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Case Study: Comparative Analysis of Population Forecasting Methods for Mumbai Suburban District

Sahil Yogesh Rohira[1]

[1]*Final Year B.Tech. Student, Department of Civil and Environmental Engineering, Veermata Jijabai Technological Institute, Matunga, Mumbai, Maharashtra, India*

Abstract – *Determination of population is one of the most important factors in planning of a project, if the project has to serve the community for a certain design period. Design of water supply and sanitation scheme is based on the projected population of a particular city, estimated for the design period. Normally, a design period of 2 to 4 decades is selected. What will be the population at the end of the design period is the basic question. This can be achieved by using various methods for population forecast. Any underestimated value will make the system inadequate for the purpose intended; similarly, overestimated value will make it costly. Change in the population of the city over the year occurs and the system should be designed taking into account of the population at the end of the design period. Population forecasting is an important factor and must be considered for the determination of the sustainability of the environment to the then population at the end of the design period for a particular environmental structure. Forecasting of the population helps in the determination of labor at various places in a particular area, determination of the sex ratio of the present population, the diversity in the population and the literacy rate of a particular area.*

Key Words: Population Forecasting, Environmental Engineering, Sustainability, Water Supply.

1. INTRODUCTION

Mumbai Suburban District is a coastal District, located on the West coast of India. It lies between 18º 58' and 19º 17' North latitudes and 72º 46' and 72º 60' East longitudes. The District is surrounded by Arabian Sea at the West, Thane District at the East and North and Mumbai District at the South. The District is Northern part of Greater Mumbai Municipal Corporation which, spreads over an area of 446.0 sq. km as per Surveyor General of India and has a population of 93,56,962 as per 2011 Census. The District shares 0.14 per cent of area of the State and 8.33 per cent of the total population of the State. This District alone accounts for 18.41 per cent of the total urban population of Maharashtra, which has a total of 534 urban centers. The density of population is 20,980 persons per sq.km. Amongst the 35 Districts of the State, this District ranks 34th in terms of area, 3rd in terms of population and 1st in terms of density. The District is well connected by roads, railways and airways from the other parts of the Country. It has an International airport at Sahara. A well-developed International Sea port is also located in Mumbai District which is hardly 15 km from this District.

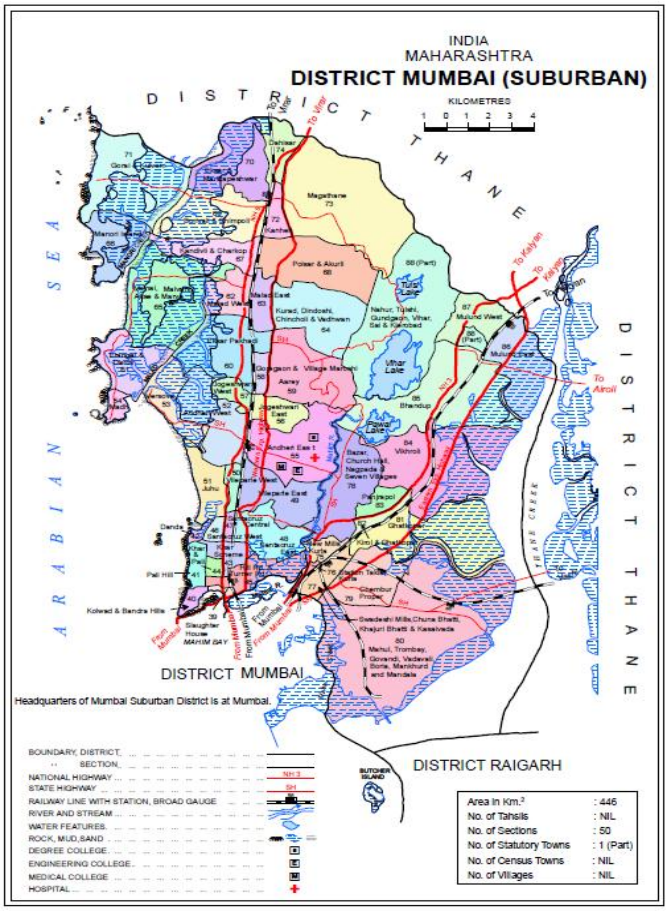

Fig -1: Mumbai Suburban District Map

Mumbai Suburban District is spread over 15 Wards of Greater Mumbai Municipal Corporation. District recorded a total population of 93,56,962 comprising of 50,31,323 males and 43,25,639 females. Population of this District increased by 7,16,543 persons during the last decade with the growth rate of 8.3 percent. Mumbai Suburban District has 18.41 percent of the urban population of the State.

The population growth for the District and percentage decadal variation since 1901 are given in the following Table-1.

Table -1: Decadal Change in distribution of population of Mumbai Suburban District

Census Year	Population	Decadal Variation	Percentage Decadal Variation
1901	2,06,218	-	-
1911	2,55,276	49,058	23.8
1921	3,06,763	51,487	20.2
1931	3,10,621	3,858	1.3
1941	4,00,297	89,676	28.9
1951	6,65,424	2,65,127	66.2
1961	13,80,123	7,14,699	107.4
1971	29,00,197	15,20,074	110.1
1981	49,58,365	20,58,168	71.0
1991	67,51,002	17,92,637	36.2
2001	86,40,419	18,89,417	28.0
2011	93,56,962	7,16,543	8.3

2. METHODS OF POPULATION FORECASTING

The following methods of population forecasting are going to be taken into consideration for the comparative analysis of population forecasting methods for Mumbai Suburban District.

