# Travel Time, User Rate & Cost of Supply
## Drinking Water in Rural Kerala, India

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Working Paper No. 266

**Centre For Development Studies**
**Thiruvananthapuram**
**June 1996.**

# TRAVEL TIME, USER RATE AND COST OF SUPPLY
## Drinking Water in Rural Kerala, India*

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## ABSTRACT

*Analysis of Census and Validation Survey on rural water supply in Kerala, a southern state in India, shows that coverage by habitation is not a real measure of scarcity of drinking water. The state has the lowest user rate of public sources in the country which is explained by applying Becker's theory of allocation of time to rural household. Statistical estimation of cost function indicates very limited input substitutability and hardly any technological change in this public utility. This implies that cost minimising technology and innovative financial options are required for achieving full coverage.*

*[Revised version of the paper presented at the Third National Water Congress held in February, 1996 at IIT, New Delhi. This paper is based on the "Status report on rural water supply in Kerala" submitted to Rajiv Gandhi National Drinking Water Mission, Ministry of Rural Development, Government of India, New Delhi, in January 1995. The comments and suggestions of the participants in a one-day workshop on the report held on 19 April 1995 were very helpful in finalising this paper. We thank Sam Jose and M. Suresh Babu for excellent research assistance.]

## Travel time, user rate and cost of supply.

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### Introduction

Infrastructure development is an important prerequisite for modern economic growth. Among such public capital, water supply ranks very high due to its direct impact on health and quality of life of people living in rural areas. Since the benefits from such investments are mostly social, private initiative in the early stages of development, especially in sectors like water supply, sanitation, garbage disposal etc. is very hard to come. As a result, provision of these services has traditionally been the responsibility of the government. This role of the state has been recognised in India and has been incorporated in the Bombay plan[1] as early as in 1944. But the governmental provision of drinking water to rural areas on a large scale assumed prominence only during post-independence era in India culminating in the establishment of an exclusive agency - National Drinking Water Mission - in 1986.

In 1986, at the time of institution of the National Mission, about 4.21 lakhs out of 5.83 lakh villages in India as per 1981 population census have been covered with potable water[2]. By April 1994, the uncovered villages have been reduced to less than 700 by providing at least a spot source in each village. This was mainly due to the priority assigned by the Government of India in order to meet the U.N. declaration of universal coverage by the end of the century. In order to ascertain the availability of and accessibility to drinking water from public sources among the various sections of society and their regional variations and to build a data base, the Mission launched an all India census survey durin 1991-93, perhaps the first of its kind in the world, on all aspects of rural water supply. This census used habitation - permanent and clearly identifiable human settlement of reasonable size - as the unit of coverage which is much smaller than the earlier unit, i.e., village[3]. The results indicated that around 2.66 lakh habitations in India still remained without potable water. This steep increase in the number of uncovered human settlements created concern among the policy makers and it was decided to explore the reasons. For this purpose a validation of census survey was conducted in all the states during 1994. Data contained in the two surveys on various aspects of rural water supply have not been systematically analysed so far. This paper makes such an attempt by a case study of Kerala, a southern state in India.

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1 See Thakurdas, et. al., [1944].

2 A village is said to be covered if there is an assured source of potable water within a reasonable distance of 1.6 Kms. or within a depth of 15 metres. Potable water means it should be free from all sorts of contamination and quality problems such as fluoride, salinity, and other toxic elements. See GOK [1983] for details.

3 According to Population Census 1991, a village has on an average 6.7 habitations in Kerala.

The paper is organised as follows. Section I is on the data base. Section II deals with the coverage of habitations and population along with per capita availability of water by size-class. User rates of public sources and their determinants are examined in section III. Section IV forecasts future financial outlay for full coverage using cost function. The final section provides summary and conclusions of the study.

# I

## 1.1 Data

The main sources of data for the study are: (i) Census Survey, 1[illegible]-93 on water supply (hereafter **Water Census**); and (ii) a validation survey in 1994 (hereafter **Validation**). According to Water Census, 2289 habitations were 'not-covered'[4] **(NC)** in the state. These habitations were further classified as 'main' and 'other'. The former has the largest cluster of houses within the village and bears its name and has important institutions like, school, hospital, post office, market, etc. and the latter is independent clusters of houses distinct from 'main' but forming part of the same census village. Using the above criteria, Kerala has 217 'main' and 2072 'other' NC habitations. The sample for validation is drawn from all NC habitations in the state. The size consists of all main (271) and 30 percent of randomly selected other habitations (639). The distribution of the sample size by district[5] is given in table 1.

The sample size indicates that Idukki district has the maximum number of NC habitations followed by Malappuram and Trissur; while the lowest is in Wayanad.

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4 It means a habitation without a single safe source of drinking water. See GOI [1994], page 5 for details.

5 The lowest administrative unit in the state is village. This is followed, in ascending order of size, by Community Development Blocks and Districts.

