**INDIAN WATER WORKS ASSOCIATION**

# MANUAL

## ON

## WATER DEMAND ASSESSMENT

## FOR URBAN WATER SUPPLY PROJECTS

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# For Urban Water Supply Projects

## 1.0 BACKGROUND

Water demand assessment has been an integral part of various feasibility studies, detailed project reports and master plans being prepared for water supply projects in the urban sector. Formulation of proposals for rehabilitation or augmentation of water supply facilities requires the water demand for consumers in the project service area to be identified to the required accuracy. In the case of minor schemes of relatively smaller magnitudes or at pre-feasibility stage of relatively major schemes, the water demand assessment could be based on per capita water demand rates recommended in the publications of CPHEEO, Indian Standards or other Government Water authorities. For water supply projects of larger magnitude for cities and towns and especially where the projects need to be posed to financial institutions for loan assistance, it is necessary to conduct a detailed basic study for realistic assessment of water demand for the project service area. A great emphasis is laid on this aspect during technical appraisal of such projects by financial institutions. In short, these financial institutions ascertain that the water demand assessment for the project is based on actual field studies and not on any ready per capita figures available elsewhere. Various techniques for assessment of water demand are being used during project preparation. A need was felt for writing a manual which will share the knowledge of methodology adopted and the techniques used on various projects with fellow water supply engineers who may be called upon to prepare water supply projects for eventual appraisal by financial institutions and hence this manual. An attempt has been made herein to identify the techniques used for population forecasting and in conducting field studies for collecting data on domestic and non-domestic water demand for the service area of proposed water supply projects and in statistically analysing the field data for a realistic assessment of water demand.

### 1.1 General

Water demand is normally classified as domestic water demand and non-domestic water demand. Domestic water demand covers use of water for drinking, washing, bathing, cooking and flushing i.e. for domestic purposes. Non-domestic water demand covers the use of water mostly for public purposes such as hospitals, hotels, educational institutions, offices, commercial establishments, railway stations, airports, gardens, swimming pools, theatres and fire fighting etc.

Water demand is necessarily assessed for 100% satisfaction of the consumers. Under constrained resources, water is allocated to consumers and the actual water supply thus may not be able to meet the demand. Since most of the water supply schemes have to be generally designed to meet the water demand in the long run, it is necessary to estimate the water demand on 100% satisfaction basis. Design of system components is usually carried out for the critical scenario which could be the ultimate scenario based on 100% satisfaction of demand or any of the intermediate scenarios based on water allocation and partial satisfaction of demand.

It is therefore necessary to assess domestic water demand and non-domestic water demand on a basis of full satisfaction of consumers. The actual approach and the methodology used for such assessment depends upon local conditions and on the type of information / ready data available in each case.

## 2.0 METHODS FOR FORECASTING POPULATION

It is necessary to have inputs of population forecasts for the service area of a project before water demand assessment can be made. There are a number of alternate methods to forecast future population for urban / rural service areas. It is not always possible to make accurate population forecasts except for immediate future. However, it is advisable to use these methods to have alternate population forecasts and then select one of them for use in water demand assessment. The choice will be mostly governed by an in-depth knowledge of the characteristics of the service area in terms of its past growth, existing ward wise population densities, degree of saturation reached in terms of the densities by some wards, availability of infrastructure facilities, present and future land use employment opportunities, degree of industrialisation etc. Considering the above background information, it may be possible to have reasonably sound population forecasts for immediate future and relatively approximate forecasts for distant future.

It must be remembered that the population forecasts for distant future will lead to a general idea of the overall picture of water supply / sewerage system needed in the long run. The system to be executed will be generally for the initial phase for immediate future for which the population forecasts can be reasonably sound. The overall system identified based on the approximate forecasts of population for distant future allows the designer to ensure that the initial phase system which is going to be executed fits the overall system in the long run. In any case, for execution of additional system at a later stage the exercise of overall population forecasting is repeated all over again. Following paragraphs describe various methods of forecasting population with worked examples.

## 2.1 Arithmetic Increase Method

Based on past population data, this method works out an average arithmetic increment in population per decade and uses this increment to forecast future population. **Table 1** depicts the method of forecasting population by this method.

**TABLE 1 : POPULATION FORECAST BY ARITHEMETIC INCREASE METHOD**

| **Past Population of a Typical City** | | |
|---|---|---|
| **YEAR Y** | **Population X** | **Arithmetic increment / decade** |
| 1941 | 9,50,541 | -- |
| 1951 | 11,38,650 | 1,88,109 |
| 1961 | 13,30,758 | 1,92,108 |
| 1971 | 15,10,866 | 1,80,108 |
| 1981 | 16,90,184 | 1,79,318 |
| 1991 | 19,01,082 | 2,10,898 |
| | | Arithmetic mean increment = 1,90,108 |

Population (2001) = Population (1991) + mean increment

= 19,01,082 + 1,90,108 = 20,91,190

Population (2011) = Population (1991) + 2 x mean increment

= 19,01,082 + 2 (1,90,108)

= 22,81,298

## 2.2 Geometric Increase Method

This method presupposes that the population growth takes place in a geometric progression rather than a simple linear arithmetic progression. Thus, forecasting of population can be carried out by using the arithmetic increase method to deal with logarithms of population. **Table 2** depicts forecasting of population by this method.

**TABLE 2 : POPULATION FORECAST BY GEOMETRIC INCREASE METHOD**

| **Past Population of a Typical City** | | | |
|---|---|---|---|
| **Year Y** | **Population X** | **Log $_{10}$ x** | **Increement / decade** |
| 1941 | 9,50,541 | 5.978 | -- |
| 1951 | 11,38,650 | 6.056 | 0.078 |
| 1961 | 13,30,758 | 6.124 | 0.068 |
| 1971 | 15,10,866 | 6.179 | 0.055 |
| 1981 | 16,90,184 | 6.228 | 0.049 |
| 1991 | 19,01,082 | 6.279 | 0.051 |
| | | | Average Increment/ decade = 0.0602 |

Log Population (2001) = Log Population (1991) + mean increment

= 6.279 + 0.0602 = 6.3392

Population (2001) = 21,83,735

Log Population (2011) = Log Population (1991) + 2 x mean increment

= 6.279 + 2 (0.0602)

= 6.3994

Population (2011) = 25,08,418

## 2.3 Geometric Ratio Method

This method is similar to Geometric Increase Method. Geometric ratios of consecutive decadal populations are formed and averaged out. Future population is forecast by compounding the latest population using the above average geometric ratio. In another version of the method, only the latest geometric ratio is considered for forecasting future population. The method is depicted in **Table 3**.

