uiry into the Rationale for the Selection of Medium id Small Towns for Organized Piped Water Supply Schemes

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1. CALCUTTA METROPOLITAN DISTRICT AND FRINGE AREA

The Calcutta Metropolitan District (CMD) which spreads over an area of 1365 sq. km. (533 sq. miles) is an urban agglomeration housing 8.30 million population as recorded in 1971 population census. A sizeable portion of CMD area is predicted to have a population density of 25 persons per acre (ppa) even in the year 1991 and is termed as "Fringe Area". A relative magnitude of the fringe to the CMD both in area and population is given in Table 1.

TABLE 1.

	Area		Population (1971)	
	Km²	Per cent	Number (in million)	Per cent
C.M.D.	1365	100	8.30	100.0
Fringe	709	52	1.12	13.5

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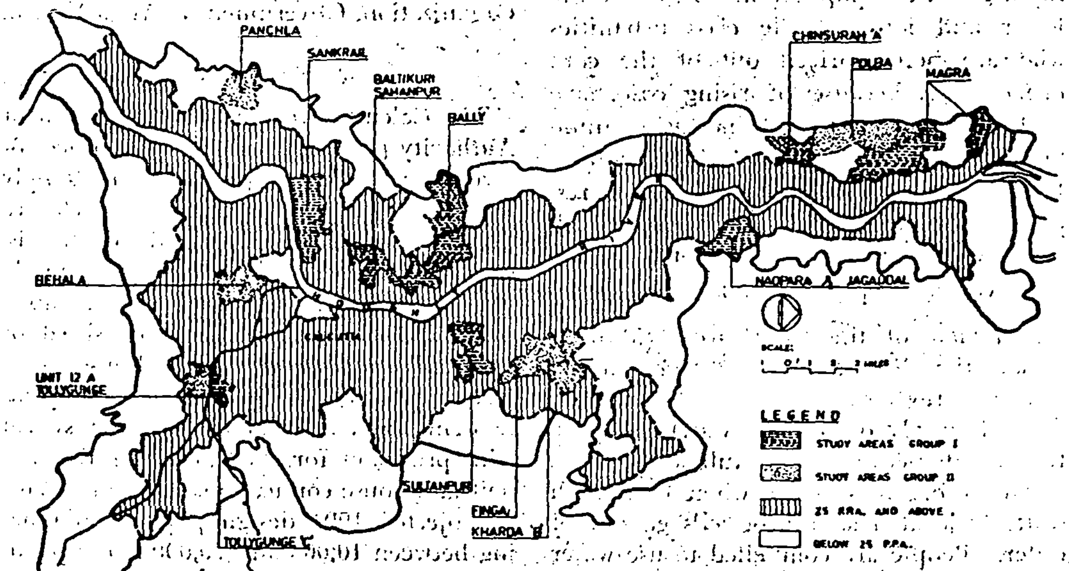

CALCUTTA METROPOLITAN DISTRICT

Map 1

2. FRINGE AREA WATER SUPPLY SCHEMES

The Master Plan[1] for water supply and sewerage, prepared in 1966, for the metropolitan district excluded the fringe area from its perview. These fringe areas being contiguous to Corporation and Municipal areas of CMD, people living in these areas would naturally clamour for basic amenities of living, more so when they see their contiguous areas are improving rapidly. To meet this expectation and to provide a safeguard against endemic cholera and other gastro-intestinal diseases in this urban complex through the supply of safe drinking water for the entire CMD population, there was thinking aloud for atleast an assured minimum domestic supply of water for such population for which the Master Plan had made no specific recommendation. These fringe areas have also an important role to play in the fast growing urbanisation within the CMD. A comparison of growth rates in the various areas within the CMD between the census 1961 and the 1971 indicates that many of these fringe areas are the areas of rapid growth in population. In effect, the lower and lower-middle class urbanities who are being priced out of the core urban areas because of rising cost have settled in these areas in increasing numbers. This led the Calcutta Metropolitan Development Authority (the agency responsible for the development of the Calcutta Metropolis) to take up the Fringe Area Water Supply Schemes.

