

# NEED FOR POPULATION PROJECTION APPROACH: THE SURAT CASE

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**Abstract:** *Population projection is a scientific attempt to peep into the future population scenario, conditioned by making certain assumptions, using data relating to the past as available at that point of time. Assumptions used and their probability of adhering in future, forms a critical input in this mathematical effort. Population forecasting is the useful tool for infrastructure service design and planning without which urbanization cannot be turned into a positive opportunity to ascertain improvement in economic conditions at optimized cost of large investments. It helps in visualizing the needs for future planning to the Urban Local Bodies and Authorities. For finding the future infrastructure demands, an essential task is to perform population projection exercise. Available methods and models are based on mathematical or birth, death and migration correlation base. Present paper discusses the application of five methods for Surat differently, it was observed that projected population for years 2021, 2031 and 2041 was as lowest as 56.94, 65.84 and 74.74 lacs (using Arithmetical Increase Method) and as highest as 88.13, 168.77 and 339.76 lacs (Geometrical General Method) respectively. The approach was made different in a way that various methods were applied to each of the 125 wards/villages (including the city of Surat) individually – uniformly with mathematical methods and with consideration of certain restrictions of future development in statistical method. The difference observed show no coherence in the results hence a need has been identified to develop an approach to establish relationships among diverse parameters that may lead to certain assured results with minimum of deviations.*

**Keywords:** Urbanization, Population forecast, Population projection, Surat

## I. INTRODUCTION

Urbanization is flourished with rise in the population of the urban centre. Over a period of time, Surat of Gujarat State has seen a rapid movement in increase of population with remarkably higher growth rates in past a few decades. Still, the population is increasing with development activities and health, educational and economic opportunities. Different mathematical population forecasting methods are used to analyse projection of population for Surat city. In past, many times, the administrative boundaries of the Surat Municipal

Corporation (SMC) has been observed expansion to accommodate increasing number of citizens; however, the Surat Urban Development Authority (SUDA) has never so far seen any spatial expansion (722 Sq. Km.) of administrative limits since its establishment (year 1978). The SUDA encompasses the SMC (having administrative area of 326 Sq. Km.). The composition of SUDA is based on 125 numbers of villages and Surat City. The population of each of the village and city as per the available records of Census of India since 1961 have been obtained and used for the analysis. **Table – I** shows the details of area of Surat city over a period of time. It has been revealed that the village boundaries has remained consistent since the independence of India and that is the only reliable spatial base on which population is recorded by Census of India. Hence, the effect of growth and development shall only be determined by examining each of these villages/wards individually.

TABLE 1:- SPATIAL SPREAD OF SURAT

Year	Area (Sq. Km.)	
	SMC	SUDA
1664 (Inner wall Area)	1.8	-
1707 (Outer wall Area)	7.4	-
1901	7.4	-
1941	7.4	-
1951	7.4	-
1961	8.18	-
1963	21.95	-
1971	33.9	-
1975	55.7	-
1981	55.7	722.00
1986	110.0	722.00
1991	111.15	722.00
1994	112.28	722.00
2001	112.28	722.00
2006	326.515	722.00
2011	326.515	722.00

(Source: Surat CDP revised [2006-2012])

Below **Table - II** states the population within SMC and SUDA areas respectively based on source of Census.

TABLE 2:- SMC AND SUDA POPULATION AS PER CENSUS YEAR

Sr. No	Year	Population		
		SMC	SUDA	SMC+SUDA
1	1951	223182	---	---
2	1961	288026	---	---
3	1971	471656	21345	493001
4	1981	776583	137223	913806
5	1991	1498817	20133	1518950
6	2001	2433785	377679	2811464
7	2011	4473143	331739	4804882

(Source: Surat CDP revised [2006-2012] and Census of India, 2011)

Existing administration setup leaves 396 Sq. km. area for SUDA upon exclusion of SMC. The SUDA area is the area identified for urban agglomeration by the State

Government of Gujarat and available for future expansion of the city as and when need is ‘felt’. Growth rate in the table remarkably identifies the difference of development pace accommodating citizens near their workplaces.

## II. RECONSTRUCTION OF DATA SET

Details in Table – II are reflected from the Surat CDP and Census of India, 2011. These details are based on present boundary of SMC however, the same are somewhat misleading from the actual scenario with observed changes in administrative boundary and any judgement based on gross population may affect adversely. Actually out of 125 villages in entire of SUDA, the area except SMC is comprising of 95 villages of Four Taluka namely, Chorasi, Olpad, Kamrej and Palsana. To observe uniformity and better projection results, it is essential to keep the spatial boundaries constant and reformulation of population shall be worked out. Hence, following is the reconstructed population of previous decades considering present boundary of SMC and SUDA.