**TABLE 3 : POPULATION FORECAST BY GEOMETRIC RATIO METHOD**

| Past Population of a typical city | | Population Ratio |
|---|---|---|
| **Year Y** | **Population X** | |
| 1941 | 9,50,541 | --- |
| 1951 | 11,38,650 | 11,38,650 / 9,50,541 = 1.198 |
| 1961 | 13,30,758 | 13,30,758 / 11,38,650 = 1.169 |
| 1971 | 15,10,866 | 15,10,866 / 13,30,758 = 1.135 |
| 1981 | 16,90,184 | 16,90,184 / 15,10,866 = 1.119 |
| 1991 | 19,01,082 | 19,01,082 / 16,90,184 = 1.125 |
| | | Latest ratio = 1.125<br>Average ratio = 1.1492 |

a) Average Geometric Ratio Method

Population (2001) = Population (1991) x average ratio

= 19,01,082 x 1.1492 = 21,84,723

Population (2011) = 19,01,082 x $(1.1492)^2$ = 25,10,684

b) Latest Geometric Ratio Method

Population (2001) = Population (1991) x latest ratio

= 19,01,082 x 1.125 = 21,38,717

Population (2011) = 19,01,082 x $(1.125)^2$ = 24,06,057

## 2.4 Incremental Increase Method

This is a modification over the Arithmetic Increase Method. After computing the arithmetic increments in consecutive decades, the increments in above consecutive increments are also recognised and considered. Thus population forecasts are prepared by considering the latest population as the starting point and adding to the same not only the average increment of decadal population but also the average increment in above increments. **Table 4** depicts this method.

**TABLE 4 : POPULATION FORECAST BY INCREMENTAL INCREASE METHOD**

| Past Population of a typical city | | Arithmetic Increment / decade | Incremental Increase / decade |
|---|---|---|---|
| **Year Y** | **Population X** | | |
| 1941 | 9,50,541 | --- | --- |
| 1951 | 11,38,650 | 1,88,109 | --- |
| 1961 | 13,30,758 | 1,92,108 | + 3,999 |
| 1971 | 15,10,866 | 1,80,108 | - 12,000 |
| 1981 | 16,90,184 | 1,79,318 | - 790 |
| 1991 | 19,01,082 | 2,10,898 | + 31,580 |
| | | Average Increment = 1,90,108 | Average Incremental Increase = 5,697 |

Population (2001) = Population (1991) + Average Increment + Average incremental increase
= 19,01,082 + 1,90,108 + 5,697
= 20,96,887

Population (2011) = Population (1991) + 2 (Average Increment) + Average incremental increase + 2 (Average incremental increase)
= 19,01,082 + 2 (1,90,108) + 5,697 + 2 (5,697)
= 22,98,389

## 2.5 Logistic Method

This method presupposes that the population trend will be S-Shaped which combines a geometric growth rate at low population with a declining growth rate as the city approaches limiting population. The logistic projection can be based on the equation :

$$P = \frac{P\ sat}{1 + e^{a+b\Delta t}}$$

where, P sat is the saturation population of the community, a and b are constants and $\Delta t$ is the period beyond base year corresponding to Po. Psat, a and b can be determined from three consecutive census populations and using the following equation :

$$Psat = \frac{2\ Po\ P_1\ P_2 - P_1^2\ (Po + P_2)}{PoP_2 - P_1^2}$$

$$a = Log_e \left( \frac{Psat - P_2}{P_2} \right)$$

$$b = \frac{1}{n}\ Log_e \left( \frac{Po\ (Psat - P_1)}{P_1\ (Psat - Po)} \right)$$

where 'n' is the time interval between succeeding censuses.

The method is illustrated in **Table 5**.

## TABLE 5 : POPULATION FORECAST BY LOGISTIC METHOD

| Past Population data for a city | |
|---|---|
| **Year Y** | **Population X** |
| 1971 | 1,13,302 |
| 1981 | 1,65,205 |
| 1991 | 2,35,661 |

$P_o$ = 1,13,302, $P_1$ = 1,65,205, $P_2$ = 2,35,661

for forecasting population in 2031, $\Delta t$ = 2031 - 1971 = 60 years

$$Psat = \frac{2\,P_oP_1P_2 - P_1^2\,(P_o + P_2)}{P_oP_2 - P_1^2}$$

$$= \frac{2 \times 1.133 \times 1.652 \times 2.357 - 1.652^2\,(1.133 + 2.357)}{1.133 \times 2.357 - 1.652^2}$$

$$= 11.9676 \text{ lakh}$$

$$a = \text{Log}_e \left( \frac{Psat - P_2}{P_2} \right) = \text{Log}_e \left( \frac{1.9676 - 2.3566}{2.3566} \right)$$

$$= 1.4057$$

$$b = \frac{1}{n}\,\text{Log}_e \left( \frac{P_o\,(Psat - P_1)}{P_1\,(Psat - P_o)} \right)$$

$$= \frac{1}{10}\,\text{Log}_e \left( \frac{1.133\,(11.9676 - 1.652)}{1.6521\,(11.9676 - 1.133)} \right)$$

$$= -0.04263$$

$$P_{2031} = \frac{P\,sat}{1 + e^{a + b\,\Delta t}}$$

$$= \frac{11.9676}{1 + e^{1.4057 - 0.04263 \times 60}}$$

$$= 9.094 \text{ lakh}$$

## 2.6 Ratio Method

The ratio method of forecasting population relies on the population projections made by professional demographers for the state. The method is based on the assumption that the ratio of the population of the city being studied to that of the larger region will continue to change in future in the same manner that has occurred in the past. The ratio is calculated for a series of censuses, the trend line is projected into the future and the projected ratio is multiplied by the already projected state population to obtain the city's population in the year of interest. This method is demonstrated in **Table 6**.

**TABLE 6 : POPULATION FORECAST BY RATIO METHOD**

| Past population data and population forecasts for a state | | Past Population Data for a City | | Ratio of City Population to State Population |
|---|---|---|---|---|
| **Year** | **Population** | **Year** | **Population** | |
| 1951 | 84,50,931 | 1951 | 8,30,000 | 0.0982 |
| 1961 | 95,23,520 | 1961 | 9,10,000 | 0.0956 |
| 1971 | 1,10,52,350 | 1971 | 10,50,000 | 0.0950 |
| 1981 | 1,25,23,530 | 1981 | 11,21,000 | 0.0895 |
| 1991 | 1,51,38,191 | 1991 | 12,05,000 | 0.0796 |
| 2001 | 1,80,50,230 | | | Trend 0.0717 |
| 2011 | 2,10,93,313 | | | Forecast 0.0643 |

**Fig. 1** shows the graph of the Ratio of City population to State population against years. The trend is extended up to the year 2011. The ratios for 2001 and 2011 read from the trend are 0.076 and 0.068 respectively. The projected population for future years for the City are as follows :

Population (2001) = 0.0717 x 1,80,50,230

= 12,94,201

Population (2010) = 0.0643 x 2,10,93,313

= 13,56,300

## 2.7 Shift & Share Method

This is similar to the ratio method described above. In this method, the overall population projections for the nation are available and past population data for the State, District and the City are available. The method is applied by considering the nation as a larger entity and the state as a smaller entity. The ratio trend of state to nation is extended and future population of the state is estimated by applying this trend to already forecast nation population for future. In the next step, the method is applied to the district as the smaller entity and state as the larger entity. This is again repeated for the city as the smaller entity and the district as a larger entity.

