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## RCM APPROACH FOR POPULATION PROJECTION: SURAT CASE

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### ABSTRACT

Population projection is a scientific attempt to peep into the future population scenario, conditioned based on assumptions, using data and information related to the past. Assumptions used and their probability of occurrence in future acts as a critical input in this effort. A scientific population projection has useful role as a tool to plan and design the crucial infrastructure service without which urbanization cannot be turned into an opportunity to ascertain improved in economic conditions at an optimized cost of larger investments. Projected population aids in visualising need towards future planning for the Urban Local Bodies and Authorities. The paper discusses on projection of population for Surat city along with fringe area consisting of 197 constituencies in total that comprises 102 designated administrative wards of SMC and 95 villages in SUDA. In each of these wards and villages, the population volume, growth rate and density are showing different trends due to diverse development activities. An attempt was made to obtain total population for future decades by applying established mathematical methods as well as an approach of Ratio & correlation method using constituency level growth rates and densities. Considering base year of 2011, population for years 2021, 2031 and 2041 was projected. Out of five different methods, it was observed that projection obtained using RCM method show central tendency among results of all methods and may be put to further use of planning and designing tasks. The results show that projections obtained using IIM are very much in vicinity to projections of RCM which seems to be a pure coincidence as the density restrictions are applied in the RCM along with grouping of constituencies. Hence it is recommended to apply and use RCM for population projection in past-based prevailing scenario of Surat.

**Keyword:** Arithmetical Increase (AIM), Geometrical Increase (GIM), Geometrical General (GGM), Incremental Increase (IIM), Population projection, Ratio & Correlation method (RCM), SMC, Surat, SUDA, Urbanization.

## 1. INTRODUCTION

The users of population projections that many people think of first are belonging to Government departments, generally responsible for policy making, planning and designing in different sectors. While user designation may differ somewhat in countries globally, they include mainly revenue spending departments responsible for providing different services. If a country has a central Ministry of Planning, population forecasts will undoubtedly form a central input into its activities. Population forecasts are also important for the work of a range of international organizations, including United Nations agencies and the development banks. Estimates of future population trends are a crucial input into models of global environmental change and its impact as well. Calculations of future populations play very important role and practiced extensively in urban land use planning, for economic development initiatives; for infrastructure, transportation and health services planning; for water demand assessments, and for natural resource management and protection, among other applications. Government policymakers and planners around the world use population projections to gauge future demand for food, water, energy, and services, and to forecast future demographic characteristics. Population projections can alert policymakers to major trends that may affect economic development and help policymakers craft policies that can be adapted for various purposes. There are traditional methods available such as mathematical, component and non-component methods which generally uses uniform rate of increase or effect of growth rate to some extent. However, the major limitation is, the existing methods hardly consider the “on field development” aspect or say, governing factors responsible for population increase or decrease which ultimately lead to evolving customised or tailor-made approach for population projection. This means, one method approved for projected population of one place may not be applicable to other place. There may be similarity of governing factors but these needs to be identified and applied effectively while projecting population for a city.

## 2. SURAT–A GROWING MEGA CITY

Urbanization is flourished with rise in the population of the urban centre. Over a period of time, Surat of Gujarat State in India has seen a rapid rise of population with remarkably higher growth rates in past a few decades. Still, the population is increasing with development activities generating ample health, educational and economic opportunities. Many times in past, administrative boundaries of Surat Municipal Corporation (SMC the urban local body) is expanded to accommodate increasing number of citizens; however, the Surat Urban Development Authority (SUDA – the authority governing over SMC as well as urban fringe) has never so far seen any spatial expansion (722 Sq. Km.) of administrative limits since its constitutional inception in year 1978. The SUDA encompasses the SMC (having administrative area of 326 Sq. Km.). The composition of SUDA is based on 95 numbers of villages and Surat Municipal Corporation which has 102 wards. The population of each of the village and ward as per the available records of Census of India since 1981 have been obtained and used for the analysis. **Figure 1** show historical growth of Surat.