TABLE 3:- RECONSTRUCTED POPULATION OF SMC & SUDA

Year	SMC as per area on 2006			SUDA except SMC			SMC+SUDA		
	Population	Density	Growth rate	Population	Density	Growth rate	Population	Density	Growth rate
1981	999373	3066	--	120993	306	--	1120366	1552	--
1991	1624135	4982	62.52%	155501	393	28.52%	1779636	2465	58.84%
2001	2868603	8799	76.62%	236521	597	52.10%	3105124	4301	74.48%
2011	4473143	13721	55.93%	331739	838	40.26%	4804882	6655	54.74%

(Source: Authors)

Note: Density unit is population per Sq. Km.

Above **Tables 2** and **3** show the difference between census based and derived population growth and density for entire of Surat city (i.e. SMC and SUDA both combined). Here, with the effect of SUDA area population growth is visible and affecting the SMC population rise giving it moderate trend. Still, the decadal growth rate of the population in area is alarmingly above 54% which has reduced by around 20% from the previous decade. However the same for the entire of SUDA area shows the effect of lower growth rate of areas outside of SMC.

As clearly observed in the **Figure 1**, SMC population is increased at a very higher growth rate comparison with rest of SUDA. It indicates that SMC serves as a growth magnet which attracts the people for living. Distribution of population in administrative area of SMC and the four Taluka are shown in **Table 4**.

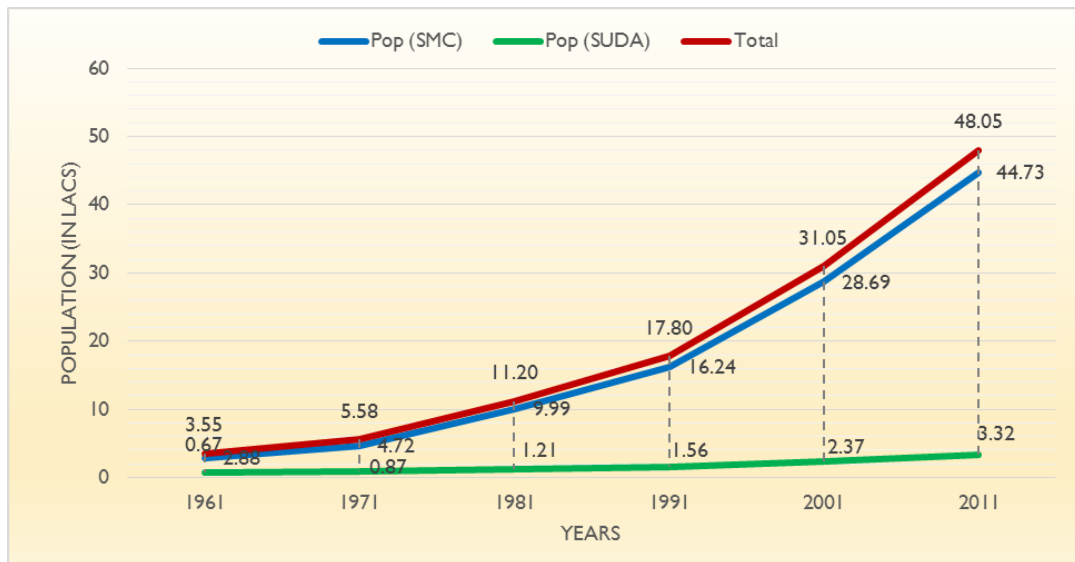


FIGURE 1:-POPULATION OF SMC, SUDA AND COMBINED POPULATION

The major contribution (almost above 90%) in total population is through Surat city whereas rest is distributed almost equally among four Taluka forming rest of SUDA.

TABLE 4 :- POPULATION DISTRIBUTION

Sr. No.	Area	Population & percentage share in total population							
		1981		1991		2001		2011	
1	S M C	999373	89.20%	1624135	91.26%	2868603	92.38%	4473143	93.10%
	<b>Total (SMC)</b>	<b>999373</b>	<b>89.20%</b>	<b>1624135</b>	<b>91.26%</b>	<b>2868603</b>	<b>92.38%</b>	<b>4473143</b>	<b>93.10%</b>
2	Olpad Taluka	16173	1.44%	17799	1.00%	20632	0.66%	19657	0.41%
3	Chorasi Taluka	54030	4.82%	68078	3.83%	106974	3.45%	162776	3.39%
4	Palsana Taluka	20787	1.86%	27886	1.57%	49691	1.60%	75783	1.58%
5	Kamrej Taluka	28562	2.55%	39920	2.24%	56848	1.83%	71409	1.49%
	Total (Rest of SUDA)	120993	10.80%	155501	8.74%	236521	7.62%	331739	6.90%
	<b>Grand Total</b>	<b>1120366</b>	<b>100.00%</b>	<b>1779636</b>	<b>100.00%</b>	<b>3105124</b>	<b>100.00%</b>	<b>4804882</b>	<b>100.00%</b>