A review of the study areas (Map 1) under the Fringe Area Water Supply Schemes[2] reveals that the areas have no assured supply of potable water except a few hand-operated spot tubewells. The situation becomes worst when even such scatterly located spot tubewells go out of order. People are compelled to use water from open dug wells (privately owned) and open ponds and tanks for domestic purposes. Survey determines that the water from such sources is polluted to different degrees and as a result there is chronic problem of various water borne communicable diseases.

Conservancy and night soil disposal systems are practically absent. A very small percentage of population has individual septic privy or pit privy. Except natural drainage to canals, rivers or nearby ponds, drainage facilities are limited or non-existent. The road system is also poor. Except a few national/state highways or district roads, most of the roads are narrow, zig zag and unmetalled. Ofcourse, the CMDA has also taken up road development programme in some of the areas. Population is fairly scattered and a large fraction lives either in thatched houses or under tiled roof with mud and brick walls. Some pucca one or more storied houses are, however, visible in more developed urban pockets. The picture is not much different in other urban agglomerations and towns of West Bengal with similar population range from 10,000 to 70,000, a fact corroborated by a study carried out by the Calcutta Metropolitan Planning Organization, Government of West Bengal.

3. OBJECTIVE

The Calcutta Metropolitan Development Authority (CMDA) utilised the services of several consultants to prepare water supply schemes for the fringe areas which are divided into several independent administrative areas. Forty such water supply schemes were ready in all respect for implementation and each scheme consisted of tubewells, pumps and pump house, overhead reservoir, staff quarter for pump attendents, and skeletal distribution system with provision for standposts for the present and house connections in future. With a projected 1991 design population ranging between 10,000 and 70,000 and a population density ranging between 6 and 58, these fringe areas represented the present characters of many small and medium towns in India.

Considering that a significant volume of information is available on the costs of various components of piped water supply with groundwater source and skeletal distribution system it is thought that it would be appropriate to scrutinize the scheme components, the cost components closely and to derive rational correlation between cost components, population, and population density. The objectives of the present study are to evolve a rationale for estimation of cost for providing organized piped water supply of reasonable standard to such community sizes ranging between 10,000 and 70,000, and to establish a relationship between system costs and population densities which would provide a basic guideline for selection of communities for piped water supply depending on their size, population density and available financial resources. A careful selection of 14 schemes is made to have representative picture of the actual state of affairs and to make the conclusions valid for generalisation and wider application (Map 1).

DESIGN GUIDES

4. SUPPLY SOURCE

Groundwater being reasonably copious in CMD area it is considered as the source for the schemes. The depth at which good quality water bearing stratum is available ranges between 80 and 150 metres. The *per capita* water supply is considered at 100 litres for a projected population of 1991. The design being based on projected population of 1991, the standard of supply in areas where the scheme will be completed within 5 or 10 years from 1970 will be higher than 100 litres *per capita* per day (lpcd). Again the designed scheme is not expected to be under-capacitated in 2001 A.D. as the additional water demand required by the population exceeding the design population may be met by running the tubewells a few extra hours or by sinking an extra tubewell as an extreme measure. The distribution system designed to accommodate for a demand with a peaking factor of 2.25 should remain suitable in 2001 A.D.

5. DESIGN POPULATION

A water supply scheme conceived in 1971, constructed within a year or so for a population which is expected to reach in 1991 should create a financial burden on the present population much to their dislike. But in the context of 5 to 10 years gap between project conception, its implementation and the services reaching the beneficiaries the acceptance in 1991's population as the design one seems reasonable. To remind again, the skeletal distribution system is expected to cater to public standposts for the present and adequate provisions are there for individual house-connections.