## 2.8 Graphical Trend Method

In this method a graph is drawn of the past population of a city against the years and the same is extended by eye judgement. The future population is then read on this graph. **Fig. 2** depicts this method.

## 2.9 Comparative Graphical Trend Method

In this method, past population data of minimum two cities 'A' and 'B' similar in their character to the city 'C' whose population needs to be forecast are selected. It is necessary for the cities 'A' and 'B' to have larger populations than that for 'C'. This means that cities 'A' & 'B' have reached the present level of population in city 'C' quite earlier in the past and have grown further to have populations larger than that in city 'C'. This enables one to know the growth trends of cities 'A' & 'B' beyond the present population level of city 'C' and it is then possible to identify an average trend for population growth for city 'C'. **Fig. 3** shows a graph of population growths in City 'A' and City 'B'. These cities had reached the 1991 population level of City 'C' namely 2.36 Lakh in 1955 and 1958 respectively. In the graph, the growth curves for City 'A' and City 'B' beyond 1955 and 1958 have been shifted parallel to themselves, extended further up to year 2031 and attached at the 1991 end of City 'C' growth curve. An average trend between the above trends has been interpolated and future populations have been read from this average trend as given in **Table 7**.

**TABLE 7 : POPULATION FORECAST BY COMPARATIVE GRAPHICAL TREND FOR CITY 'C'**

| Year | Projected Population (Lakh) |
|---|---|
| 2001 | 3.32 |
| 2011 | 4.47 |
| 2021 | 5.51 |
| 2031 | 6.23 |

## 2.10 Ward-wise Population Projections

The design of water distribution systems/sewerage systems would require inputs in terms of projected ward-wise populations in the city. If past data of ward-wise population are available, the methods described above can be used in forecasting ward-wise future populations.

## 3.0 DOMESTIC WATER DEMAND GUIDELNES

As mentioned earlier, the domestic water demand could be assessed based on guidelines given in the publications of CPHEEO or Indian Standards for minor schemes of relatively smaller magnitudes or at pre-feasibility stages of relatively major schemes. **Table 8** gives the water requirements for domestic purposes as per I.S. 1172. It is seen that I.S. recommends 40 lpcd to 200 lpcd of domestic water needs based on the population in the service area. The recommendations of CPHEEO are given in **Table 9** . However it appears that the lpcd rates given by CPHEEO cover domestic needs as well as non-domestic needs if the latter are reasonable and moderate. In the cases where the non-domestic needs are heavy, CPHEEO recommends additional water demand to be considered.

**TABLE 8 : WATER SUPPLY FOR RESIDENCES**

| | | |
|---|---|---|
| 1) | For communities with population up to 20 000 and without flushing system | |
| | a) water supply through stand post | 40 lpcd ( Min ) |
| | b) water supply through house service connection | 70 to 100 lpcd |
| 2) | For communities with population 20,000 to 100,000 together with full flushing system | 100 to 150 lpcd |
| 3) | For communities with population above 100 000 together with full flushing system | 150 to 200 lpcd |

NOTE - The values of water supply given as 150 to 200 litres per head per day may be reduced to 135 litres per head per day for houses for Lower Income Groups (LIG) and Economically Weaker Section of Society (EWS), depending upon prevailing conditions.

**Ref : Code of Basic Requirements for Water Supply, Drainage and Sanitation I.S. 1172 : 1993**

| TABLE 9 : DOMESTIC AND NON-DOMESTIC USE | | |
|---|---|---|
| RECOMMENDED PER CAPITA WATER SUPPLY LEVELS FOR DESIGNING SCHEMES | | |
| **S.No.** | **Classification of towns / cities** | **Recommended Maximum Water Supply Levels (lpcd)** |
| 1. | Towns provided with piped water supply but without sewerage system | 70 |
| 2. | Cities provided with piped water supply where sewerage system is existing/ contemplated | 135 |
| 3. | Metropolitan and Mega cities provided with piped water supply where sewerage system is existing/ contemplated | 150 |

**Note :**

(i) In urban area, where water is provided through public standposts, 40 lpcd should be considered;

(ii) Figures exclude "Unaccounted for Water (UFW)" which should be limited to 15%

**Ref : Manual on Water Supply & Treatment, CPHEEO May, 1999**

## 4.0 DOMESTIC WATER DEMAND SURVEY

Field Surveys for water demand assessment need to be carried out for large projects, especially where they are to be posed for loan assistance from financial institutions. Present domestic water consumption for a service area forms the basis for estimating the future water demand for the same. The present water consumption is estimated by conducting field studies on samples of population after classifying the same as per housing categories. It is necessary to select areas where the demand satisfaction is assessed to be very good. The sample size should be as large as possible. However, it may not be always possible to locate sufficiently large sample of a given housing category in a locality. Constraints in the form of non-working meters and time available at disposal, also operate. Following housing categories have been considered in the studies carried out in the past.

(a) Bungalows with attached gardens/lawns

(b) Bungalows without gardens / lawns

(c) Traditional houses

(d) Flats

(e) Chawls

(f) Slums

Final selection of categories depends upon local conditions and may differ from city to city. Water supply projects for urban centres most of the times also cover adjoining smaller suburbs/groups of villages etc. The housing categories may have to be reduced, accordingly for these areas. A thorough knowledge of the type of housing in the project service area is necessary to identify the housing categories to be considered in the survey.

The number of houses of each category to be surveyed depends upon the desired accuracy. In the past, as few as 50 houses of a category have yielded fairly accurate estimates of water demand for the same. If possible, the number should be on the larger side. In a typical case, about 350 houses of a category have been surveyed yielding excellent estimates of the water demand. In case of flats system, a co-operative society consisting of number of buildings housing several flats per building may be selected if available. The houses have to have working water meters otherwise the same can be replaced/installed. In the case of housing societies having similar category of houses/flats, a single meter for the whole society is adequate.

A questionnaire is normally prepared and filled in by the investigator to record the number of persons staying in the house during the survey and the amount of water normally drawn by the household from any alternate source such as well etc. Consumer meter readings are taken initially and after a minimum period of a fortnight. This leads to the estimation of per capita per day consumption / demand for each household. A typical format for such a questionnaire is given in Annexure A.

The above survey is repeated for other housing categories in the project service area. Specific statistical techniques need be used in drawing meaningful conclusions from the water consumption data generated in the above domestic consumption field surveys.

Following useful statistical techniques have been described below with the help of typical case studies.

(a) Estimation of representative per capita domestic water consumption rates for various categories of housing.

(b) Justification of housing categories for classifying consumption data.

(c) Comparison between ledger data and field survey data.