(Source: Authors)

### III. POPULATION PROJECTIONS

The concepts of population estimates and population projections often are confused even though the distinction between the two is relatively simple and straightforward. Both concepts involve the generation of a number that is intended to indicate the size of the population of a given geographic area at a specific point in time. Both techniques make use of the basic demographic equation:

$$P_2 = P_1 + B - D + I - O$$

It indicates that the population at any given point in time ( $P_2$ ) is a function of the population at a previous point in time ( $P_1$ ) plus the amount of natural increase (births minus deaths) and the net migration (in-migration minus out-migration) during the interim. As per Census of India-GoI, basically there are two types of population projection methods:

1. Component and Non-component methods
2. Mathematical methods

Both methods have different characteristics so that they are used at large scale and small scale respectively. For projecting the population of Surat, different type of methods have been used, they are [1] Arithmetical increase method (AIM), [2] Incremental increase method (IIM), [3] Geometrical increase method (GIM), [4] Geometric general method (GGM) and [5] Ratio and correlation method (RCM).

All the above methods are applied to village-wise population for past five decades. Population totals are derived as per the administrative boundaries of SMC and SUDA as per existing status (year 2011) of administrative inclusion.

#### A. Arithmetical Increase Method (AIM)

Rate of population increase is constant and expression is  $\frac{dp}{dt} = K_a$  where  $K_a$  is an arithmetic constant. The formula is,  $P_{\text{future}} = P_{\text{last}} + (K_a)(t_{\text{future}} - t_{\text{last}})$  and  $K_a = \frac{\sum_{i=1}^x Kai}{x}$  where  $x$  = number of past records time intervals. This methods is more or less a straight line projection method where the projected values follow a uniform rate of growth, as obtained from past trends without consideration of any other effects.

#### B. Incremental Increase Method (IIM)

In incremental increase method not only average increase but difference of increment is also add. So that method is focus on variation of increment. The applicable formula used is

$$P_n = P + n.X + \{n(n+1)/2\} Y$$

Where,  $n$  = difference of future and present decade;  $P_n$  = future population;  $P$  = Current population;  $X$  = average population increment and  $Y$  = average of increment

#### C. Geometrical Increase Method (GIM)

In this method the percentage increase in population from decade to decade is assumed to remain constant. The formula used is as,  $P_n = P(1 + \frac{I_G}{100})^n$  Where,  $I_G$  is the Geometric growth rate,  $n$  is the number of decade with  $P$  as present population. GIM method gives higher population projection results and for prevailing condition in Surat this type of growth is not suitable.

#### D. Geometrical General Method (GGM)

Given the case of Geometric General method here,  $\frac{dP}{dt} = K_g P$

Where,  $P$  = Present population,  $t$  = time,  $K_g$  is the arithmetic growth constant which altogether are used to find projections through Integrated population formula:

$$\frac{dP}{dt} = K_g P, \text{ cross multiply } \frac{dP}{P} = K_g dt, \text{ integrate}$$

$$\int_{P1}^{P2} \frac{dP}{P} = K_g \int_{t1}^{t2} dt \quad \text{with } \ln P2 - \ln P1 = K_a (t2 - t1), \text{ solving for } K_a \text{ and, } K_g = \frac{\ln P2 - \ln P1}{t2 - t1},$$

substituting

$$\ln P2 = \ln P1 + K_g (t2 - t1) \quad \text{At any } P \text{ and corresponding } t$$

$$\ln P = \ln P1 + K_g (t - t1) \quad P = e^{\ln P + K_g (t - t1)}$$

Using this method, it was observed that growth rate of projection are worked out as more than 70, 95 and 100 % for future three decades respectively considered under projection.