Table 1. Sample size by district.

| Districts | NC Habitation | | |
|---|---|---|---|
| | Main | Other | Total |
| Kasaragod | 5 | 4 | 9 |
| Kannur | 10 | 17 | 27 |
| Wayanad | 1 | 5 | 6 |
| Kozhikode | 2 | 24 | 26 |
| Malappuram | 30 | 77 | 107 |
| Palakkad | 10 | 26 | 36 |
| Trissur | 38 | 65 | 103 |
| Ernakulam | 19 | 40 | 59 |
| Idukki | 22 | 92 | 114 |
| Kottayam | 17 | 59 | 76 |
| Alappuzha | 23 | 66 | 89 |
| Pathanamthitta | 16 | 49 | 65 |
| Kollam | 9 | 64 | 73 |
| Thiruvananthapuram | 15 | 51 | 66 |
| Kerala | 217 | 639 | 856 |

Source: Water census.

There were two parts for Water Census: Part I contains the availability of drinking water and quantity of supply in rural habitations, and Part II assesses the quality of water. This study limits its analysis to Part I of Water Census and Validation.

# II

Coverage of rural water supply in India has been assessed in two different ways. First approach is the complete enumeration by counting the number of actual users or user-households, as done in decennial population census as well as in National Sample Surveys. In the second method, coverage is estimated as the product of the number of public sources in the village/habitation and the norm-based number of persons per source. The current norm, set by Government of India, is that a public tap/hand pump should provide 40 litres of drinking water daily for 250 persons. The estimates of coverage narrated here are based on the second method. Accordingly, the surveys had classified village/habitation into covered or not-covered depending on the availability of safe water within a 'reasonable' distance. More specifically, the village/habitation is identified as fully covered **(FC)** if everyone gets at least 40 litres per day, approximately two buckets; and if not, partially covered (**PC**). Using this criteria, Water Census provides estimates on the coverage until 1991 and Validation since 1991. The evolution of coverage in the state is examined below.

## 2.1 Coverage of villages

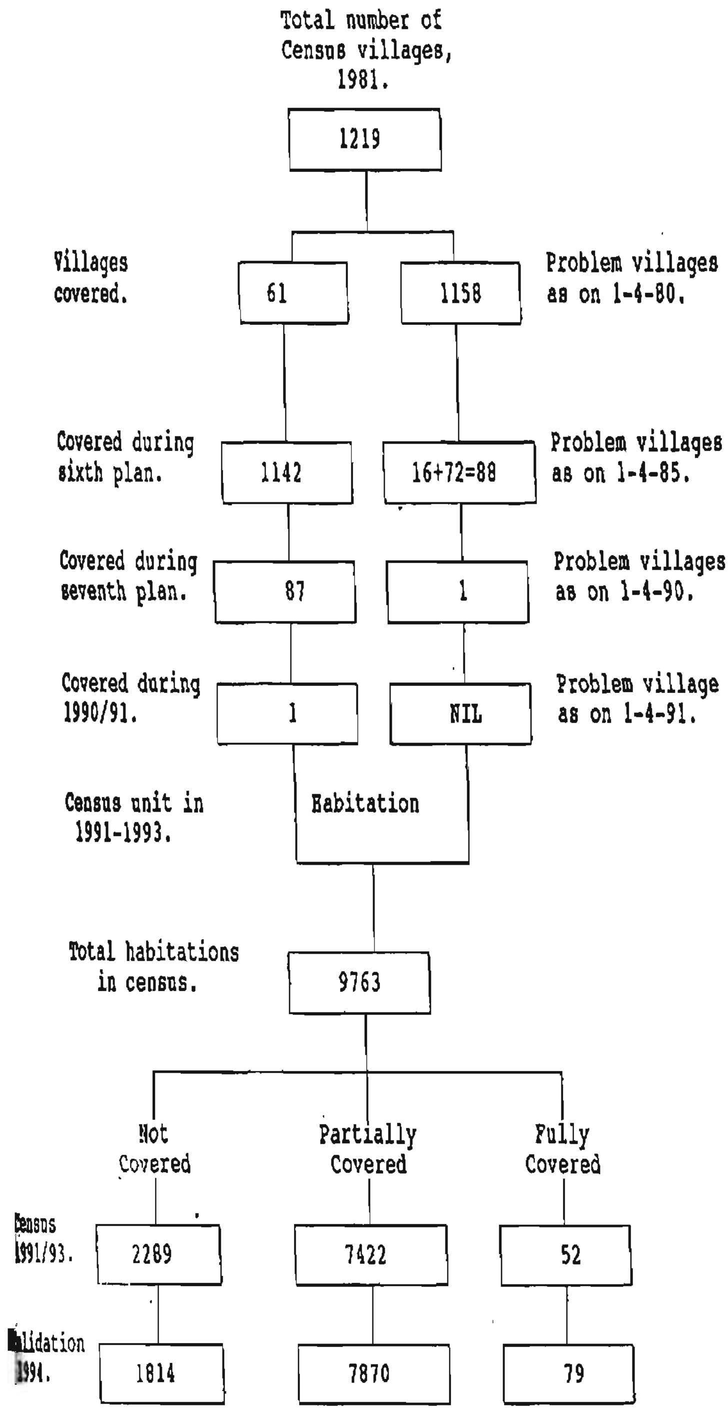
The norms used for coverage were not uniform over the years. Prior to Water Census the unit of coverage was the smallest administrative unit, i.e., village. The criteria followed was that there should be at least one assured potable source free from all quality problems both chemically and bacteriologically within a distance of 1.6 kms. or 15 metres depth[6]. If a village did not satisfy any one of these criteria, then it was classified as 'problem village'.

