

Population Forecast – a first step for water supply design

Er. P V K Kalyan Srinivas¹, Prof. M.V.S.S.Giridhar²

¹ Research Scholar, JNTUH, Associate Vice President (Projects),
Megha Engineering and Infrastructures Limited Bala Nagar, Hyderabad – 500037
kalyanps2003@yahoo.com

² Professor of Water Resources and Director IQAC,
Jawaharlal Nehru Technological University Hyderabad, Kukatpally, Hyderabad - 500085
mvssgiridhar@gmail.com

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1. Abstract

Any water supply scheme . design period is the crucial parameter and CPHEEO (Central public health and environmental engineering organisation) defines the same . For the design period , projected population becomes the key parameter and various methods of calculating the projected population. Each projection method gives different projected population values for the design period. Based on the census data of the preceding decades, the data can be projected for next 30 to 40 years for realistic assessment of the basic input data for any water supply scheme or sewage treatment plants. Based on the output, realistic data projection is made available for further steps.

Census data provides many inputs and the developments taking place in terms of water supply, electricity, sanitation, schools and other socio economic developments of the particular location. These factors need to be considered for the holistic development of the respective towns.

Key words : Population projection, design period, water supply design, comparison of methods

2. Introduction:

India is the 7 th largest country in the world with an area of 32.87 Lakh Sq. KM. India is one of the oldest civilizations and has varied culture and languages. India is the largest populated country with 145.46 Crores population as of 2025 which is about 18% of world population of 820 crores. India has surpassed China population in April 2023 to become highest populated country. India has experienced year on year growth of 2.15% to 2% from the year 1950 to 1991. The population is growing but with less growth rate for the past 30 years. Present growth rate is approximately 0.8%.

India is expected to reach 166 – 170 crores by the year 2050 after which it is expected to decline. India's average population density is 441 persons per Sq. KM. The urban population is increasing in a faster pace because of the globalization and migrating for livelihood. The rural population is decreasing which is a concern for nation's food productivity.

Population forecast is a major parameter for arriving at financial parameters and also for design of various projects / schemes which will be designed for atleast 15 to 25 years down the line. There are various methods for arriving at the projected population. The main philosophy of these methods is taking the past data and arriving at the projected population in various methods. This study is to arrive at nearer to realistic projections based on the past data.

3. Study area :

The study area for arriving at the projected population is outskirts of city of Hyderabad where Outer Ring road has been in place. Roads built the prosperity and prosperity come by people. The population growth in this study area is typical as there is vast development in some of the villages which are now transformed into wealth centres with lot of activities and advancement in terms of education, medical, business, logistics, entertainment and so on. The villages / towns are classified based on their population.

Urban towns are classified when the minimum population is 5000, minimum population density is 400 persons per sq km, minimum 75% of the male working population shall be under non agriculture sector. They are further classified into the following based on the population.

Population	Class
Above 1 Lakh	I
50000 to 99999	II
20000 to 49999	III
10000 to 19999	IV
5000 to 9999	V
Below 5000	VI

The growth rates vary based on population and cannot be considered uniform growth rate in all the above categories.

40 Nos. of villages are considered as study area in Erstwhile Medak and Rangareddy Districts , however data of 10 nos. are presented in this as a representative data. The study area has the census data available officially is upto census 2011. In 2014, state of Andhra Pradesh is bifurcated in to Andhra Pradesh and Telangana

The study area, which under state of Telangana has several modifications after the formation. The erstwhile districts are considered for comparison and arriving at the projected populations. However, care is taken in to account regarding the latest developments and growth prospects of the area and scope for further development and migration of the people. By creating the smaller districts, the district administration and development of the areas is visible in the past decade. Number of small Nagar panchayats are made Urban Local Bodies (ULB) / municipality. Urban population has also seen the unexpected growth. requiring the infrastructure like water supply, sewerage network / treatment , storm water network, road network development. As per central Government's initiative of **Atal Mission for Rural and Urban Transformation (AMRUT)** and **Swatch Bharat Mission (SBM)**, all the parts of the country need to have better infrastructure with safe drinking water and sanitation facilities . Government aims at open defecation free society and moving towards better facilities to all the citizens of India . Similarly there are many state and central schemes for providing safe drinking water at the door step of every house hold as part of Mission Bhagiradha (Telangana State Government Initiative) and also Jal Jeeven mission (By Central Government).