## 4.1 Representative Consumption Rates

**Table 10** gives typical data obtained from water consumption survey of 213 houses. The aim is to identify representative consumption rates for various categories of houses as a pre-requisite for water demand forecasts. The measures of central tendency such as mean and medium would indicate the representative consumption rate for a given category. However we have to select between them for this purpose. This is accomplished by computing the Pearsons's first coefficient of skewness 'Jp' for various frequency distributions representing the four categories. 'Jp' is computed as given in **Table 11** for the above typical data.

**TABLE 10 : TYPICAL FREQUENCY DISTRIBUTION FOR WATER CONSUMPTION DATA**

| Class Interval Lpcd | Number of Houses | | | |
|---|---|---|---|---|
| | Bungalows With Gardens | Bungalows Without Gardens | Traditional House | Flats |
| 0-25 | 0 | 0 | 0 | 0 |
| 25-50 | 0 | 0 | 0 | 0 |
| 50-75 | 0 | 0 | 6 | 0 |
| 75-100 | 0 | 3 | 7 | 9 |
| 100-125 | 6 | 5 | 19 | 5 |
| 125-150 | 4 | 5 | 15 | 8 |
| 150-175 | 5 | 6 | 9 | 4 |
| 175-200 | 6 | 3 | 10 | 4 |
| 200-225 | 7 | 2 | 5 | 2 |
| 225-250 | 13 | 2 | 2 | 4 |
| 250-275 | 3 | 1 | 0 | 4 |
| 275-300 | 5 | 2 | 0 | 1 |
| 300-325 | 3 | 4 | 0 | 3 |
| 325-350 | 3 | 2 | 0 | 0 |
| 350-375 | 3 | 3 | 0 | 0 |
| 375-400 | 0 | 0 | 0 | 0 |
| $\sum fi$ | 58 | 38 | 73 | 44 |

$$Jp = \frac{\text{Mean - Mode}}{\text{Standard deviation}}$$

| TABLE 11 : STATISTICAL PARAMETERS FOR VARIOUS HOUSING CATEGORIES | | | | |
|---|---|---|---|---|
| | Categories | | | |
| Parameters | **Bungalows With Gardens** | **Bungalows Without Gardens** | **Traditional Houses** | **Flats** |
| Mean (lpcd) | 225.4 | 205.3 | 139.7 | 172.1 |
| Median (lpcd) | 226.9 | 175.0 | 127.4 | 150.0 |
| Mode (lpcd) | 235.4 | 157.3 | 119.8 | 93.3 |
| Stand Deviation (lpcd) | 71.4 | 87.3 | 44.2 | 71.0 |
| Pearson's first coefficient of skewness, Jp | -0.14 | 0.55 | 0.45 | 1.11 |

The distributions are not symmetrical. Their skewness is measured by the magnitude of the Pearson's first coefficient of skewness Jp. If Jp $\leq 1$ then the distributions are moderately skewed and the mean represents the distribution. In case Jp $\geq 1$ the skewness is not moderate and median will be the representative value for the distribution. It is therefore concluded that the consumption rates for bungalows with and without gardens and traditional houses can be taken to be the mean values of their distributions, while the same for flats can be taken as the median value of the distributions. Based on these conclusions, demand forecasts can be then prepared.

## 4.2 Justification Of Housing Categories

Consumers are normally categorised presuming that the water consumption rates will hopefully differ from each other for these categories. The representative values for these categories as computed above may appear different from each other. It is however necessary to know if the difference amongst representative values is statistically significant to justify their classification under different categories. If not so, then some of the categories could be merged together thus reducing the number of categories. This situation can be sorted out by using the technique known as Analysis of Variance. The methodology is explained below in a typical case study.

**Table 12** shows various statistical parameters in a typical consumption survey of 858 houses. The parameters have been computed in following steps.

(a) Means for individual categories are computed. ( $\overline{X1}$, $\overline{X2}$, $\overline{X3}$, $\overline{X4}$ and $\overline{X5}$ )

(b) Group mean is computed for all 858 houses taken together. ( $\overline{X}$ )

(c) Variations between samples and within samples are computed by using formulae given in **Table 12**.

(d) SUMA and SUMB are calculated by summing up the values of variations between samples and variations within samples respectively.

(e) Degrees of freedom D1 are calculated as No. of Categories-1.

(f) Degree of freedom D2 are calculated as total number of observations - number of categories.

(g) Parameters C & D are computed by dividing SUMA and SUMB by their degrees of freedom D1 and D2 respectively.

(h) Parameter F for 'F' distribution is estimated by dividing C by D.

(i) The above estimated parameter F is then compared with the interpolated value of F from standard **Table 13** for 'F' distribution for degrees of freedom D1 and D2.

| TABLE 12 : ANALYSIS OF VARIANCE | | | | | | |
|---|---|---|---|---|---|---|
| **Housing Categories** | | | | | | |
| | **Bungalows with gardens** | **Bungalows without gardens** | **Traditional Houses** | **Flats** | **Slum** | **Total No. of observations** |
| Number of Houses | $\sum f1i=57$ | $\sum f2i=344$ | $\sum f3i=128$ | $\sum f4i=133$ | $\sum f5i=196$ | = 858 |
| Mean | $\overline{X1} = 279.3$ | $\overline{X2}=223.9$ | $\overline{X3}=161.8$ | $\overline{X4}=147.5$ | $\overline{X5}=119.0$ | |
| Group Mean | ← $\overline{X} = 182.5$ → | | | | | |
| Variation between samples | $\sum f1i.(\overline{X1}-\overline{X})^2$ =534104 | $\sum f2i.(\overline{X2}-\overline{X})^2$ =589602 | $\sum f3i.(\overline{X3}-\overline{X})^2$ =54847 | $\sum f4i.(\overline{X4}-\overline{X})^2$ =162925 | $\sum f5i.(\overline{X5}-\overline{X})^2$ =790321 | = SUMA 2131799 |
| Variation within individual samples | $\sum f1i.(X1-\overline{X1})^2$ =2525668 | $\sum f2i.(X2-\overline{X2})^2$ =6844715 | $\sum f3i.(X3-\overline{X3})^2$ =1380957 | $\sum f4i.(X4-\overline{X4})^2$ =1560896 | $\sum f5i.(X5-\overline{X5})^2$ =1194329 | =SUMB 13506565 |

D1 = No. of categories-1 = 5 -- 1 = 4

D2 = Total number of observations-Number of categories
= 858-5 = 853

SUMA = Total variation between samples

SUMB = Total variation within individual samples

$$C = \frac{SUMA}{D1} = \frac{2131799}{4} = 532950$$

$$D = \frac{SUMB}{D2} = \frac{13506565}{853} = 15834$$

$$F = \frac{C}{D} = \frac{532950}{15834} = 33.66$$

From **Table 13** for 5% points for F Distribution for D1=4 & D2=853, F 0.05 = 2.4 < 33.66
Hence there is significant difference amongst sample means and the categories are justified

