

Comparative Study of Population Forecasting Methods for Surat City (Gujarat-India)

Nikita Patel^{#1}, Manoj Gundalia^{*2}

[#]Department of Civil Engineering, Uka Tarsadia University, Gujarat, India

¹nikita.apatel@utu.ac.in

²manoj.gundalia@utu.ac.in

Abstract— forecasted population is indispensable input requirement for planning and designing of many public sector projects. Planning of many structures of water resources, transportation, water and sewage treatment plant, are dependent upon the future population of the area for a specific design period. Incorrect estimate of population may hamper the project objective. Therefore, one needs to figure out accurately population estimation of the cities for the preferred span of years. In this paper, we compare frequently used and popular methods of population forecasting to estimate population of Surat city (India-Gujarat). Results show that all the methods are underestimated the population. This implies the rapid growth of the Surat district.

Keywords— Population, Population forecasting, Census, Incremental increase method, Logistic method

I. INTRODUCTION

India is the second most populous country after China in the world and the rate of increase in population is also high. Precise population forecasting is highly needed to plan and design many important public sector projects. Inaccurate or unsuitable methods of the population forecasting when used may result in increased cost of the construction or unable to satisfy the project requirements. Formulation of state and central government policies, national and international agencies, research scholars, business people, industrialists and many more rely on this population forecast data. They used these data for their planning and strategies. Despite the importance of population forecasts for a broad array of users, population forecasters have paid very little attention to forecast accuracy, uncertainty, and approaches. Because accuracy has been the dominant criterion for judging population forecasts, and other forecasts (Armstrong 2001 b), however, it can be used to judge population forecasts (Long 1995; Murdock et al. 1991; Smith, Tayman and Swanson, 2001). Decision makers may not know what they need: what aspect of population (total? age detail?) or what horizon is needed? There are so many users and so many uses of these forecasts but unfortunately, the forecasting process very loosely tied to the decision-making process. Forecasters have to be looked out on decision makers need before they develop the forecast model.

There are various methods used for forecasting the population each assuming various factors and assumptions. Each method gives the different value of future population. An attempt is made in this paper to compare the population of Surat district for a year of 2011 with the estimated population of the same year by five different methods. The populations of year 1971 to 2001 were taken for calculation and calibration purpose. The population of Surat city consisted the populations of the wards involved in the city. In this study, the population of Surat city for the year 2011 is forecasted by using selected methods.

II. STUDY AREA

Geographical region of Surat (Gujarat-India) lies between 21° 10' 12.86'' North latitude and 72° 49' 51.819'' East longitude (Fig. 1). According to global economic research report Surat, renowned as a diamond processing and trading hub in Gujarat, would be the world's fastest growing city in the 2019-35 periods. The report prepared by Oxford Economics, which is engaged in global forecasting and quantitative analysis, further said all the top ten fastest-growing cities in the world in 2019-35 will be from India. Besides Surat, the other nine cities are Agra, Bangalore Hyderabad, Nagpur, Tiruppur, Rajkot, Tiruchirappalli, Chennai and Vijayawada. (<https://economictimes.indiatimes.com/news/politics-and-nation/surat-to-be-worlds-fastest-growing-city-during-2019-35-report>)

III. METHODS OF POPULATION FORECASTING

The following methods are commonly used for population forecasting (nptel.ac.in, 2018):

- 1) Arithmetic Increase method
- 2) Geometric Increase method
- 3) Incremental Increment method
- 4) Simple Graphical method
- 5) Logistic Curve method

a. Arithmetic Increase method:

In arithmetic increase method, it is assumed that from decade to decade, the population increases at a constant rate. This mean increase in population is estimated from the past census data. The population of future decade is obtained by adding the mean increase population to the present population Equation (01).

$$P_t = P_0 + Kt$$

01

Where P_t = Population of the future decade,

P_0 = Population of the present decade

K = Constant = dP/dt

This method is better applicable to large and established cities. It will give lower population estimate than actual value if used for small, average or comparatively new cities.