This study is the base for all the facilities to be planned and provided and preparation of master plan, vision document and blueprint for every village.

4. Objective :

The objective of this study is to ensure proper planning and implementation of the water supply and sewerage projects for the population projected for the design period. This will explain the advantages and disadvantages of various methods and the parameters to be considered for arriving the master plan and also the financial planning / allocations for different sectors over the vision period of 25 years.

5, Methodology :

Popular methods for arriving at population forecast are as below.

1. Arithmetical increase/ Arithmetical mean method
2. Geometrical increase method
3. Incremental increase method
4. Decreasing rate of growth method

1. Arithmetical Increase or Arithmetical Mean Method

The arithmetical Increase Method is mainly adopted for old and developed towns, where the rate of population growth is nearly constant. Typically, population projected by this method is lowest of all methods

$$P_n = P_o + n\bar{x}$$

where,

P_o - last known population

P_n - population (predicted) after 'n' number of decades,

n - number of decades between P_o and P_n and,

$\bar{x}$ - the rate of population growth.

2. Geometrical increase method

This method is adopted for **young and developing towns**, where the rate of growth of population is proportional to the population at present .**population projected by this method is highest of all methods. Geometric mean increase is used to find out the future increment in population**

$$P_n = P_o[1 + (r/100)]^n$$

P_o - last known population,

P_n - population (predicted) after 'n' number of decades,

n - number of decades between P_o and P_n and,

r - growth rate = (increase in population/initial population) * 100 (%).

$$r = \sqrt[n]{(r_1 * r_2 * r_3 * r_4)}$$

3. Incremental increase method

This method is adopted for **average-sized towns under normal conditions**

Its used where the rate of population growth is not constant i.e., either increasing or decreasing. It is a combination of the arithmetic increase method and geometrical increase method. Population predicted by this method lies between the arithmetical increase method and the geometrical increase method.

The incremental increase is determined for each decade from the past population and the average value is added to the present population along with the average rate of increase.

$$P_n = (P_o + n\bar{x}) + ((n(n+1))/2) * \bar{y}$$

where, P_o - last known population,

- ▶ P_n - population (predicted) after 'n' number of decades,
- ▶ n - number of decades between P_o and P_n ,
- ▶ $\bar{x}$ - mean or average of increase in population and
- ▶ $\bar{y}$ - algebraic mean of incremental increase (an increase of increase) of population.

4. Decrease Rate of Growth Method or Decreasing Rate Method

- ▶ This method is adopted for a town which is reaching **saturation population**, where the rate of population growth is decreasing.
- ▶ In this method, an average decrease in growth rate (S) is considered.

$$P_n = P(n-1) + ((r(n-1) - S)/100) * P(n-1)$$

where, P_n = population at required decade

- ▶ $P(n-1)$ = population at previous decade (predicted or available),
- ▶ $r(n-1)$ = growth rate at previous decade
- ▶ S = average decrease in growth rate.

Population data of the study area ie. 46 villages is analysed using the first three methods and found different scenarios of the out put. The population data for various methods is tabulated. It is important to have sufficient historic data to have proper projections. The rate of growth (r) shall be uniform in geometric progression otherwise the projected population is varying too erratic. If there is any negative growth in any of the past decades, the results in geometric progression are not reliable.

Arithmetic increase is suitable for most of the cases where the increase in population is more or less constant and man of the past increase can be a suitable solution for small and medium towns.

In geometrical increase method, **R** value varies from 14 to 200 and even some negative values are observed when population is decreased by even 1% over the decade results in abnormal values. Hence R value upto 20 are giving proper results and very reliable data of projected population is coming.

Incremental Increase method is useful where erratic values will be resulted in geometric progression.

If we are getting any erratic values of a town, we shall analyse the overall mandal growth, district growth, state growth and so on . Urban growth rate also to considered if there is any deviation between actual growth and calculated growth.

If you have the data of population of 1971, 1981, 1991, 2001 and 2011. It is prudent to calculate the projected population of 2011 to verify the deviation in each method to the actual 2011 population. Based on the less percentage deviation, we may decide which method is appropriate for projected population.