Based on the above criteria, 1158 villages have been identified as problem villages out of the total 1219 villages in Kerala in 1980, as shown in fig.1. By the end of VI plan, 1980-85, this had come down to 88 including 72 additional problem villages identified subsequently. Towards the end of the decade, according to the figures available, all problem villages have been provided with at least one spot source.

In spite of the above achievements, village as the unit of survey ignored the dispersion of coverage among diverse social, cultural, economic and religious groups with distinct settlement patterns. In order to measure the effect of the above factors, Water Census has adopted 'habitation' as the unit, which is summarised below.

6 See GOK [1983], page 5.

**Fig. 1 Evolution of coverage in Kerala, 1980 - 1994.**



2. 2. Coverage of habitations

Water Census, with habitation as the unit, has replaced a depth of 15 metres by an elevation difference of 100 metres for hilly areas in the definition of coverage. Over and above, a minimum availability of 40 litres per capita per day (lpcd) has also been brought in[7].

The census collected information in respect of 9763 rural habitations[8]. Out of these, 2289 (217 main + 2072 others) were found to be NC which is about 23.4 percent of total habitations. Among the remaining, 7422 are PC and 52 FC (76.1% and 0.5% respectively). Validation estimated that 475 NC habitations have become covered (448 PC and 27 FC) since the census. The coverage status in 1994 is given in table 2.

**Table 2. Coverage status of habitations, 1994.**

| | NC | PC | FC | Total |
|---|---|---|---|---|
| Water census | 2289 | 7422 | 52 | 9763 |
| Validation | -- | 448 | 27 | -- |
| Coverage | 1814 | 7870 | 79 | 9763 |

Source: Pushpangadan et. al. (1995).

Table 2 reveals that there still remains 1814 (18.6 %) habitations without a single public source. Full coverage in the state is very negligible, only 0.8 percent. This means that, coverage is only partial, i.e., inhabitants get, only less than two buckets per day. The spatial distribution of coverage is given in table 3.

7 See GOI [1994] for details.

8 This total does not tally with the number of habitations in the population census of 1991 due to the existence of 12 uninhabited habitations.

Table 3. Coverage status of habitations by district, 1994.

| District | Not Covered | | Partially Covered | | Fully Covered | | Total |
|---|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent | Number |
| Kasaragod | 13 | 3.05 | 395 | 94.56 | 10 | 2.39 | 418 |
| Kannur | 47 | 9.46 | 449 | 90.54 | 0 | 0.00 | 496 |
| Wayanad | 17 | 5.97 | 265 | 91.95 | 6 | 2.08 | 288 |
| Kozhikode | 70 | 10.06 | 625 | 89.51 | 3 | 0.43 | 699 |
| Malappuram | 241 | 23.45 | 785 | 76.35 | 2 | 0.19 | 1028 |
| Palakad | 74 | 7.87 | 865 | 91.92 | 2 | 0.21 | 941 |
| Trissur | 140 | 14.20 | 827 | 83.90 | 19 | 1.90 | 986 |
| Eranakulam | 92 | 12.67 | 632 | 86.92 | 3 | 0.41 | 727 |
| Idukki | 284 | 50.80 | 274 | 49.02 | 1 | 0.18 | 558 |
| Kottayam | 176 | 23.76 | 540 | 72.81 | 25 | 3.43 | 742 |
| Alappuzha | 199 | 29.93 | 467 | 70.07 | 0 | 0.00 | 666 |
| Pathanamthitta | 132 | 24.72 | 401 | 75.28 | 0 | 0.00 | 533 |
| Kollam | 198 | 23.45 | 646 | 76.43 | 1 | 0.12 | 846 |
| Thiruvananthapuram | 130 | 15.59 | 698 | 83.57 | 7 | 0.84 | 835 |
| Kerala | 1814 | 18.58 | 7870 | 80.61 | 79 | 0.81 | 9763 |

Source: Same as in Table 2.

From table 3 it is evident that Idukki has the lowest coverage followed by Alappuzha. Pathanamthitta, Kottayam, Kollam and Malappuram have more or less the same percentage of NC habitations. The absence of at least a single FC habitation in the districts of Alappuzha, Pathanamthitta and Kannur is very much dismaying considering the relatively large investment that had gone into this sector. In the PC category, again Idukki has the lowest share followed by Alappuzha. Further the districts of Trissur, Kollam, Pathanamthitta and Kottayam have below state -average partial coverage in ascending order of magnitude.