**TABLE 13 : 5% POINTS OF FISHER'S F - DISTRIBUTION**

| D1 / D2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 101.45 | 199.50 | 215.71 | 224.58 | 230.16 | 233.99 | 236.77 | 238.88 |
| 2 | 18.513 | 19.000 | 19.154 | 19.247 | 19.290 | 19.330 | 19.353 | 19.371 |
| 3 | 10.126 | 3.3567 | 3.2039 | 3.0948 | 9.0123 | 2.9480 | 8.8808 | 8.8452 |
| 4 | 7.7086 | 6.9445 | 6.5914 | 6.5883 | 6.2500 | 6.1631 | 6.0942 | 6.0410 |
| 5 | 5.0079 | 5.7861 | 5.4095 | 5.1922 | 5.0503 | 4.9503 | 4.8750 | 4.8183 |
| 6 | 5.9874 | 5.1433 | 4.7571 | 4.5337 | 4.3874 | 4.2839 | 4.2055 | 4.1400 |
| 7 | 5.5914 | 4.7374 | 4.3468 | 4.1203 | 3.9715 | 3.8500 | 3.7870 | 3.7257 |
| 8 | 5.3177 | 4.4590 | 4.0062 | 3.8378 | 3.6875 | 3.5800 | 3.5005 | 3.4341 |
| 9 | 5.1174 | 4.2565 | 3.8026 | 3.6331 | 3.4817 | 3.3738 | 3.2927 | 3.2290 |
| 10 | 4.9045 | 4.1028 | 3.7083 | 3.4780 | 3.3238 | 3.2172 | 3.1355 | 3.0717 |
| 11 | 4.8443 | 3.9823 | 3.6874 | 3.3567 | 3.2039 | 3.0948 | 3.0123 | 2.9480 |
| 12 | 4.7472 | 3.8853 | 3.4903 | 3.2502 | 3.1059 | 2.9961 | 2.9134 | 2.8480 |
| 13 | 4.5672 | 3.8056 | 3.4105 | 3.1791 | 3.0254 | 2.9153 | 2.8321 | 2.7058 |
| 14 | 4.5001 | 3.7380 | 3.3439 | 3.1122 | 2.9582 | 2.8477 | 2.7542 | 2.0987 |
| 15 | 4.5431 | 3.0823 | 3.2874 | 3.0538 | 2.9012 | 2.7005 | 2.7000 | 2.5408 |
| 16 | 4.4940 | 3.6337 | 3.2389 | 3.0069 | 2.8524 | 2.7413 | 2.6572 | 2.5911 |
| 17 | 4.4513 | 3.5916 | 3.1908 | 2.9647 | 2.8100 | 2.0987 | 2.6143 | 2.5480 |
| 18 | 4.4139 | 3.5546 | 3.1699 | 2.9277 | 2.7720 | 2.6613 | 2.5707 | 2.5101 |
| 19 | 4.3808 | 3.5219 | 3.1274 | 2.8951 | 2.7401 | 2.6263 | 2.5435 | 2.4768 |
| 20 | 4.3513 | 3.4928 | 3.0084 | 2.8661 | 2.7100 | 2.5990 | 2.5140 | 2.4471 |
| 21 | 4.6248 | 3.4668 | 3.0725 | 2.8401 | 2.6848 | 2.5727 | 2.4870 | 2.4205 |
| 22 | 4.3009 | 3.4434 | 3.0491 | 2.6167 | 2.6613 | 2.5491 | 2.4638 | 2.3965 |
| 23 | 4.2793 | 3.4221 | 3.0280 | 2.7955 | 2.6400 | 2.5277 | 2.4422 | 2.3748 |
| 24 | 4.2597 | 3.4028 | 3.0088 | 2.7763 | 2.6207 | 2.5082 | 2.4220 | 2.3551 |
| 25 | 4.2417 | 3.3852 | 2.9912 | 2.7687 | 2.6030 | 2.4904 | 2.4047 | 2.8371 |
| 26 | 4.2252 | 3.3090 | 2.9751 | 2.7420 | 2.5868 | 2.4741 | 2.3883 | 2.3205 |
| 27 | 4.2100 | 3.3541 | 2.9504 | 2.7278 | 2.5719 | 2.4591 | 2.3732 | 2.3053 |
| 28 | 4.1950 | 3.3404 | 2.9467 | 2.7141 | 2.5581 | 2.4453 | 2.3593 | 2.2913 |
| 29 | 4.1830 | 3.3277 | 2.9340 | 2.7014 | 2.5454 | 2.4324 | 2.3489 | 2.2782 |
| 30 | 4.1709 | 3.3158 | 2.9223 | 2.0896 | 2.5338 | 2.4205 | 2.3343 | 2.2662 |
| 40 | 4.0846 | 3.2317 | 2.8337 | 2.0000 | 2.4495 | 2.3359 | 2.2490 | 2.1802 |
| 60 | 4.0012 | 3.1504 | 2.7581 | 2.5003 | 2.3689 | 2.2540 | 2.1665 | 2.0910 |
| 120 | 3.9201 | 3.0718 | 2.6802 | 2.4472 | 2.2900 | 2..1750 | 2.0867 | 2.0104 |
| ∞ | 3.8415 | 2.9957 | 2.6049 | 2.3719 | 2.2141 | 2.0985 | 2.0098 | 1.9384 |

(j) In case the interpolated value of 'F' from **Table 13** is less than the above estimated value of 'F' then it is inferred that there is statistically significant difference amongst sample means and the categorisation adopted is justified. In case the interpolated value of 'F' is greater than the estimated value of 'F' then there is no significant difference amongst the means for various categories and merging of some categories will be justified. Merging can be attempted on a trial and error basis and above technique can be again used to draw inferences.

## 4.3 <u>Comparison Between Ledger Data And Survey Data</u>

It is possible to statistically compare the observed water consumption data generated in the field survey with ledger readings noted down by the water meter readers of the Municipal / Water Board Authority for similar season for a given category of consumers and draw suitable inferences. For this, it is necessary to use a statistical technique to find out whether there is statistically significant difference between the means of the two distributions, namely the observed consumption mean in the field survey and the mean of the recorded ledger readings available with the authority on a probability level of say 99%. The procedure is presented below for a case study.

**Table 14** shows the frequency distribution prepared from data gathered in a locality from a typical consumption survey of 216 traditional houses and also data collected from ledger records of the client for 177 traditional houses located in the same area where the actual survey was carried out. The aim is to find out whether there is statistically significant difference between the mean consumption rates as evolved by the survey and those computed from ledger data. Various steps involved in the technique are as follows :

(a) Compute means $\overline{X1}$ and $\overline{X2}$ and standard deviations $\sigma 1$ and $\sigma 2$

(b) Compute factor Z as shown in **Table 15.** Ninety nine percent area under a standard normal curve is covered when $Z = 2.58$

In case $Z > 2.58$ then it is inferred that there is a significant difference between means otherwise there is no significant difference on a 99% probability level (**Table 15**).