The 14 schemes with 1971 (actual) and 1991 (projected) population and population density are presented in Table 2 in two groups and also indicated in Map 1. The design population of the scheme in Group I ranges between 10,000 and 35,000, while that of the schemes in Group II ranges between 20,000 and 70,000.

6. ESTIMATION OF COSTS

The capital cost for all the fringe area water supply schemes include components such as:— Skeletal distribution, storage (overhead), source (tubewell), pump, motor and electric installations, pump house and caretaker's quarter, and land.

The last component being a low fraction of the total cost and any judicial estimation of the cost of land being practically impossible owing to its very nature of uncertainty in cost standards this component has not been taken into account while considering the total cost. This, it is hoped, will make the conclusions more widely applicable.

While analysing the cost of components calculations[3] are based on rates taken from the CMDA's "Schedule of Rates for Water Supply Works", (March 1975). The accepted rates of tenders based on above schedule

TABLE 2: FRINGE AREA POPULATION: 1971 AND 1991 GROSS AND NETT DENSITIES

Sl. No.	Fringe Area	Population		Density of (1991) population (ppa)	
		1971	1991	Gross	Nett
(1)	(2)	(3)	(4)	(5)	(6)
1.	Magra	17,800	20,000	6.59	9.96
2.	Baltikuri-Sahanpur	44,771	64,000	39.70	48.04
*3.	Polba	7,200	10,000	2.73	5.46
*4.	Behala	10,643	18,000	21.25	45.00
5.	Tollygunge C	25,245	33,000	20.91	43.13
6.	Sankrail	29,447	36,800	16.34	30.07
*7.	Khardah B	**N.K.P.	13,500	7.61	12.94
8.	Noapara-Jagaddal	20,117	43,000	20.56	41.80
*9.	Tollygunge Unit 12A	19,300	35,000	39.06	57.10
*10.	Finga	**N.K.P.	15,000	13.53	21.64
11.	Bally	N.K.P.	30,000	9.35	12.68
12.	Sultanpur	N.K.P.	70,000	43.20	53.42
13.	Chinsure A	19,800	34,000	9.51	25.94
*14.	Panchla	12,390	21,500	19.09	34.90

* Low-cost group.

** N.K.P.: Not known precisely, 1961 and earlier census figures are available.

presently vary from 10 per cent below to 3 to 5 per cent above (in limited cases) except in the case of R.C.C. overhead reservoirs, where the currently accepted tender rates vary from 10 to 30 per cent above the scheduled rates depending on the location of reservoirs, prevailing communication facilities and possibility of theft of construction materials.

To compute the cost of pumps, motors and electrical installations the market rates have been taken into consideration as those are not available in the CMDA schedule. The cost summary is presented in Table 3.

OBSERVATIONS

7. POPULATION DENSITY

Wide variation in densities exists in the fringe areas and is also reflected in the projected densities. In addition, each area demonstrates pockets of development for reasons of physiography, road and/or rail communication, nodality in communication system. The pattern of water supply infrastructure is expected to follow the pattern of growth within the fringe area and hence it should also demonstrate pockets of distribution within nodes of growth with connecting line between two growth nodes or more if one of the growth nodes serve as the source of supply. Alternatively, each growth node may have an independent source to distribution system if the design population justifies the scheme. In view of the above, it is found that gross density of population, defined as 1991 population per acre of total area of fringe area, bears no coherent relationship with the cost of the total system or any component of it. When density of population is estimated as nett taking designed popu-

TABLE 3: COMPONENTWISE COST OF FRINGE AREA WATER SUPPLY SCHEMES

(Unit: Rupees in lakhs)