Coverage by unit of settlement is the same as by population only if the population is distributed proportionately among the units. In order to verify this hypothesis, coverage by population and its spatial dimension have been examined.

## 2.3 Coverage of population

Population covered can be computed if total population and number of public sources (public taps/hand pumps) in a habitation are known. The former is available from decennial census of population, and the latter from Water Census supplemented by Validation. The estimates on coverage, ratio of potential users to total rural population, at the state and district level are shown in table 4.

**Table 4. Coverage status of population by district, 1994.**

(Percent)

| District | Covered to total population PC | FC | NC | Covered SC To Total SC | Covered ST To Total ST |
|---|---|---|---|---|---|
| Kasaragod | 49.15 | 2.02 | 48.83 | 52.25 | 32.45 |
| Kannur | 24.92 | 0.00 | 75.08 | 26.88 | 32.60 |
| Wayanad | 29.42 | 0.52 | 70.06 | 22.45 | 28.29 |
| Kozhikode | 12.83 | 0.10 | 87.06 | 20.04 | 6.41 |
| Malappuram | 19.63 | 0.05 | 80.32 | 21.29 | 5.93 |
| Palakkad | 37.37 | 0.20 | 62.43 | 31.20 | 26.21 |
| Trissur | 37.30 | 0.56 | 62.13 | 31.78 | 8.31 |
| Eranakulam | 50.49 | 0.55 | 48.96 | 35.45 | 18.37 |
| Idukki | 17.53 | 0.09 | 82.38 | 10.35 | 21.16 |
| Kottayam | 34.37 | 1.99 | 63.64 | 32.86 | 31.84 |
| Alappuzha | 38.99 | 0.00 | 61.01 | 27.39 | 13.00 |
| Pathanamthitta | 33.04 | 0.00 | 66.96 | 19.90 | 0.38 |
| Kollam | 30.95 | 0.10 | 68.96 | 25.53 | 10.28 |
| Thiruvananthapuram | 45.33 | 0.58 | 54.08 | 30.12 | 18.15 |
| Kerala | 32.39 | 0.42 | 67.18 | 27.45 | 24.93 |

Source : Same as in Table 2.

Table 4 rejects the hypothesis that coverage by habitation is the same as that by population. The difference is also very substantial: NC by population is almost four times higher than NC by habitation. Hence coverage in terms of habitation grossly underestimates the extent of availability and is misleading. While full coverage in terms of habitation is 0.8 percent, it has halved in terms of population. The remaining 32.4 percent are only partially covered (PC) as against 80.6 percent by habitation. This reaffirms our earlier conclusion that coverage is entirely partial in the state.

At the district level, Kozhikode has the highest percentage (87.1) of NC population followed by Idukki (82.4) and Malappuram (80.0). On the other hand, Kasaragod has the lowest (48.8 %) followed by Eranakulam (50.0 %) and Thiruvananthapuram (54.1%). In almost all districts, the percentage of fully covered population is negligible.

The above proportions may differ for various socio-economic groups, especially among the weaker sections. Information in this regard is available only in the case of scheduled caste (SC) and scheduled tribe (ST) population, the most underprivileged class in the society. The coverage of SC/ST is also given in table 4. Even with the limitations in the data, the proportion of ST coverage is the lowest at the aggregate level[9]. Spatially this is found to be much prevalent in the eight southern districts of the state. In almost all the districts, ST coverage is much lower than that of SC. This may be attributable to the inaccessibility of habitations in those districts. In this context additional coverage of such habitations requires development of appropriate technology.

The above analysis shows that coverage of both habitation and population is mostly partial. But the availability of water in these habitations may vary or remain constant. This aspect is examined below.

## 2.4. Availability of water by size-class

The coverage by habitation, as shown above, indicates that 80.6 percent of them were partially covered. But does it mean that the inhabitants in these habitations get the limited water evenly? Our field visits show that it is not so. This observation is further verified by size-class distribution of these habitations. The aggregate results are given in fig. 2 and their spatial dimension in table 5

9 The coverage since 1991 could not be estimated as the number of taps/hand pumps exclusively meant for these communities are not available. This limitation is equally applicable for the estimates given in Water Census.