In this case study, it is seen that there is significant difference between the mean consumption rates as observed by field survey and as computed from the ledger data at a 99% probability level. The observed mean consumption from field survey is 216 Lpcd which is larger than 177 Lpcd which is the mean consumption computed using ledger records. It would be necessary for the municipal authority to investigate and monitor meter reading operations in this case.

**TABLE 14 : OBSERVED & LEDGER WATER CONSUMPTION RATES FOR TRADITIONAL HOUSES**

**Consumption Rates for Traditional Houses**

| Interval, Lpcd | Observed Frequency Fi | Ledger Frequency FI |
|---|---|---|
| 0-25 | 0 | 5 |
| 25-50 | 3 | 20 |
| 50-75 | 37 | 33 |
| 75-100 | 24 | 42 |
| 100-125 | 37 | 27 |
| 125-150 | 26 | 16 |
| 150-175 | 22 | 10 |
| 175-200 | 14 | 7 |
| 200-225 | 11 | 6 |
| 225-250 | 12 | 0 |
| 250-275 | 10 | 2 |
| 275-300 | 5* | 2 |
| 300-325 | 4 | 3 |
| 325-350 | 8 | 4 |
| 350-375 | 3 | 0 |
| | $\sum Fi = 216$ | $\sum FI = 177$ |
| | Mean $\overline{X1} = 151.62$ | Mean $\overline{X2} = 109.53$ |

Standard deviation $\sigma 1 = 79.70$

Standard Deviation $\sigma 2 = 68.59$

$$\textbf{Factor Z} = \frac{\left|\overline{X1} - \overline{X2}\right|}{\sqrt{\frac{\sigma 1^2}{\sum Fi} + \frac{\sigma 2^2}{\sum FI}}}$$

$= 5.62 > 2.58$ (**Table 15** )

There is significant difference between sample means

**TABLE 15 : AREA UNDER STANDARD NORMAL CURVE**

| Z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .0000 | .0040 | .0080 | .0120 | .0160 | .0199 | .0239 | .0279 | .0319 | .0359 |
| 0.1 | .0398 | .0438 | .0478 | .0517 | .0557 | .0596 | .0636 | .0675 | .0714 | .0753 |
| 0.2 | .0793 | .0832 | .0871 | .0910 | .0948 | .0987 | .1026 | .1064 | .1003 | .1141 |
| 0.3 | .1179 | .1217 | .1255 | .1293 | .1331 | .1368 | .1406 | .1443 | .1480 | .1517 |
| 0.4 | .1154 | .1591 | .1628 | .1664 | .1700 | .1736 | .1772 | .1808 | .1844 | .1879 |
| 0.5 | .1915 | .1950 | .1985 | .2019 | .2054 | .2088 | .2123 | .2157 | .2190 | .2224 |
| 0.6 | .2257 | .2291 | .2324 | .2357 | .2389 | .2422 | .2454 | .2486 | .2517 | .2549 |
| 0.7 | .2580 | .2611 | .2642 | .2673 | .2704 | .2734 | .2764 | .2794 | .2823 | .2852 |
| 0.8 | .2881 | .2910 | .2959 | .2967 | .2995 | .3023 | .3051 | .3078 | .3106 | .3133 |
| 0.9 | .3159 | .3186 | .3212 | .3238 | .3264 | .3289 | .3315 | .3340 | ..3365 | .3389 |
| 1.0 | .3413 | .3438 | .3461 | .3485 | .3508 | .3531 | .3554 | .3577 | .3599 | .3621 |
| 1.1 | .3643 | .3665 | .3686 | .3708 | .3729 | .3749 | .3770 | .3790 | .3810 | .3830 |
| 1.2 | .3849 | .3869 | .3888 | .3907 | .3925 | .3944 | .3962 | .3980 | .3997 | .4015 |
| 1.3 | .4012 | .4049 | .4066 | .4082 | .4099 | .4115 | .4131 | .4147 | .4162 | .4177 |
| 1.4 | .4192 | .4207 | .4222 | .4236 | .4251 | .4265 | .4279 | .4292 | .4306 | .4319 |
| 1.5 | .4332 | .4345 | .4357 | .4370 | .4382 | .4394 | .4406 | .4418 | .4429 | .4441 |
| 1.6 | .4452 | .4463 | .4474 | .4484 | .4495 | .4505 | .4515 | .4525 | .4535 | .4545 |
| 1.7 | .4554 | .4564 | .4573 | .4582 | .4591 | .4599 | .4606 | .4616 | .4625 | .4633 |
| 1.8 | .4641 | .4649 | .4656 | .4664 | .4671 | .4678 | .4686 | .4693 | .4699 | .4706 |
| 1.9 | .4713 | .4719 | .4726 | .4732 | .4738 | .4744 | .4750 | .4756 | .4761 | .4767 |
| 2.0 | .4772 | .4778 | .4783 | .4788 | .4793 | .4798 | .4803 | .4808 | .4812 | .4817 |
| 2.1 | .4821 | .4826 | .4820 | .4834 | .4838 | .4842 | .4846 | .4850 | .4854 | .4857 |
| 2.2 | .4861 | .4864 | .4868 | .4871 | .4875 | .4878 | .4881 | .4884 | .4887 | .4890 |
| 2.3 | .4893 | .4896 | .4898 | .4901 | .4904 | .4906 | .4909 | .4911 | .4913 | .4916 |
| 2.4 | .4918 | .4920 | .4922 | .4925 | .4927 | .4929 | .4931 | .4932 | .4934 | .4936 |
| 2.5 | .4938 | .4940 | .4941 | .4943 | .4945 | .4946 | .4948 | .4949 | .4951 | .4952 |
| 2.6 | .4953 | .4955 | .4956 | .4957 | .4959 | .4961 | .4962 | .4963 | .4963 | .4964 |
| 2.7 | .4965 | .4966 | .4967 | .4968 | .4969 | .4970 | .4971 | .4972 | .4973 | .4974 |
| 2.8 | .4974 | .4975 | .4976 | .4977 | .4977 | .4978 | .4979 | .4979 | .4980 | .4981 |
| 2.9 | .4981 | .4982 | .4983 | .4984 | .4984 | .4985 | .4985 | .4985 | .4986 | .4986 |
| 3.0 | .4987 | .4987 | .4987 | .4988 | .4988 | .4989 | .4989 | .4989 | .4990 | .4990 |

Area covered for z= 2.58 = 0.4951 x 2

= 0.9902

Say 99%

## 4.4 Domestic Water Demand Projections

The per capita representative water consumption rates for various housing categories as developed above can be used in consultation with population projections for estimating domestic water demand for specific areas in the service area. Where specific areas have a mix of housing categories, a weighted average per capita water consumption rate for all housing categories in the area can be worked out and used in the water demand projections. For improvements in living conditions, the water demand may be increased in future suitably (typical improvement could be 2.5 to 5% of domestic demand per decade). Seasonal variation could be accounted for if data are available. Urban centres, most of the times have surrounding rural areas which need to be considered in the service area. For surrounding villages, depending upon the living standards, the domestic water consumption would be a fraction of the urban rates and the same has to be assessed.