Sl. No.	Fringe Area	Storage over-head	Source tube-well	Pump, motor, electric installations.	Pump-house caretaker's quarter	Total excluding Distribution 3+4+5+6	Skeletal Distribution	Total including Distribution 7+8	Per capita Unit (Rupees)
1	2	3	4	5†	6†	7	8	9	10
1.	Magra	3.53	0.80	0.85	0.41	5.59	37.70	43.29	216
2.	Baltikuri Sahanpur	9.18	2.82	2.45	0.81	15.26	21.80	37.06	58
*3.	Polba	2.42	0.48	0.42	0.20	3.52	22.40	25.92	259
*4.	Behala	2.42	0.66	0.55	0.20	3.83	9.20	13.03	72
5.	Tollygunge C	2.42	1.63	1.00	0.41	5.46	23.00	28.46	86
6.	Sankrail	4.83	5.06	2.59	1.22	13.70	24.00	37.70	102
*7.	Khardah B	3.72	1.22	0.37	0.20	5.51	15.40	20.91	155
8.	Noapara-Jagaddal	5.03	2.23	2.20	0.81	10.27	26.50	36.77	86
*9.	Tollygunge Unit 12A	6.42	2.50	1.97	0.81	11.70	16.60	28.30	81
*10.	Finga	3.72	1.22	0.69	0.41	6.04	13.10	19.14	128
11.	Bally	6.23	1.84	1.04	0.61	9.72	30.60	40.32	134
12.	Sultanpur	11.03	4.28	2.39	1.42	19.12	30.10	49.22	70
13.	Chinsura A	6.70	3.72	2.05	1.22	13.69	23.80	37.49	110
*14.	Panchla	2.52	0.90	0.53	0.20	4.15	10.20	14.35	67
							304.40‡	431.96‡	

* Low cost group.

† Col. 5 & 6 combined is MISCELLANEOUS.

‡ Skeletal distribution system is (304.40/431.96) × 100 = 70 per cent.

lation per acre of areas under pockets of development, the correlation is better achieved which appears reasonable, as because the cost of the scheme is dependent primarily on the extent of these developed areas and population pattern within such areas. It is for this reason "net" and not "gross population" density is considered as a better parameter for correlation with systems cost.

8. PARAMETRIC RELATIONSHIP

Using the data obtained from the 14 study areas of CMD fringe as given in Table 2 and 3 cost components with design population are graphically presented in Figure 1. The three components of cost, i.e. (a) storage; (b) source (tubewells); and (c) miscellaneous accessories such as pumps, motor and electrical connections, and caretaker's quarter etc. increase linearly with the increase in population.

The cost of skeletal distribution which constitutes the major cost component on an average about 70 per cent of the total

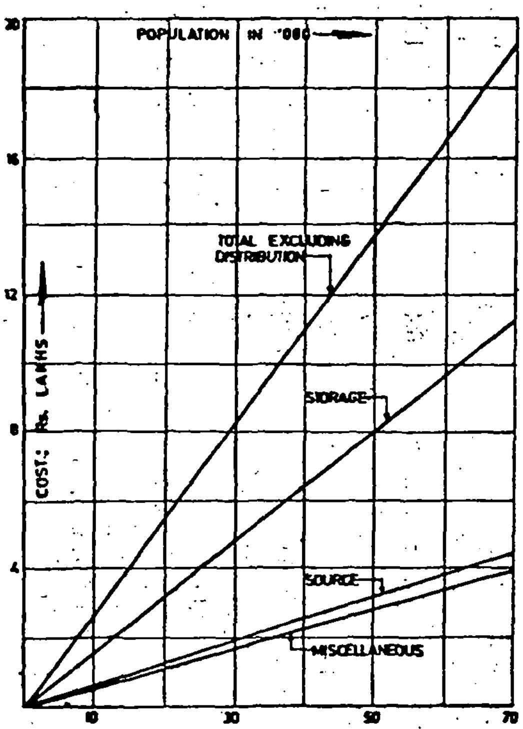

Figure 1.