**Fig. 2 Habitations by size class,1994**

(Litres per capita per day)

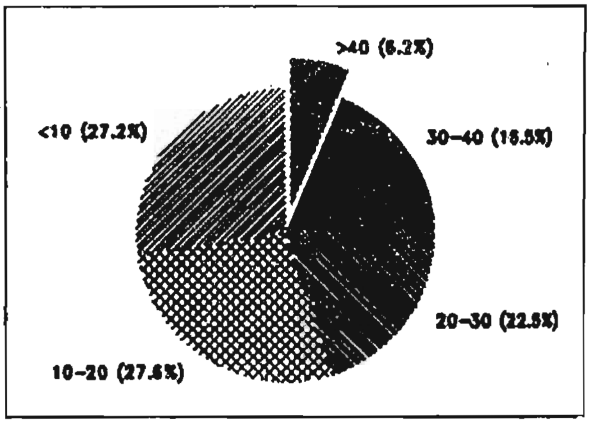



Figure 2 manifests itself that 54.8 percent of PC habitations get water supply at the rate of one bucket or less a day, i.e. less than or equal to 20 lpcd; 22.5 percent between 20 and 30; and 16.5 percent between 30 and 40 lpcd. Only 6.2 percent of the habitations have full coverage.

**Table 5. Per capita daily availability by size-class and by district, 1994.**

| District | < 10 | | 10-20 | | 20-30 | | 30-40 | | 40+ | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Percent | No. | Percent | No. | Percent | No. | Percent | No. | Percent | No. |
| Kasaragod | 77 | 19.5 | 156 | 39.5 | 108 | 27.3 | 47 | 11.9 | 7 | 1.8 | 395 |
| Kannur | 110 | 24.5 | 141 | 31.4 | 8 | 1.8 | 101 | 22.5 | 89 | 19.8 | 449 |
| Wayanad | 44 | 16.6 | 118 | 44.5 | 58 | 21.9 | 42 | 15.8 | 3 | 1.1 | 265 |
| Kozhikode | 179 | 28.6 | 232 | 37.1 | 68 | 10.9 | 93 | 14.9 | 53 | 8.5 | 625 |
| Malappuram | 427 | 54.4 | 173 | 22.0 | 89 | 11.3 | 57 | 7.3 | 39 | 4.9 | 785 |
| Palakkad | 196 | 22.6 | 319 | 36.9 | 261 | 30.2 | 83 | 9.6 | 6 | 0.7 | 865 |
| Trissur | 368 | 44.5 | 97 | 11.7 | 85 | 10.3 | 140 | 17.0 | 136 | 16.5 | 827 |
| Eranakulam | 141 | 22.3 | 190 | 30.1 | 171 | 27.0 | 67 | 10.6 | 63 | 10.1 | 632 |
| Idukki | 98 | 35.8 | 66 | 24.0 | 65 | 23.8 | 38 | 14.0 | 6 | 2.4 | 274 |
| Kottayam | 122 | 22.7 | 203 | 37.6 | 148 | 27.4 | 38 | 7.0 | 29 | 5.4 | 540 |
| Alappuzha | 74 | 16.0 | 156 | 33.4 | 201 | 43.2 | 31 | 6.6 | 4 | 0.9 | 467 |
| Pathanamthitta | 155 | 38.6 | 144 | 36.0 | 64 | 16.0 | 18 | 4.5 | 19 | 4.8 | 401 |
| Kollam | 105 | 16.2 | 139 | 21.5 | 301 | 46.6 | 85 | 13.2 | 16 | 2.5 | 646 |
| Thiruvananthapuram | 41 | 5.8 | 38 | 5.4 | 141 | 20.3 | 460 | 65.9 | 18 | 2.6 | 698 |
| Kerala | 2137 | 27.2 | 2172 | 27.6 | 1770 | 22.5 | 1301 | 16.5 | 490 | 6.2 | 7870 |

Source : Same as in Table 2.

Malappuram, Trissur, Pathanamthitta, Idukki and Kozhikode have, in ascending order, proportionately more habitations in the lowest size-class compared to that of the state. These habitations can be treated as virtually uncovered since the inhabitants are not getting even 1/10th of their daily requirement recommended internationally for personal hygiene and health[10]. This would mean that even the partial coverage shrinks itself to 24.6 percent from 32.4 percent, leading to a lower user rate. The low user rate needs to be examined analytically. This is taken up in the next section.

# III

## 3. User rates in Kerala

From tables 4 and 5, it is evident that capacity has been created for about 33 percent of the population with varying levels of supply. However, different agencies, from time to time, have reported that actual percentage of population using this facility is very low as seen in table 6. As mentioned supra, all agencies except Kerala Water Authority (KWA) have arrived at the actual coverage based on field surveys, while that of KWA is norm-based. The estimate from Population Census indicates that only 12.2 percent actually utilise the service as against the KWA estimate of 34 percent in 1991. Validation estimates for 1994 also confirm that actual user rate is considerably less than the norm-based. This means that there exists considerable under-utilisation of capacity, the improvement of which is possible only if the reasons for such lower user rates are known.

Table 6. Estimates on population coverage

| Year | Actual | | Potential | |
|---|---|---|---|---|
| 1981 | 6.6 | (Census) | 29 | (KWA) |
| 1988 | 12.8 | (NSSO) | 39 | ( ,, ) |
| 1991 | 12.2 | (Census) | 34 | ( ,, ) |
| 1992 | 12.7 | (NFHS) | -- | |
| 1994 | 19.0 | (Valid) | 32 | (Valid) |

Source: 1. Census; GOI (1993).
2. NSSO; GOI (1992).
3. NFHS; PRC & IIPS (1995).
4. KWA; GOK (Various issues).