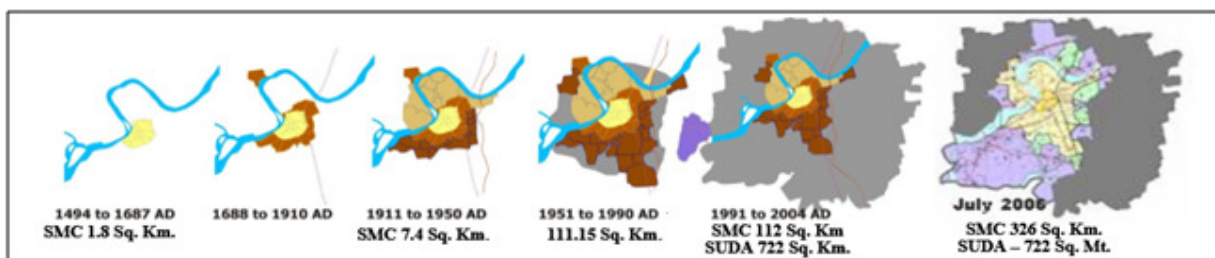


Figure 1: Boundary extension of Surat town

**Table 1** show the details of area and population for Surat. As per prevailing practice in the nation, the village boundaries are the sole authentic source on which spatial planning works are relying upon, though advancement in the land record keeping and surveys are under progress. Census of India follows the village boundary structure for the population records, updated every decade. It means, to measure the population growth in a region, an examination over village level population can be a key. **Table - 2.**

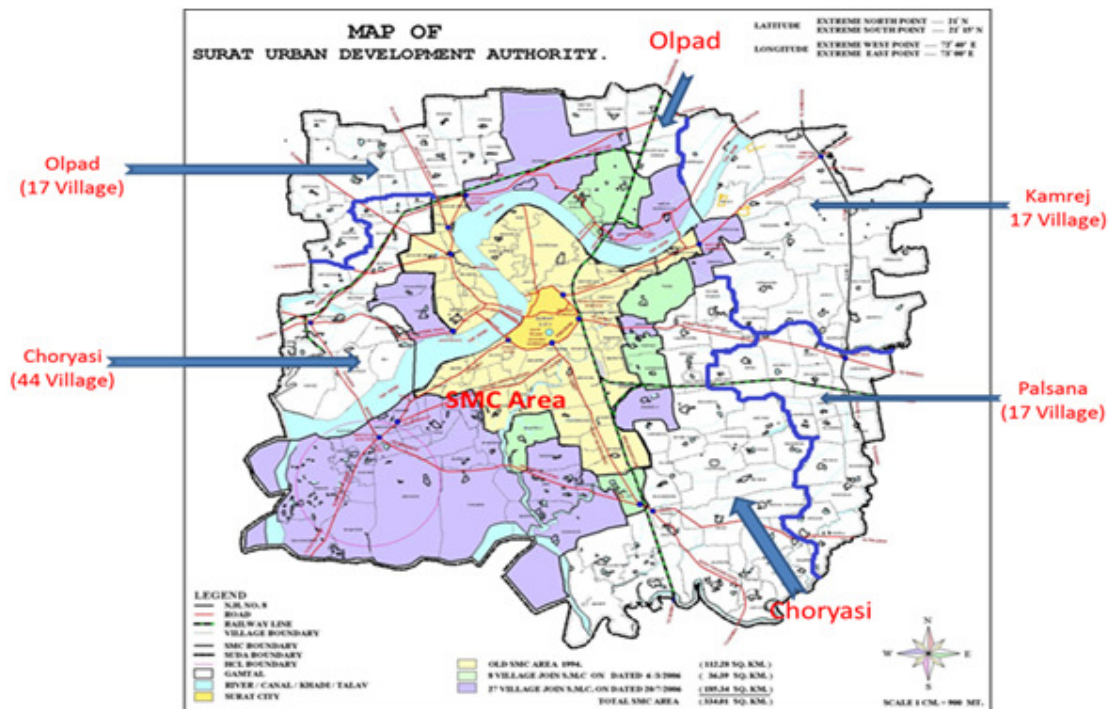
**Table 1: SMC and SUDA area and population as per census year**