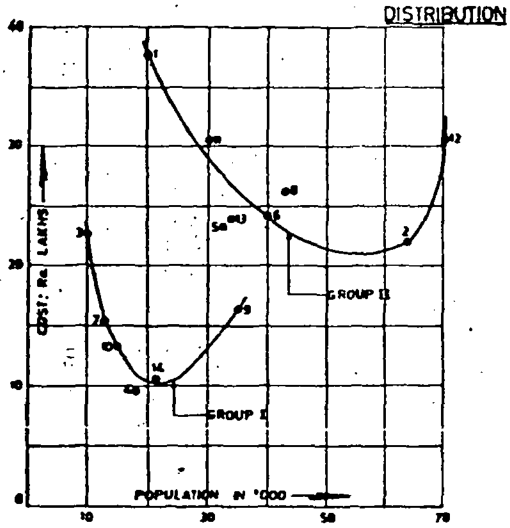

Figure 2.

cost (Table 3), does not demonstrate any such linear relationship with design population (Figure 2). The cost of distribution appears to be classed in two distinct groups, one group apparently more cost-intensive than the other. The design population range for the low-cost schemes lies between 10,000 and 35,000 and that for the high-cost schemes lies between 20,000 and 70,000 and are designated as Group I and Group II, respectively.

The cost of distribution being the major component of the systems cost its dominant character is sure to be reflected in the plot between total systems cost and population (which is not presented in Figure 2). For a decided design norms such as *per capita* daily supply, hours of supply, peaking factor, and terminal pressure etc. the cost of distribution and inter-alia the systems cost are not only dependent on design population, but also on the spread of population which is reflected by the population density parameter. The "systems cost" and the "cost of distribution" are plotted against "nett density of population" for both the groups of the schemes. The high-cost and the low-cost groups are better segregated in the plot of Figure 3 as compared to Figure 2, and indicates certain

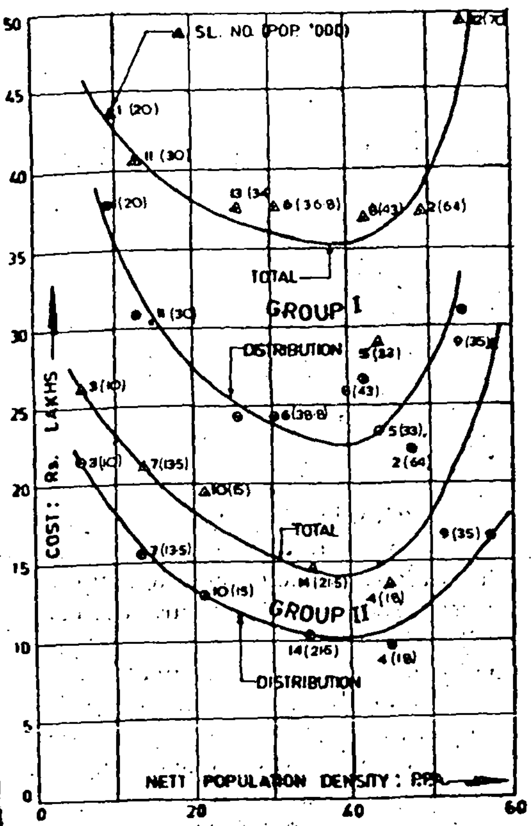

Figure 3.

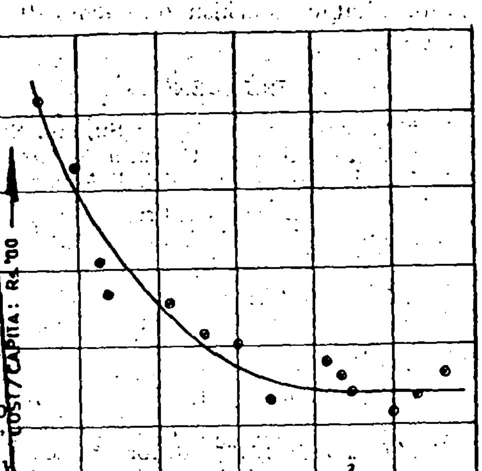

Figure 4.

logical conclusions. With a view to evolving rationale for estimation of systems cost for providing organized piped water supply to communities with a population range between 10,000 and 70,000 and nett densities between 5 and 60 persons per acre a plot is presented for *per capita* systems cost with nett density of population (Figure 4).