10 The international standard is 100 lpcd. See Falkenmark and Widstrand [1980] for details.

User rates which reflect the household demand for drinking water and other household activities depend on both economic and non-economic factors. Economic factors can be identified if demand is related to some aspects of the behaviour of rural households. For this purpose, we use a simplified version of Becker's household production model as outlined below[11].

According to Becker, household maximises its utility over commodities such as food, family health, quality children, skills and esteem etc., which are produced within the household using market and non-market goods. The most important non-market good included in the model is `time of household members'. The following simplifying assumptions are made for expository purposes.

Let the division of labour in rural households be in the traditional way: male labour is allocated for market goods and female for non-market goods. In other words, female time is mainly allocated for activities within the household[12]. Under the assumption of separability of food (F) and health (H) from other commodities, the household production model becomes:

$$\max_{(X, t_f, t_h)} U(F, H) \qquad \text{-------------- (1)}$$

subject to
$$F = F(X, t_f),$$
$$H = H(X, t_h), \text{ and}$$
$$P.X + w_f t_f + w_h t_h = I$$

where $U(F, H)$ is the household preference function;
$F(X, t_f)$ and $H(X, t_h)$ are the production functions of food and health respectively;
$X$, the vector of market goods and $P$, their vector of prices;
$t_f$, female time allocated for food preparation and $w_f$, its opportunity cost;
$t_h$, female time allocated for the health of the family and $w_h$, its shadow price;
and $I$, total household income from all sources including labour.

Let $(X^*, t_f^*, t_h^*)$ be the optimum bundle from equation (1). For explaining user rates of public sources, we need only consider the optimum time allocated for health. It is

11 See Becker [1965] for the pioneering work; Pollak and Wachter [1992] for the extension.

12 The assumption is valid since female work participation rate in the rural area in Kerala is only 17 percent in the state according to Population Census, 1991.

observed that a substantial part of $t_h$ in poor rural households is allocated for fetching water for drinking and other health related activities. Obviously the household uses public sources only if travel time to the source is lower than the optimum time. Otherwise, the household depends only on traditional sources, mainly open wells. If the average distance to be travelled is higher for a public source, this would result in a lower user rate of the facility by the households around it. In other words, travel distance and user rates are inversely related. If supply from public source is inadequate and uncertain, as is evident from table 5, $t_h$ will be high due to waiting time and the possibility of repeated travel for fetching the required quantity. As a result, lower the lpcd in a public source, higher is the waiting time and lower the user rate. Therefore lpcd and user rates are directly related. Let us examine the empirical validity of these hypotheses.

In order to test the hypotheses, estimates on travel distance and user rate of covered habitations are required. However, Validation contains only user rate but not travel distance. Both can be estimated at the district level if we combine Validation with decennial population census.

Travel distance at the district level is defined as the square root of the area of rural households occupied by 250 persons, the number of users recommended by Government of India per public source[13]. The area per norm is calculated as the product of area per household and number of households per 250 persons. The area per household is equal to total rural area divided by total number of households. The number of households per norm is obtained from dividing 250 by average household size, the ratio of total rural population to total number of rural households. Using this methodology, the travel distance for each district is calculated from the population census, 1991. The user rates and lpcd at the district level were estimated from the covered habitations in Validation. For testing the hypotheses, the twelve districts were classified into two groups: (1) districts above-state average user rates; and (2) districts below-state average user rates[14].

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13 Strictly speaking, the distance of the households falls in the interval (0, d) where `d' stands for the square root of the area of the households per 250 persons. In such a case, the average travel distance is the mean of the uniform distribution which is equal to d/2. The relative positions of the various districts remain the same even if we take the maximum travel distance.

14 See Pushpangadan, et. al. [1995] for methodology. Out of fourteen districts in Kerala, two of them, Idukki and Wayanad, were excluded. Former is an outlier in the calculation of travel distance and the latter has no covered habitation.

The arithmetic means of travel distance and per capita availability of the two groups are given in Table 7.

**Table 7. Determinants of user rate**

| User rate | Litres per capita per day | Distance (Kms.) |
|---|---|---|
| < State average | 47.80 | 0.64 |
| > State average | 55.45 | 0.58 |

Source : 1. Validation; 2. GOI (1993).

Note [1] Districts below state average user rates are : Kasaragod, Pathanamthitta,Kottayam,Eranakulam and Malappuram; and districts above state average include all other districts in the state except Wayanad and Idukki.