Rates of 70 to 75 percent of that for urban rates have been adopted in typical cases for surrounding rural areas. During future demand projections, it is prudent to consider about 5% increase per decade in the water consumption due to improvement in living conditions of people.

## 5.0 NON-DOMESTIC WATER DEMAND

This can be assessed based on water consumption data for various users based on I.S. / CPHEEO guidelines. For major projects, some of the data could be obtained by field measurements or by circulating questionnaires to various major consumers such as hotels, hospitals or other bulk consumers. Guidelines of I.S. 1172 are given in **Tables 16 and 17** and the same from CPHEEO are given in **Table 18**. Typical questionnaires to collect data from major consumers are given in Annexures B and C.

## 6.0 GROSS WATER DEMAND

Gross water demand for the project service area can be computed by adding the domestic and non-domestic water demand assessed using the above techniques and also considering the losses in the water treatment plants, transmission mains and the local distribution networks. Present leakage losses in the local distribution networks in most of the Indian Cities are very high. In a few typical cases 40% losses have been reported. In major metro cities, leakage monitoring operations and repairs to reduce leakages are in the on-going stage and future water demand projections should consider reduced leakages as a consequence of the above activities. In any case it would be almost impossible to have financially viable projects if the future leakages are not controlled by above measures. A typical future target could be 15% losses in the local distribution network which could be considered in projecting the gross water demand though, at times, the financial institutions might prefer 10%.

**TABLE 16 : WATER REQUIREMENTS FOR BUILDINGS OTHER THAN RESIDENCES**

| Sl No. | Type of Building | Consumption Per Day, litres |
|---|---|---|
| (1) | (2) | (3) |
| i) | Factories where bath rooms are required to be provided | 45 per head |
| ii) | Factories where no bath rooms are required to be provided | 30 per head |
| iii) | Hospital (including laundry) : | |
| | a) Number of beds not exceeding 100 | 340 per head |
| | b) Number of beds exceeding 100 | 450 per head * |
| iv) | Nurses' homes and medical quarters | 135 per head |
| v) | Hostels | 135 per head |
| vi) | Hotel | 180 per head * |
| vii) | Offices | 45 per head |
| viii) | Restaurants | 70 per seat |
| ix) | Cinemas, concert halls and theatres | 15 per seat |
| x) | Schools : | |
| | a) Day schools | 45 per head |
| | b) Boarding schools | 135 per head |

Ref : Code of Basic Requirements for Water Supply Drainage And Sanitation I.S. 1172 : 1993

* Remarks : In a typical sample survey following rates were observed

| | | |
|---|---|---|
| Hospitals (beds > 100) | - | 590 l/bed per day |
| Major hotels ( 3 star to 5 star) | - | 820 l/bed per day |
| Gardens | - | 80 kl / HA per day |
| Swimming Pools | - | 5% of treatment plant capacity |

**TABLE 17 : WATER SUPPLY FOR TRANSPORTATION CENTRES**

| | Nature of Station | Where Bathing Facilities are Provided litres / capita | Where Bathing Facilities are not Provided litres / capita |
|---|---|---|---|
| | a) Railways, bus stations and sea ports | | |
| i) | Intermediate stations (excluding mail and express stops) | 45 | 25 |
| ii) | Junction stations and intermediate Stations where mail or express stoppage is provided | 70 | 45 |
| iii) | Terminal stations | 45 | 45 |
| | b) Airports | | |
| | International and domestic airports | 70 | 70 |

NOTES :

1) The number of persons shall be determined by average number of passengers handled by the station daily; due consideration may be given to the staff and vendors likely to use facilities.

2) Consideration should be given for seasonal average peak requirements.

Ref : Code of Basic Requirements for Water Supply, Drainage and Sanitation I.S. 1172 : 1993.

| TABLE 18 : INSTITUTIONAL NEEDS | |
|---|---|
| **Institutions** | **Litres per head per day** |
| Hospital (including laundry) | |
| (a) No. of beds exceeding 100 | 450 (per bed) |
| (b) No. of beds not exceeding 100 | 340 (per bed) |
| Hotels | 180 (per bed) |
| Hostels | 135 |
| Nurses' homes and medical quarters | 135 |
| Boarding schools / colleges | 135 |
| Restaurants | 70 (per seat) |
| Air ports and sea ports | 70 |
| Junction Stations and intermediate stations where mail or express stoppage (both railways and bus stations) is provided | 70 |
| Terminal stations | 45 |
| Intermediate stations (excluding mail and express stops) | 45 (could be reduced to 25 where bathing facilities are not provided |
| Day schools / colleges | 45 |
| Offices | 45 |
| Factories | 45 (could be reduced to 30 where no bathing rooms are required to be provided). |
| Cinema, concert halls and theatres | 15 |

**Ref : Manual on Water Supply & Treatment CPHEEO May, 1999**

## 7.0 EFFECT OF PRICE ON WATER DEMAND

Studies have been carried out by a number of researchers on the influence of price of water on the demand for water. However most of the research work has been carried out for foreign cities and the results are not relevant in the Indian context. In most of the Indian Water Supply Projects, after the water demand is assessed on 100% satisfaction basis, water still has to be allocated and the demand is only partially satisfied due to paucity of available water sources. One can image water demand to be affected by price considerations if the same is already satisfied to the extent of almost 100% and then the consumers accepting some what reduced levels due to price hike of tariff. However, when the consumer get only partial satisfaction of their demands, by having water supply for a few hours (2 to 3 hours) in a day, the price hike in tariff may not affect their consumption significantly or may affect the same only marginally.

Researchers in the past have used the parameter 'Price Elasticity of demand' for measuring the influence of price on demand. It is defined as the percentage change in quantity consumed associated with 1% change in price. Typical price elasticity magnitudes as evolved by various researches range between – 0.21 to – 0.62.

In the Indian context, to make water supply projects financially viable, situations arise where the already low tariff may have to be hiked considerably say by 100 to 200%. If the above price elasticities are considered, then the water consumption rates would go down as shown in **Table 19.**

**TABLE 19 : INFLUENCE OF PRICE ELASTICITY ON DEMAND**

| Price Elasticity | Tariff Hike | Demand Reduction |
|---|---|---|
| – 0.21 | 100% | 21% |
| | 200% | 42% |
| – 0.62 | 100% | 62% |
| | 200% | 100% |

It is seen from the Table that the demand reduction figures of 42% and 62% appear to be very high and the last figure of 100% is absurd. This is because the price elasticity figures mentioned above are not suitable for the range of tariff hikes of the order suitable for Indian conditions. The price elasticity of – 0.21 and lower might be applicable under Indian conditions. However the same may have to be confirmed by research using data for Indian cities. A typical value such as – 0.05 to – 0.1 is suggested as an approximation estimate for use in the exercises of forecasting water demand under the influence of tariff hikes in future for projects.