#### E. Ratio and Correlation Method

In this method, average Growth Rate was obtained for 6 decades for all 125 villages & Surat City within SUDA. The future growth of population was kept limited to 300 ppha density (considering future planned development through T. P. Schemes). This is an ideal limit for healthy atmosphere and infrastructure facilities provided and maintained properly. However, Puna, Godadara and Amroli units seems to be already congested in 2011, in these areas the population density is already more than 300 ppha hence, 2011 population was kept constant for these 3 areas while projecting future population leaving no scope for further development. The procedure followed in the method was as below:

- Calculate six decade growth rate for all villages and generate its average growth rate for individual.
- Classify (Categorization) all villages as per growth rate. A-1, A-2, A-3, A-4, B, C, D, E, F in different categories.
- All villages arrange as per growth rate category and then take average as per particular group and that average growth rate use for population projection to every category individual.

Population projection in ratio & correlation method is under control and direct dependency of density. This method is more reliable because it takes care by giving attention to city physical characteristic and its capacity to accommodate population.

Following **Table 5** below shows the summary of village classified under each growth rate group. In population projection, First decade 2011-21 growth rate is kept almost the same and then for 2021-31 and 2031-41 growth rate is reduced somewhat as many areas of the city achieved base line 300 ppha density and these areas are restricted for the population increase. Citizens will be shifting to other areas of the city and so pulling factor will be in effect towards maintaining the natural density limit.

TABLE 5:- GROWTH RATE BASED DISTRIBUTION OF VILLAGES

Village	Group								
	A-1	A-2	A-3	A-4	B	C	D	E	F
<b>Growth Rate</b>	<b>Less than 0.25</b>	<b>0.25 to 0.50</b>							
Chorasi	31	13	9	7	8	3	1	1	1
Kamrej	8	5	2	2	0	0	0	0	1
Olpad	13	4	0	0	0	0	0	0	0
Palsana	10	3	1	1	2	0	0	0	0
Total	62	25	12	10	10	3	1	1	2

(Source: Authors)

Table 6 shows the calculation summary for population projection using different methods. On an average, population for the horizon year is approximate 3.5 times from today. It is due to the effect of GIM method that give boosted results. In mathematical model, the effect of physical and other demographic characteristics are not visible and its effect is not observed as that should be. Following is the average of projected population for Surat using four different methods.

TABLE 6:- POPULATION PROJECTED

Projection methods	Year (with population in Lacs)								
	1961	1971	1981	1991	2001	2011	2021	2031	2041
Method - 1 (AIM)	3.55	5.58	11.20	17.80	31.05	48.05	56.95	65.85	74.75
Method - 2 (IIM)							60.69	77.07	97.20
Method - 3 (GIM)							82.31	144.86	261.43
Method - 4 (GGM)							88.13	168.77	339.77
Method - 5 (GRM)							65.37	73.13	81.99
Average =							<b>70.69</b>	<b>105.93</b>	<b>171.03</b>

(Source: Authors)

Upon omitting the result of GGM which shows a superficially higher growth in population, the combination of results provide with following average of projected population. Projected 2041 population is 128.84 lacs which is lesser than earlier average value which was 171.03 lacs. Hence, GGM may not be suitable for a city like Surat for projection of population over a horizon of three decades. Mathematical method has certain barriers which are reflected from results obtained using above methods.

TABLE 7:- POPULATION PROJECTED

Projection methods	Year (with population in Lacs)								
	1961	1971	1981	1991	2001	2011	2021	2031	2041
Method - 1 (AIM)	3.55	5.58	11.20	17.80	31.05	48.05	56.95	65.85	74.75
Method - 2 (IIM)							60.69	77.07	97.20
Method - 4 (GGM)							88.13	168.77	339.77
Method - 5 (GRM)							65.37	73.13	81.99
Average =							<b>66.33</b>	<b>90.23</b>	<b>128.84</b>

(Source: Authors)

Hence, it becomes essential to collect and incorporate different parameters such as birth rate, death rate, migration, age-sex group, effect of industries and commercial establishments,



housing availability and so on and there shall be evolution of a unique relationship among these parameters which leads prepare a model for each of such urban area considering different effect of above parameters. A statistical approach using regression analysis may be opted in to evolve relationship among these parameters and by performing sensitivity analysis, the governing parameter may be identified.

#### **IV. CONCLUSION**

- Population projection of an urban area shall be performed considering village/ward-wise reconstruction of census data.
- Mathematical methods are not useful for projecting population of an urban area having considerable effect of dynamic parameters like birth rate, death rate, migration, age-sex, industrial and economic activities, housing and so on.
- There is a need for developing unique relationship among various parameters to project population of a rapidly growing urban area. The same may not be applicable to another urban area as though overall urbanization is almost uniform but the governing parameter may be different.

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