Table 7 validates both hypotheses. The travel cost hypothesis provides only a partial explanation of the demand for public sources. Other socio-economic factors such as per capita income, educational status of women etc. also do influence the user rate. This requires further micro-level studies. Hitherto the analysis was primarily concentrated on the demand side and the utilisation pattern of these public sources ignoring completely its supply side. On the supply side, cost aspect is essential for estimating the resource requirement for providing potable water to the remaining uncovered population. The next section addresses this issue.

# IV

## 4.1 Resource requirement for full coverage

During the period 1966-67 to 1992-93, the state government mobilised from various sources, a total of Rs. 435 crores and invested in creating assets for providing drinking water to 32 percent of rural population. Even this level of attainment is due to the priority given by the international agencies and Government of India during eighties and nineties for rural coverage as part of the decade programme. Further a special emphasis has also been given to accomplish full coverage by year 2000. However the financial burden to achieve the above objective has not been examined systematically. This section examines it from cost function.

The standard neoclassical cost function is defined as

$$C = f(O, P_1, P_2,.., P_n) \quad \text{--------------} \quad (2)$$

where C, total cost; O, output; and $P_1$, $P_2$,.., $P_n$ are the 'n' input prices.

The above cost function can be estimated in two ways. In the first method, cost is estimated as a function of input prices and output. In the second method, cost is deflated by index of input prices and the resulting cost in constant prices is regressed on the level of output[15]. The latter method is applied here. For this purpose, total cost in constant prices and level of output need to be estimated. Systematic time series data on production are not available; hence cumulative population coverage is taken as a proxy for the same[16]. Total cost is the sum of expenditure on capital and operation & maintenance. Expenditures on these are published under two broad heads of accounts, plan and non-plan. The former is mainly on capital and the latter on operation & maintenance.

Measurement of capital, as is well known, is the most problematic and difficult[17]. In spite of this we follow the standard practice of estimating it with the perpetual inventory method[18]. In order to apply this method a benchmark year has to be identified for which gross-net ratios (purchase value to book value) are available for all capital components. This ratio can be applied to the book value of fixed capital for obtaining the gross value. Here the benchmark year is taken as 1977 since coverage estimates are available systematically only from this year onwards. Plan expenditures in constant prices have been cumulated till 1977

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15 See Johnston [1960] for methodology.

16 Since estimates of KWA on rural coverage fluctuate widely during the period, a smoothened series have been used. See for details, Pushpangadan and Murugan [1995], appendix $A_4$.

17 Very few studies exist even in developed economies about the stock of public capital. A partial explanation may be its inherent problem of measurement. See Gramlich [1994] for details.

18 See Hashim and Dadi [1973] for the details.

to obtain the benchmark capital stock without obtaining the gross value from book value and without adjusting for age structure of plant and machinery[19]. The capital stock in any year is then calculated using the formula:

$$K_t = K_0 + \sum_{t=1}^{n} I_t$$

Where $I_t = C_t / D_t$
$C_t$ is the capital expenditure in current prices in year t;
$K_0$ is the capital stock in the benchmark year[20]; and
$D_t$ is the appropriate deflator in year t.

The capital stock thus obtained in any year is then added to operation & maintenance in constant prices of the corresponding year to get the total cost[21].

The estimate of equation (2) is given below[22].

$$\underset{(3.5)}{c = 82.6\,o} \qquad \text{--------------} \qquad (3)$$

Adj.$R^2$ = 0.98, D-W = 1.26

where $c = C - \bar{C}$,

$o = O - \bar{O}$,

$\bar{C} = 1019$ and $\bar{O} = 59.2$.

From duality, the underlying production function is of the Leontief-type. It is obvious that cost minimisation is not possible under such a technology because of fixed input-

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19 Age structure and book values of previ us capital structure are not available.