## ANNEXURE - A

## SAMPLE QUESTIONNAIRE FOR DOMESTIC DEMAND ASSESSMENT

| S.No. | Item | | |
|---|---|---|---|
| 1. | Name of the Consumer | : | |
| 2. | Address / Ward No. | : | |
| 3. | Plot Size / Flat Size | : | |
| 4. | Meter number | : | |
| 5. | Housing Category * | : | I / II / III / IV / V |
| 6. | Number of Storeys | : | 1 / 2 / 3 / 4 / multi-storeyed |
| 7. | Number of rooms | : | |
| 8. | Number of persons residing | : | |
| 9. | Number of taps | : | |
| 10. | Meter working ? | : | Yes / No |
| 11. | Water Supply arrangement | | |
| | Direct to O.H. tank | : | Yes / No |
| | To Sump at G.L and pumped to O.H. tank | : | Yes / No |
| | Any other (Describe arrangement) | : | |
| 12. | Additional source of water present ? (Describe Additional Source) | : | |
| 13. | Water consumption from past record of billing for one year, if available | : | ________ x 1000 litres in _______ days |
| 14. | Survey observations | : | Start Date _____________<br>Start reading _____________<br>End date _____________<br>End reading _____________ |

| | | | |
|---|---|---|---|
| 15. | Water consumption from additional source if any (to be assessed) | : | Total consumption<br>_______________ litres |
| 16. | Level of satisfaction of consumer (to be assessed) | : | very satisfactory (100%) / satisfactory |

---

* Housing Category

I - Bungalows with attached garden / lawn
II - Bungalows without garden / lawn
III - Traditional house
IV - Flats
V - Chawls

---

Conclusion

Average lpcd rate _________

Name & Signature
of Investigator

Date

## ANNEXURE - B

## SAMPLE QUESTIONNAIRE FOR HOTEL WATER DEMAND ASSESSMENT

1. Name of the Hotel :
2. Address :
3. Category : Star
4. Plot Area : Sq.m.
5. Rooms / Beds : At present / Future planning 2005 2010 2015
   rooms
   beds
6. If tubewell has been installed
   (a) No. of tubewells
   (b) Total quantity of water being drawn daily litres / day :
7. Air conditioning plant
   (a) Total Capacity :
   (b) Running hours :
   (c) Consumption of water :
8. Swimming Pool treatment Plant Capacity :
9. Water requirement for swimming pool per day :
10. Water consumption for Restaurants / Coffee Shop :
11. Water consumption of laundry water / day :
12. Consumption water for gardening / day :
13. Estimated Total Consumption of water / day :
14. Consumption assessed per year from past water bills :
15. Any other details :

Name & Signature of Investigator

Date

## ANNEXURE - C

## SAMPLE QUESTIONNAIRE FOR HOSPITAL WATER DEMAND ASSESSMENT

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Name of the Hospital | : | | | | |
| 2. | Address | : | | | | |
| 3. | Plot Area | : | Sq.m. | | | |
| | | | | Future planning | | |
| | | : | At present | 2005 | 2010 | 2015 |
| 4. | Number of beds | : | | | | |
| 5. | Total No. of staff | : | | | | |
| 6. | Residential flats / quarters | | | | | |
| | (a) No. of flats / quarters | : | | | | |
| | (b) No. of persons residing | : | | | | |
| 7. | Air conditioning plant | : | | | | |
| | (a) Total capacity | : | | | | |
| | (b) Running hours / day | : | | | | |
| | (c) Consumption of water / day | : | | | | |
| 8. | Water Coolers in Offices | | | | | |
| | (a) Number | : | | | | |
| 9. | If tubewell has been installed | | | | | |
| | (a) No. of tubewells | : | | | | |
| | (b) Total quantity of water being drawn daily | : | | | | |
| 10. | Capacity of underground tank | : | | | | |
| 11. | Capacity of overhead tank | : | | | | |
| 12. | Requirement of water for laundry / day | : | | | | |
| 13. | Is canteen facility available ? if yes, water consumption requirement for canteen / day | | | | | |
| 14. | Any other details | : | | | | |

Name & Signature of
Investigator

Date

**ANNEXURE - D**

**LIST OF REFERENCES**


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Fig 1: Population Projections By Ratio Method

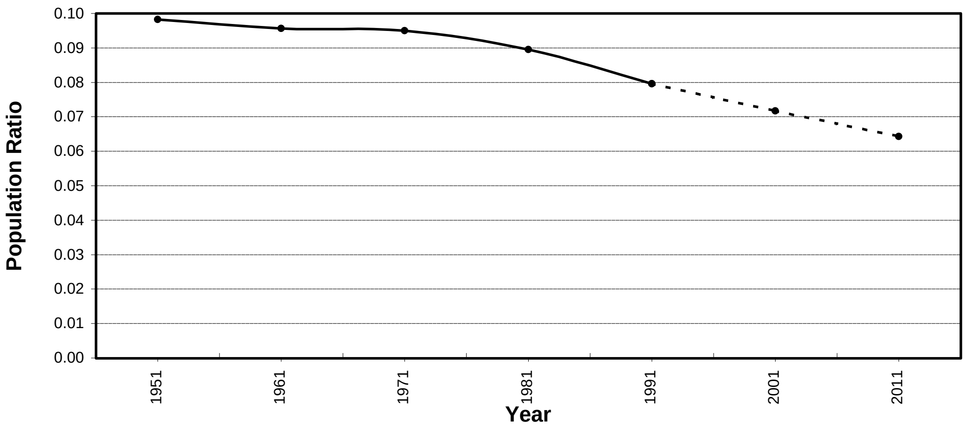


Fig 2: Graphical Trend Method

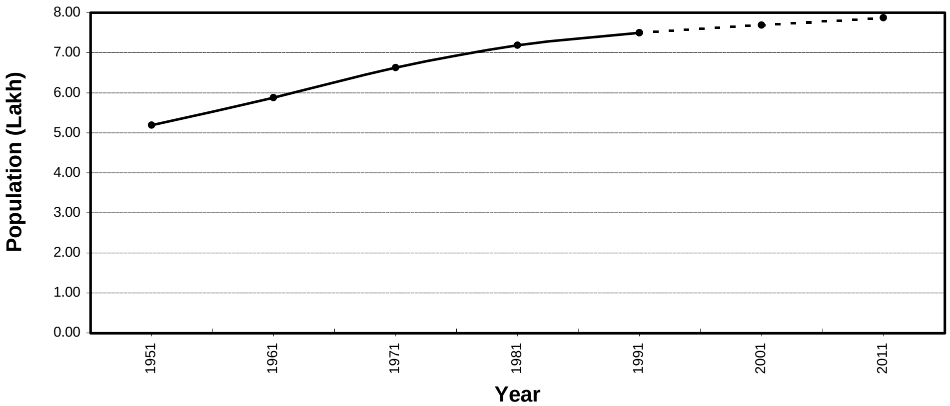


Fig 3: Comparative Graphical Trend Method