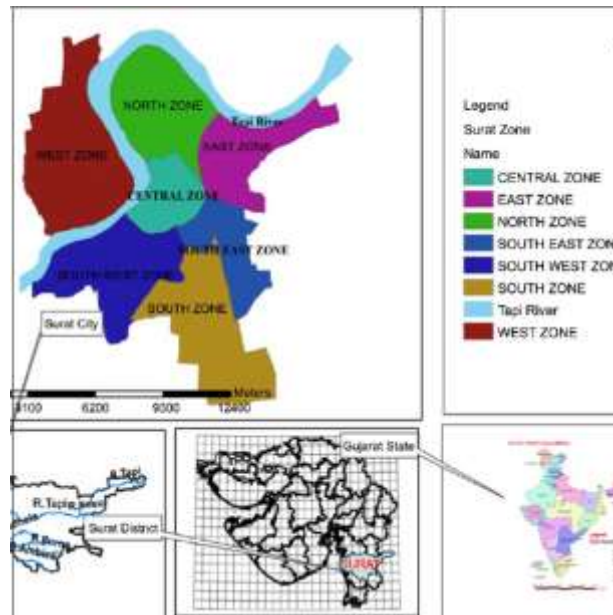


Fig. 1 Surat city of Gujarat (India)

2.1 Geometric Increase method:

The percentage growth rate of the population is assumed constant in geometric increase method. From the past census reports, decade wise mean increase population is calculated. The population of the next decade is determined by adding this increase to the present population Equation (02).

$$P_t = P_0 (1 + g)^t \tag{02}$$

Where g = Geometric mean of the rate of growth of each previous decade.

It may extensively overestimate the population for rapidly grown cities within shorter time, therefore must be used with caution. It is more applicable to relatively new cities with unlimited scopes of expansion.

2.2 Incremental Increase method:

In this method, the population growth rate is assumed progressively increasing or decreasing. The method is extension of the arithmetic increase method. The mean arithmetic increase is added to the last known population similar to the arithmetic increase method. The population for a future decade is computed by adding the average of incremental increases to this quantity Equation (03).

$$P_t = P_0 + K_t + [t (t+1)/2] I \tag{03}$$

Where I = Average incremental increase of past decades.

It is suitable for the cities of moderate size and age.

2.3 Simple Graphical method:

In this method the populations of last few decades are correctly plotted to a suitable scale on the graph with respect to decade. The curve is smoothly extended to forecast the future population. Fig. 2 shows the typical growth curve of a Surat. After extending the curve population for 2011 is forecasted as shown in Fig. 2.

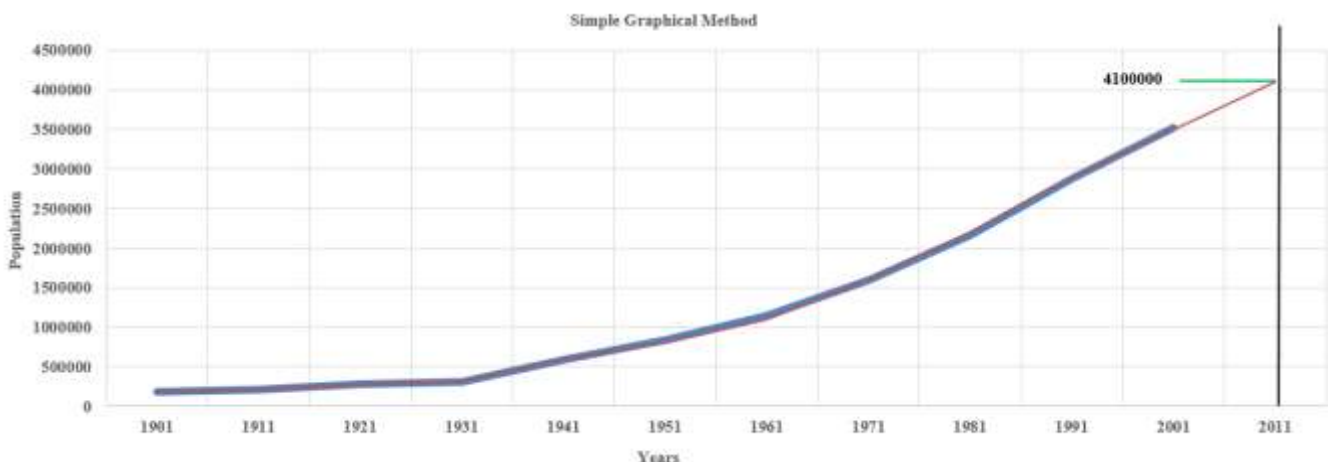


Fig. 2 Population forecasting by Simple Graphical method, Population of year 2011 = 4100000

2.4 Logistic Curve method:

This method is based on the assumption that the population growth has a certain logical mathematical relationship with the decade. The population assumed to follow the logistic curve which starting at low rate followed by high rate and then at the lower rate towards the saturation limit. It is also assumed that the growth rate of population due to births, deaths and migrations takes place under the normal situation only. Variation in population due to any extraordinary changes like pandemic, epidemic, war, earthquake or any natural disaster, etc., are not considered. The population follows the growth curve characteristics of people living things. The Population grows at similar rate of this curve but within limited space and economic opportunity. The logistic curve is S-shaped curve which expresses reasonable trend of entire growth of the city. It shows the growth from beginning to saturation limit state of the population. The population of last 3 censuses P_0 , P_1 and P_2 at time t_0 , t_1 and t_2 respectively are important for the calculation. Here, P_2 is the population at the last census, P_1 is the population one before the last census and P_0 is the population one before P_1 . The population forecast for a future decade is estimated by using Equation (04).