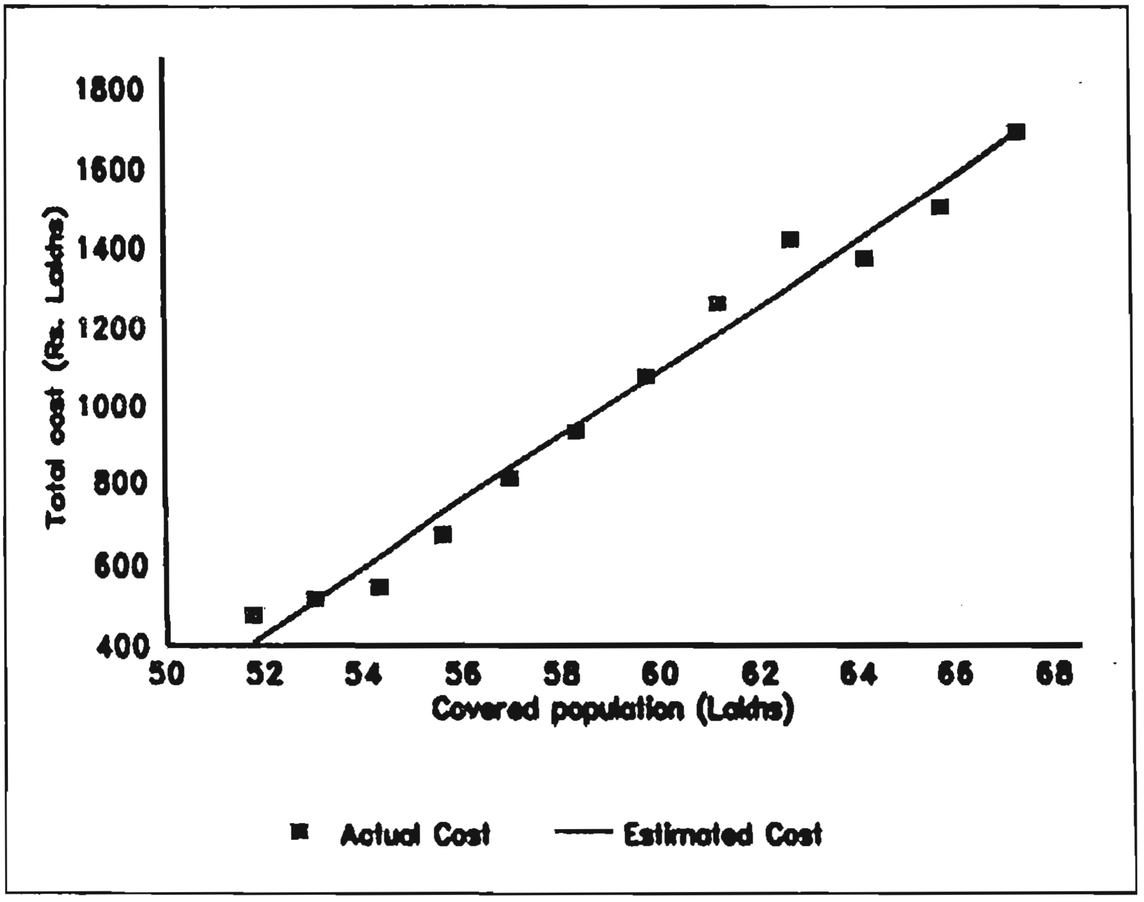
20 No depreciation allowance has been permitted since the discarding rate is unknown.

21 See Pushpangadan and Murugan [1995] for details of appropriate deflators.

22 The cost function shows a negative sign for the intercept which has no meaning in the case of total cost function. Hence, cost function in deviation of the variables is estimated. It satisfies all 'desirable' statistical properties only if it is estimated from 1980/81 onwards, treating the first three points as outliers. The number in brackets is the standard error of the estimate. The table from Farebrother [1980] shows that there is no autocorrelation.

proportions[23]. Moreover, there is hardly any technological change during the period. This could be due to X-inefficiency of state ownership which has very weak incentives for cost consciousness and efficient management[24]. The estimated cost function and its scatter plot are shown in fig 3.

**Fig. 3 Cost function and coverage**
(1970/71 prices, 1980/81 - 1991/92)




Projected cost for full coverage by year 2000 has been extrapolated from equation (3) for an estimated total rural population of 221 lakhs for the year 2000. The additional cost is

23 See Varian [1984].

24 For details, Leibenstein [1960].

of the order of Rs. 833 crores in 1994 prices[25]. Raising this amount within such a short period from the government exchequer is a herculean task given the low resource base of the state. In this situation the only way to achieve full coverage in a relatively shorter period is to introduce cost minimising technology with innovative financing options.

For this purpose, a critical analysis of World Development Report, 1994 (World Bank 1994) on various ways of financing infrastructure development can provide some insight.

# V

**Summary and conclusions.**

Analysis of data from Water Census and Validation survey on rural water supply shows that coverage by habitation is not a real measure of availability of drinking water in the state. It is estimated that there are only 18.6 percent of habitations remaining uncovered, while in terms of population it comes to 67 percent. The fully covered population is only 0.8 percent. This would mean that coverage is predominantly partial, i.e., the inhabitants are being provided with only less than `two buckets' per day. Even among the 32 percent partially covered population, more than half of them receive only less than a bucket per day. This being the supply side, only 19 percent of the inhabitants actually use the facility. This lower user rate is explained in terms of a simple version of Becker's model on allocation of time in rural households. Empirical evidence from district level data identifies travel distance and uncertainty in supply as the most important factors influencing the demand for public sources. The cost of production examined from expenditure data shows a linear relationship, implying limited substitutability of inputs and lack of technological change. Cost based projection of financial outlay needed for full coverage in year 2000 is of the order of Rs. 833 crores in 1994 prices.

The following conclusions emerge from the study. The present definition of coverage should be further broadened to include quality, consumption and settlement pattern of the region. It also brings forth the inevitable need for technological change and innovative financial options for reducing the burden of additional finance for full coverage.

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25 The earlier estimate of Rs.1970 crores for full coverage of population in year 2000 given in the report on rural water supply is purely based on statistical projection without any economic theory. See Pushpangadan, et. al. [1995].

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