By analysis, decreasing rate method is not at all useful for the villages / towns progressively increase in the population.

Census data of 1971, 1981 , 1991 , 2001 and 2011 is considered from Government Census department. Various annexures are studied for growth of population, population density and the amenities available like water supply, roads, electricity, schools, land use pattern etc. to know the progress of villages over the period. Over the period , there are some changes of villages being merged with town wise. Urban agglomeration and giving different population and need to study in proper manner to assess the requirements. Towns with more than 100000 population is called **city**.

As census 2021 is not published, present population based on village info and other government web sites is collected just to compare with the projected population under various methods. Wherever abnormal variation of projected population is arrived in different methods, the same were ignored.

The data of projected population for the design period will be helpful for further calculating and design of various other projects like water supply, sewerage network / treatment, storm water management etc.

Table 1.0 : District / village / Area / Latitude / Longitude

Sl. No	Village	Area of village (sqkm)	Latitude	Longitude
1	Annaram	7.82	78° 22' 12.54" N	17° 33' 12.86" E
2	Bowrampet	10.02	78° 23' 56.84 " N	17° 33' 51.47" E
3	Dundigal	20.28	78° 24' 44.66" N	17° 36' 33.16" E
4	Gundlapochampalli	13.34	78° 28' 44.77" N	17° 34' 7.02" E
5	Jinnaram	14.17	78° 20' 44.56" N	17° 37' 24.63" E
6	Khajipalle	12.47	78° 24' 17" N	17° 33' 48.23" E
7	Medchal	15.98	78° 29' 34.49" N	17° 39' 13.63" E
8	Muthangi	8.05	78° 13' 30.18" N	17° 32' 32.60" E
9	Patancheru(CT)	11.6	78° 15' 44.48" N	17° 32' 18.05" E
10	Srirangavaram	15.90	78° 25' 29.09" N	17° 39' 18.94" E

Table 2.0: Available Census data

Available Census Data						
Sl. No	Village	1971	1981	1991	2001	2011
1	Annaram	1217	1339	2147	5371	6840

Available Census Data						
Sl. No	Village	1971	1981	1991	2001	2011
2	Bowrampet	2294	2951	3721	3879	4671
3	Dundigal	3416	4335	6482	14006	14565
4	Gundlapochampalli	1936	3330	3779	5197	9009
5	Jinnaram	2089	2482	3306	3734	4336
6	Khajipalle	865	899	1375	1471	1813
7	Medchal	5912	8660	12970	21730	35611
8	Muthangi	1474	2809	3577	5718	8777
9	Patancheru(CT)	4983	11975	26862	40273	44632
10	Srirangavaram	1088	1766	2152	2626	3241
		25274	40546	66371	104005	133495

Table 3.0: Projected Population: Arithmetic Increased Method

Arithmetic Increase Method					
Sl. No	Village	2021	2031	2041	2056
1	Annaram	8,246	9,652	11,057	13,166
2	Bowrampet	5,265	5,860	6,454	7,048
3	Dundigal	17,352	20,140	22,927	25,714
4	Gundlapochampalli	10,777	12,546	14,314	16,082
5	Jinnaram	4,898	5,460	6,021	6,583
6	Khajipalle	2,050	2,287	2,524	2,761
7	Medchal	43,036	50,461	57,885	65,310
8	Muthangi	10,603	12,429	14,254	16,080
9	Patancheru(CT)	54,544	64,457	74,369	84,281
10	Srirangavaram	3,779	4,318	4,856	5,394
		1,60,550	1,87,610	2,14,661	2,42,419

Table 4.0: Projected population (Geometric Increase Method)

Geometric Increase method					
Sl. No	Village	2021	2031	2041	2056
1	Annaram	9,556	13,349	18,649	30,794
2	Bowrampet	5,416	6,280	7,282	9,093
3	Dundigal	18,648	23,874	30,566	44,280
4	Gundlapochampalli	12,651	17,767	24,950	41,520
5	Jinnaram	5,160	6,140	7,307	9,486
6	Khajipalle	2,059	2,338	2,655	3,213
7	Medchal	55,627	86,893	1,35,734	2,64,995
8	Muthangi	13,434	20,563	31,475	59,605
9	Patancheru(CT)	69,362	1,07,796	1,67,525	3,24,561
10	Srirangavaram	4,179	5,389	6,950	10,177
		1,96,092	2,90,389	4,33,093	7,97,724