$$P_t = \frac{S}{1 + me^{c\Delta t}} \quad 04$$

Where S is the saturation population and m and c are constants. $\Delta t = t_{\text{projected}} - t_0$.
S is calculated by using Equation (05)

$$S = \frac{2 P_2 P_1 P_0 - P_2^2 (P_0 + P_1)}{P_2 P_0 - P_1^2} \quad 05$$

m and c are given as:

$$m = \frac{S - P_2}{P_2} \quad 06$$

$$c = \ln \frac{P_2 (S - P_1)}{P_1 (S - P_2)} \quad 07$$

The population of Surat city from 1961 to 2011 are collected from Surat Municipal Corporation website (<https://www.suratmunicipal.org/TheCity/City/Stml7>) and presented in **Table 1**. Surat Municipal Corporation is the local civic body responsible for the administration of Surat, Gujarat which has come into being under the Bombay Provincial Municipal Act, 1949. Population of year 2011 for the Surat city is forecasted using five popular methods and results are shown in **Table 2**. Comparisons of actual and forecasted population of year 2011 using selected methods are graphically presented as shown in **Fig. 3**. From

Table 1 Population of Surat City

Year	Population	Year	Population
1901	119306	1961	288026
1911	114868	1971	471656
1921	117434	1981	776583
1931	98936	1991	1498817
1941	171443	2001	2433835
1951	223182	2011	4466826

Table 2 Forecasted Population of Surat City using selected methods for Year 2011

Years	2011	Arithmetical Increase Method	Incremental Increase Method	Geometrical Increase Method	Simple Graphical Method	Logistic Curve Method
Population	4466826	2665288	2769672	3160479	4100000	3278764.24
	% Error	-40.33	-36.24	-29.25	-26.50	-26.60

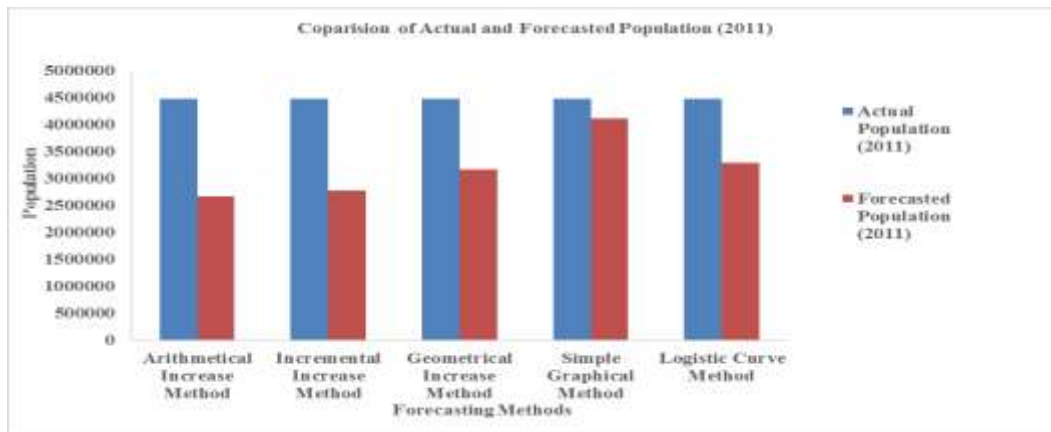


Fig. 3 Forecasted Population for year 2011 using selected methods

From **Table 2** and **Fig. 3**, it is evident that all the methods are under estimated the population of Surat city for the year 2011. The Arithmetic Increase method forecasted the population with highest error 40.33% while simple graphical method forecasted with least error 26.50%. Incremental increase, Geometrical Increase and Logistic methods forecasted the population with errors 36.24%, 29.25% and 26.60% respectively.

IV. CONCLUSION

In this study, five different methods of population forecasting are applied to estimate the population of the year 2011 for the Surat city of Gujarat (India). It is evident from results that Simple Graphical is forecasted the population with least % error of 26.50% followed by the Logistic method with 26.60%. All the methods under estimated population. Therefore, it is concluded that Surat city grows faster than the expectation. Surat city recognized as diamond city and has unlimited scope of expansion. The Simple Graphical and Logistic methods are found to be the most accurate method to forecast population of Surat city.

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