capabilities refer only to the avoidable incidence of water borne diseases. Considering the data availability, it is restricted to Jaundice and Diarrhea morbidity among the population. The assessment of the transformation of commodity/characteristics into capabilities in a comparative perspective faces several problems. The first one is the choice of the methodology for the evaluation of performance involving multiple inputs (characteristics of water supply) and multiple outputs (achieved capabilities). The simplest measure is the output-input ratio using appropriate weights for the inputs and for outputs. The major limitation of the method is the arbitrary nature of the fixed weights and the inability to discriminate the whether difference in transformation is due to change in weights or in the observations[8] . Another framework is the estimation of the Meta Production Function using regression analysis.

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8 Cooper, Seiford and Tone (2000): p.12.

The production function approaches assumes, it is well known, uniform functional relationships and is messy in the case of multi input-multi output case. The data envelopment analysis (DEA) overcomes both the problems. The weights are decided on the basis of optimality condition and do not assume any functional relationship between the inputs and outputs. DEA also measures the comparative or relative efficiency of the decision-making units (DMU). The first step is to identify the DMU, the unit of assessment for our purpose. In the present case, the state is taken as the DMU judging the quality and the reliability of data available on input and output on drinking water. The second decision is whether to use input orientation model or output orientation model of DEA. Input-orientation model is preferred if inputs are controllable and output-orientation if outputs are controllable[9]. In our case, the characteristics are controllable compared with achieved capabilities. Hence input orientation model of DEA is taken for our analysis. Our task is to specify and estimate the input orientation model first developed by Charnes, Coopper and Rhodes (1978, hereafter CCR).

CCR model:

Let the number of DMUs in the model be *N*. Let x_{ij} and y_{rj} be i^{th} input and r^{th} output of the j^{th} DMU (j = 1…N). Suppose each DMU uses *m* inputs and *s* outputs so that $i = 1 \ldots m$ and $r = 1 \ldots s$. Further, we assume that the transformation of the inputs into outputs is subject to constant returns to scale. Then the technical efficiency of DMU j_o is the optimal value of k_0 of the linear programming problem given below.

9 Thanassoulis (2001); p.23.

$$\text{Min} \qquad k_o - \varepsilon\left[\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right]$$

Subject to :

$$\sum_{j=1}^{N} \lambda_j x_{ij} = k_0 x_{ij0} - S_i^-$$

$$\sum_{j=1}^{N} \lambda_j y_{rj} = S_r^+ + y_{rjo}$$

$$\lambda_j \geq 0,\ j = 1 \ldots N,\ S_i^-, S_r^+ \geq 0 \forall i \,\&\, r, k_0 \ free.$$

ε is a non-Archimedean infinitesimal.

It may be noted that any feasible set of λ values identifies a point within the production possibility set, which can be constructed from the DMUs under certain regularity conditions[10] . Thus the model identifies a point within the *production possibility set* which uses the lowest proportion k_0 of the input levels of DMU, j_o, while offering output levels which are at least as high as those of DMU j_o.

This CCR model has to be estimated for drinking water supply. In this case, we are concerned with the commodity-capability transformation of fifteen major states (N=15). There are two outputs: jaundice morbidity and diarrhea morbidity (r = 2) and three inputs (s = 3). In order to estimate the transformation function, we need the estimates on the population coverage in drinking water and its major characteristics- sufficiency, proximity and quality. We have used the relative household size of the state for the

10 See ibid, p.64 for the details.

estimation of population coverage from household coverage. Preliminary analysis of the data shows that in many states the percentage of population with jaundice morbidity is higher than the percentage of population covered with sufficient water. As a result, the sufficiency characteristic is not included as an input for the analysis. It may be noted that we have taken the percentage of population free from water borne diseases as the output instead of percentage of morbid population from it following the suggestion of keeping isotonicity property in output variable[11]. Since the output figures are not available in the NSSO survey, we have taken the state-level estimates of Diarrhea and Jaundice from National Family Health Survey[12] in 1998/99. The CCR model for the first state in alphabetical order, Andhra Pradesh, is given below:

CCR model for Water Supply (Andhra Pradesh)

Mink- e(SP+SQ+SJ+SD)

Subject to

Inputs:

Water proximity:

$$28.7k - SP = 28.7\lambda_1 + 38.5\lambda_2 + 40.1\lambda_3 + 56.7\lambda_4 + 55.1\lambda_5 + 39.2\lambda_6 + 23.4\lambda_7 + 40.1\lambda_8 + 58.4\lambda_9 + 17.1\lambda_{10} + 87.6\lambda_{11} + 58.7\lambda_{12} + 53.9\lambda_{13} + 55.1\lambda_{14} + 30.8\lambda_{15}$$

Water quality:

$$69.3k - SQ = 69.3\lambda_1 + 38.3\lambda_2 + 56.4\lambda_3 + 60.3\lambda_4 + 83.3\lambda_5 + 83.8\lambda_6 + 27.1\lambda_7 + 64.1\lambda_8 + 71.2\lambda_9 + 50\lambda_{10} + 87.9\lambda_{11} + 59.1\lambda_{12} + 80.1\lambda_{13} + 68.1\lambda_{14} + 59.9\lambda_{15}$$

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11 See Thanassoulis (2001); p.111.

12 IIPA (2000).

Outputs:

Jaundice morbidity:

$$984.7 + SJ = 984.7\lambda_1 + 972.7\lambda_2 + 984.7\lambda_3 + 988.9\lambda_4 + 990.4\lambda_5 + 996.3\lambda_6 + 996\lambda_7 + 982.7\lambda_8 + 984.6\lambda_9 + 987.9\lambda_{10} + 990\lambda_{11} + 990.6\lambda_{12} + 988.5\lambda_{13} + 990.1\lambda_{14} + 977.8\lambda_{15}$$

Diarrhea morbidity:

$$85 + SD = 85\lambda_1 + 91.8\lambda_2 + 82.3\lambda_3 + 80.3\lambda_4 + 86.1\lambda_5 + 86.1\lambda_6 + 88.4\lambda_7 + 76.6\lambda_8 + 74.6\lambda_9 + 71.9\lambda_{10} + 91.2\lambda_{11} + 80.2\lambda_{12} + 85.6\lambda_{13} + 76.7\lambda_{14} + 91.7\lambda_{15}$$

The model is computed for all the fifteen major states using trial version of Lindo. The transformation efficiency of each state is reported in Table 5.

Table 5. State level Transformation Efficiency

States	Input Efficiency
Andhra Pradesh	0.731
Assam	0.735
Bihar	0.549
Gujarat	0.446
Haryana	0.404
Karnataka	0.546
Kerala	1
Madhya Pradesh	0.528
Maharashtra	0.391
Orissa	1
Punjab	0.318
Rajasthan	0.456
Tamil Nadu	0.411
Uttar Pradesh	0.415
West Bengal	0.749

The results show that two states, Kerala and Orissa, are efficient in the transformation. The remaining 13 states have efficiency of varying degrees, as low as .318 in Punjab as high as .749 in West Bengal. This means that the Punjab can achieve the same level of capabilities (morbidity free population) with only 31.8 % of its present level of inputs. In other words, the state has the highest input inefficiency (78.2 %) among the states. But the input inefficiency is the least, only 25 %, in the case of West Bengal. The reasons for the low efficiency of majority of states need further enquiry. Let us examine the best performers in the transformation process from the data available in NSS report. In the survey two major aspects of drinking water and hygiene were investigated. The first one is the treatment of water before consumption by the households. The second aspect is the hygiene practices in water handling at home. An examination of the data shows that the performance of Kerala may be due to the water boiling practices before consumption as shown in Table 6 below. One striking finding is that almost half of the rural households and about 65 % of the urban households in Kerala boil water before drinking it. This intervention eliminates most of the contamination in the drinking water. This may be due to the health consciousness among the people arising from total literacy in the State. This explanation is not valid for Orissa's higher efficiency of transformation since very few households practice boiling water before drinking it. But the hygiene practices among households in water handlings particularly on taking water from stored container provide some interesting results. The percentage of households taking water from stored container by dipping in a vessel with a handle, an indicator of water hygiene, is given in Table 7. However these hypothesis need further analysis for their statistical significance.