Table 5.0: Population projection (Incremental Increase Method)

Incremental Increase method

Sl. No	Village	2021	2031	2041	2056
1	Annaram	8,695	9,593	10,940	13,802
2	Bowrampet	5,310	5,400	5,535	5,822
3	Dundigal	17,232	16,992	16,632	15,867
4	Gundlapochampalli	11,583	13,195	15,613	20,752
5	Jinnaram	4,967	5,107	5,316	5,760
6	Khajipalle	2,153	2,358	2,666	3,321
7	Medchal	46,747	54,169	65,302	88,959
8	Muthangi	11,177	12,327	14,051	17,714
9	Patancheru(CT)	53,667	51,911	49,278	43,683
10	Srirangavaram	3,758	3,716	3,653	3,519
		1,65,289	1,74,768	1,88,986	2,19,199

Table 6.0 : Population Projection 2041 and 2056

Sl. No	Village	Projected population	Projected population	Method
		2041	2056	
1	Annaram	18649	30794	Geometric
2	Bowrampet	7282	9093	Geometric
3	Dundigal	22927	25714	Arithmetic
4	Gundlapochampalli	24950	41520	Geometric
5	Jinnaram	6021	6583	Arithmetic
6	Khajipalle	2666	3321	Geometric
7	Medchal	135734	264995	Geometric
8	Muthangi	31475	59605	Geometric
9	Patancheru(CT)	49278	43683	Incremental
10	Srirangavaram	6950	10177	Geometric
		305932	495485	

6.0 Results and discussion :

40 Number of villages are considered as study area. 10 Number of villages are presented with various factors effecting the projected population. The villages considered are around outer ring road of Hyderabad with in Exit 3 to Exit 6. Study area is in part of Medak & Rangareddy districts. Area of the village in Sq. KM is considered. Latitude and longitude of the village is considered. Various of aspects of Census data is studied. Census data provides various amenities available in the town especially water , sanitation, roads, electricity etc. Census data is collected from 1971 to 2011. Present population as per the website is also considered in some cases where projected population is to be compared.

Arithmetic , geometric increase methods are used for comparison of actual 2011 and projected 2011 population. Arithmetic is less by 31% than actual and geometric is more by 26% than actual population at 2025. By considering 1971 to 2011 available data, projections are made for 2021, 2031, 2041 and 2056. In arithmetic increase method, slow growth and rapid growth are averaged and certain times it will be projecting lesser population in coming period. In geometric increase method any decrease in population in next decade, it will

adversely affect the projections. Incremental increase method is in between values of arithmetic and geometric increase methods. Average increase in arithmetic is 2% and geometric increase is 9% and incremental increase is 3% per annum. As we get abnormal values in geometric increase method in some cases, it is not always considered for design population. Overall increase in the urban population may be considered as incremental increase method and for rural population, geometric methods are considered for realistic projections. r value in geometric increase method which is 4th root of $r_1 \times r_2 \times r_3 \times r_4$ shall be in the range up to 30. If it is beyond 30, the projected values are not realistic especially when it is beyond 75. The projected population is the base of further research and deriving number of designs for water supply, sewerage and storm water drainage network

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9.0 Conclusion: Various methods of projected population are carried out under study area based on census data of various past decades. Proper projection of population of the design period is enumerated. Based on this projected population and rate of increase of growth other utilities are planned for design. When there is ambiguity or abnormality in projected population, various comparison of overall growth rate, urban population growth and other factors are considered. It is to be calculated per year growth in urban population and rural population growth and accordingly the design of water supply, sewerage, storm water system etc. to be carried out. Depending on the projected population design period upto 2041 / 2056 is considered. Water supply design based on EPANET can be done with the support of this information.

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11. Declaration : The data provided in this paper is only based on my work and reference available . There is no conflict of interest in this paper

12. Conflict of Interest : There is no conflict of Interest in submitting this paper.