2.1 Arithmetical Increase Method

This is the simplest method of population forecast, though it generally gives lower results. In this method, the increase in population from decade to decade is assumed constant. Thus, it is assumed that the population is increasing at a constant rate. From the census data of the past decades, the increase in population for each decade is found, and from that an average increment is found. For each successive future decade, this average increment is added. The future population P_n after n decades is thus given by:

$$P_n=P+nI$$

Where,

P_n is the future population at the end of *n* decades from present,

P is present population,

I is the average increment for a decade.

This method should be used for forecasting population of those large cities, which have reached their saturation population.

2.2 Geometric Increase Method or Uniform Percentage Growth Method or Geometric Progression Method

In this method, it is assumed that the percentage increase in population from decade to decade is constant. From the population data of the past decades, the percentage increase in population is found and its average is found. If I_g is the average percentage increase per decade or the geometric mean percentage, the population P_n after *n* decades from present is given by:

$$P_n=P(1+(I_g/100))^n$$

While the arithmetical average method is analogous to the 'simple interest method', this method is analogous to the computation of income by 'compound interest method'. This method gives high results since the percent increase never remains constant but decreases when the growth of the city reaches to saturation.

Since this method gives higher values and hence should be used for a new industrial town at the beginning of development only for a few decades.

2.3 Incremental Increase Method

This method combines both the arithmetic average method and geometrical average method. From the census data for the past several decades, the annual increase in each decade is first found. Then the increment in increase for each decade is found. From these, an average increment of increases, known as incremental increase is found. The population in the next decade is found by adding to the present population the average increase plus the average incremental increase per decade. This process is then repeated for successive future decades. The future population P_n at the end of *n* decades is given by:

$$P_n=P+nI+(n(n+1)/2)r$$

Where,

P_n is the future population at the end of *n* decades from present,

P is the present population,

I is the average increase per decade,

r is the average incremental increase.

This method is adopted for an average size town under normal condition where growth rate is found to be in increasing order.

2.4 Decreased Rate of Growth Method

It is found that the rate of increase of population never remains constant but varies. The population of a city will grow until they reach a saturation population. Thus, all population grow according to the logistic or S-Curve, which starts with a low rate of growth, followed by a higher rate and then progressively to a lower rate until saturation. The future population P_n at the end of *n* decades is given by:

$$P_n=P_{n-1}(1+r_n/100)$$

Where,

P_n is the future population at the end of *n* decades from present,

P_{n-1} is the population after n-1 decades from the present,

r_n is the percentage increase in population after n^{th} decade and is given by: $r_n=r_{n-1}-r'$

r' is the average decrease in the percentage increase in population.

3. FACTORS AFFECTING POPULATION GROWTH

The population growth of a city depends upon the following factors:

3.1 Economic Factors

Factors such as development of a new industry, discovery of oil or other essential minerals.

3.2 Development Programmes

Development of projects of national importance.

3.3 Social Facilities

Social facilities like medical, recreational and many others.

3.4 Communication Link

Communication of towns and cities and also for transportation purposes.

3.5 Tourism

Tourist facilities, religious places or heritage sites.

3.6 Community Life

Living habits, social customs and general education in the community.

3.7 Unpredictable Factors

Climate and natural calamities in a particular region.

4. POPULATION FORECASTING OF MUMBAI SUBURBAN DISTRICT

Now, using the above described methods, following are the predicted values of population at each decade interval for the next half of the century for the particular area to be studied from the past census report.

Table -2: Population forecasting of Mumbai Suburban District

Year	Arithmetic Increase Method	Geometric Increase Method	Incremental Increase Method	Decrease Rate of Growth Method
2021	10188848	11980655	10255597	9988557
2031	11020734	15340030	11220981	105079606
2041	11852620	19641374	12253114	108915012
2051	12684506	25148816	13351996	111202228
2061	13516392	32200543	14517627	111813841

5. CALCULATION OF ERROR IN THE GIVEN METHODS OF POPULATION FORECASTING

Using the data for the population of the past census years, the error in each method is calculated. The method with least possible error is the one with the highest accuracy and that should ideally be chosen for the population forecasting.

The percent error is calculated by taking into consideration the latest census population data and is given by:

Percentage Error = (Exact Value-Expected Value/Expected value)100

The percentage error thus obtained from the above calculation is the modulus of the above value.

Table -3: Percentage Error in the above methods for population forecasting

Method	Percentage Error
Arithmetic Increase Method	1.3%
Geometric Increase Method	17.75%
Incremental Increase Method	3.5%
Decrease Rate of Growth	0.4%

6. CONCLUSIONS

From the above discussion, though the geometric increase method is a method with highest accuracy, in the particular case study of the given district, it has accounted for the maximum error. The Geometric Increase Method, though accurate at most times, fails in the particular study because Mumbai Suburban District has been experiencing very low growth rate and it is declining from decade to decade. The decadal growth for 1961-71 was 110.1 percent, 1971-81 was 71.0 percent, 1981-91 was 36.2 percent, 1991-2001 was 28 percent and 2001-2011 was 8.3 percent.

The Decrease Rate of Growth Method proves to be the method with least error and highest accuracy. All other methods have error lower than the permissible limit of 5% as well.

As discussed earlier regarding the factors affecting population growth, it is important to note that the population can only be predicted from the past and present available data. It is in no way a complete and perfectly accurate process since the process of population forecasting is itself based on certain assumptions which change not only from place to place but also from time to time.

Although it is not a perfect process, it serves to be an extremely important part for the determination of sustainability of the environment and its proper planning.

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BIOGRAPHIES

Sahil Yogesh Rohira
Pursuing B.Tech. in Civil Engineering from Veermata Jijabai Technological Institute (V.J.T.I.), Matunga, Mumbai, Maharashtra, India.