Table 6. Percentage of Households Boiling Drinking Water

States	Rural	Urban
Andhra Pradesh	2.6	6.1
Assam	21.6	28.1
Bihar	0.7	3.5
Gujarat	0.4	1.2
Haryana	0.4	2
Karnataka	2.8	12
Kerala	49.3	65.3
Madhya Pradesh	0.4	1.2
Maharashtra	1.2	9.1
Orissa	1.8	10.6
Punjab	0.3	1.6
Rajasthan	0.2	1.6
Tamil Nadu	8.1	33.7
Uttar Pradesh	0.2	1.2
West Bengal	1.3	5
India	4.3	11

Source: Same as in Table 4.

Table 7. Percentage of Households with Hygienic Water Handling Practices

States	Households dipping Vessels with Handle (%)	
	Rural	Urban
Andhra Pradesh	3.3	1.9
Assam	4.3	20.1
Bihar	58.1	35.7
Gujarat	1.0	1.3
Haryana	16.9	7.0
Karnataka	9.4	10.1
Kerala	27.4	31.2
Madhya Pradesh	18.8	9.9
Maharashtra	2.1	3.4
Orissa	57.4	35.8
Punjab	40.7	17.9
Rajasthan	11.7	3.2
Tamil Nadu	6.0	6.7
Uttar Pradesh	42.7	20.9
West Bengal	69.2	39.5
India	28.8	13.7

Source: Same as in Table 6.

Orissa is one of the three states, which shows very high hygiene in taking water from the stored containers. In addition, the ground water in the state is less polluted in Orissa than in other states. Moreover, the third principal source of drinking water, the well, may be less contaminated due to the cultural practice of using the same bucket for drawing water for all users from it, a unique cultural practice in Orissa[13]. Because of these reasons, the transformation efficiency is Pareto-efficient in Orissa. But the envelopment model shows that Kerala is the benchmark for thirteen states whereas Orissa is only for nine of them. This would mean that Kerala is more genuinely efficient and more suitable to use as a role model to be emulated by other states.

The exploratory nature of the study has certain limitations. The main one is the use of two sources, NFHS and NSSO, for estimating the relative performance of the states in transforming the commodity characteristics into capabilities. Since the sampling techniques used for the collection of data for the two reports permit us state level analysis, the comparative performance is theoretically justified. The factors affecting relative performance need to be carefully examined within a multivariate framework. This requires further work.

III

Summary and Conclusions

The study estimates the coverage of drinking water based on the principal source of drinking water from the users' survey conducted by National Sample Survey Organisation. The target of water for all is achieved only in the state of Punjab. But in terms of the major characteristics of the commodity (proximity, sufficiency and quality)

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13 This observation is due to U. S Mishra, a native of the state.

Punjab has not yet reached universal coverage. The Well-being, an index of functionings, of people from the availability of drinking water is assessed using Sen's 'Commodities and Capabilities' approach. In this approach, the 'states of existence or being' as reflected in the achieved capabilities of people only considered for detailed empirical analysis. The transformation of the commodities/characteristics into achievable capabilities is assessed using the *Input Oriented multi-input multi-output D*ata Envelopment analysis taking state as the decision-making units. The transformation efficiency of the water characteristics into achieved capabilities (avoidable morbidity rates of water borne diseases) shows that Punjab has the least efficiency while Kerala and Orissa have emerged as Pareto-efficient Peer states. The major reason for the input use efficiency in Kerala is due to boiling of drinking water before consumption. In Orissa, it may be due to better hygienic water handling practices. A systematic analysis of the factors contributing to the efficiency requires further investigation.

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