9. DISCUSSIONS AND CONCLUSIONS

From the first set of plots (Figure 1) it may be seen that the cost components increase with increase in total design population. Such relationship is obvious as because every quantum of population increase should demand a proportional increase in the capacity of reservoir, tubewell and pumping accessories. Though spatial distribution of population has in some cases influenced the number of reservoirs and tubewells because development has taken place in pockets separated by agricultural or sparsely populated areas, its effect on the above three cost components is hardly perceptible.

The characteristic U-shaped curves of the other set of plots (Figure 3) indicate the existence of an optimal range of net density of population for which the cost of distribution and also the total systems cost is minimum. Interestingly both the groups of scheme indicate similar range of optimal population density.

To search for the factors which influenced the schemes to be divided into two distinct cost groups, two schemes: Magra and Panchla may be compared. Both the schemes cater to a design population of 20,000 to 21,500 (serial Nos. 1 and 14, Figure 3). The significant cost difference is (i) for difference in "nett density of population" which is 9.96 and 34.90 ppa for Magra and Panchla, respectively and (ii) for unfavourable spatial distribution of population for Magra demanding two sets of systems components against one for Panchla. The latter cause is primarily responsible for pushing 8 of the 14 schemes in the high-cost group.

These two groups again merge into single group when "*per capita* systems cost" is plotted against "nett density of design population" (Figure 4). Although total systems cost increases when nett density of population exceeds the optimal density (Figure 3), the *per capita* total systems cost remains unchanged beyond the optimal density (nett) of population.

10. CONCLUSIONS

Scrutinizing the project costs of organized piped water supplies using groundwater, overhead reservoir and seletal distribution system for communities with population range between 10,000 and 70,000 and nett density of population range between 5 and 60 following significant conclusions are listed:

(i) The cost of system components such as storage (overhead reservoir), source (tubewell), pump and other associated accessories increase proportionately with population;

(ii) The cost of distribution is about 70 per cent of the total systems cost;

(iii) The distribution and the total systems cost exhibit a minimum at an optimal range of density of population (nett) which varies for the schemes investigated between 35 and 45 persons per acre;

(iv) The *per capita* systems cost (total). which ranges between Rs. 60/- and Rs. 260/-, decreases with increase in density of population (nett) and indicates no perceptible change beyond the optimal density range. The *per capita* systems cost (total) at and beyond optimal density of population (nett) is about Rs. 70/- (1975 price index).

11. SIGNIFICANCE OF THIS STUDY

The Planning Commission of Government of India is busy drawing sixth Plan Programme. Many medium and small towns are awaiting organized piped water supply as may be seen from Table 4 below.[4]

TABLE 4: NUMBER OF TOWNS AND POPULATION RANGING 10,000 — 70,000 HAVING NO PIPED WATER SUPPLY

Class	Population range '000	No. of towns	Population (in lakhs)
II	50 — 99	15	22
III	20 — 49	110	48
IV	10 — 19	339	55
TOTAL		464	125

The Planning Commission has provided an outlay of Rs. 815 crores in the draft Sixth Plan[5] for the urban water supply and sewerage sector. To optimise the resource utilisation, towns where population density has reached an optimal figure of 35 ppa or more should be accepted for piped water supply schemes. Assuming population increase as an inevitable phenomenon in all these towns the density criteria may be lowered to 30 persons per acre for recommending a town for organized piped water supply. Towns having lower density should still be considered for supplies from spot wells unless ofcourse groundwater is non-available, brackish or chemically not accepted.

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