| Sr. No | Year | Area (Sq. Km.) |        | Population (in Lacs) |      |          |
|--------|------|----------------|--------|----------------------|------|----------|
|        |      | SMC            | SUDA   | SMC                  | SUDA | SMC+SUDA |
| 1      | 1951 | 7.40           | -      | 2.23                 | ---  | ---      |
| 2      | 1961 | 8.18           | -      | 2.88                 | ---  | ---      |
| 3      | 1971 | 33.90          | -      | 4.72                 | 1.49 | 6.21     |
| 4      | 1981 | 55.70          | 722.00 | 7.77                 | 2.08 | 9.85     |
| 5      | 1991 | 111.15         | 722.00 | 14.99                | 2.88 | 17.87    |
| 6      | 2001 | 112.28         | 722.00 | 24.34                | 6.57 | 30.91    |
| 7      | 2011 | 326.51         | 722.00 | 44.73                | 3.32 | 48.05    |

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

### 3. RECONSTRUCTION OF DATA SET

Before carrying out projection on population, it seems important to organize rather reorganize village-wise population / ward-wise population according to SMC or SUDA boundaries. Straight away if the city administrative boundaries are considered, the projection may be misleading. Smallest unit considered for population projection is village (95 in SUDA except SMC) and ward (102 in SMC). Here, PRI administrative overlap with Taluka boundaries also exist as village in SUDA except of SMC are under Chorasi, Olpad, Kamrej and Palsana. **Figure 2** show the administrative constituencies.



**Figure 2: Villages as per taluka in SUDA boundary**

Bringing in the accuracy in trends, instead of considering population of whole city, it was found essential to group past populations of constituencies as per the present administrative boundary. Hence, the results of latest census can be related with past records. Here, **Table 2** show population of SMC and SUDA after considering the above i.e. population in past as per present administrative limits.

**Table 2: 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 | 10.29                   | 3155    | --          | 1.21            | 306     | --          | 11.50      | 1592    | --          |
| 1991 | 16.35                   | 5015    | 58.94%      | 1.56            | 393     | 28.52%      | 17.90      | 2480    | 55.73%      |
| 2001 | 28.76                   | 8823    | 75.94%      | 2.37            | 597     | 52.10%      | 31.13      | 4311    | 73.87%      |
| 2011 | 44.68                   | 13705   | 55.33%      | 3.32            | 838     | 40.26%      | 48.00      | 6648    | 54.18%      |

(Source: Authors)

Note: 1) Density unit is population per Sq. Km. 2) Population in Lacs

Above **Tables 1** and **2** show the decadal differences in derived population growth and density for Surat including fringe area. Notably, the population and growth rate contribution in total area has major contribution from the Surat city (SMC). Considering area including fringe, combined growth rate is alarmingly high as 54.18% in 2011 showing a reduction in rate of almost 20% from 2001. Simply, if this growth rate is continued, the population of the city in 2021 would be around 73 Lacs.

#### 4. POPULATION PROJECTIONS

In view of *Alan Walter Steiss* (2005), the concept of population estimate and population projection often are confused even though distinction between the two is relatively simple and straightforward. Both concepts involve generation of a number that is intended to indicate the size of population of a given geographic area at a specific point of time in future. 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 of time in future ( $P_2$ ) is a function of the population at previous point of time ( $P_1$ ) plus natural increase (births minus deaths) and net migration (in-migration minus out-migration) during the interim. **Table 3** show projected population for Surat with fringe area wherein basic mathematical approaches are used for calculations along with average of results derived using all methods. Methods used are: Arithmetical Increase Method (AIM), Geometrical Increase Method (GIM), Geometrical General Method (GGM) and Incremental Increase Method (IIM).

**Table 3: Projected population using different methods**

| 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        |
| Average of above   |                                |      |       |       |       |       | <b>72.02</b> | <b>114.14</b> | <b>193.29</b> |

(Source: Authors)

## 5. RATIO AND CORRELATION METHOD (RCM)

In this method, average Growth Rate was obtained for 4 decades for all 197 constituencies under consideration for projection. The growth of population was kept limited to different density (considering present and future developmental efforts). In accordance to UDPFI Guidelines published by CRDT, ITPI, New Delhi, the population density is considered in a range of 125-175 ppha for Metropolitan cities settling in plain terrain areas. However, these guidelines were published long back in 1996 and in that era, technology was not much in use to create high-rise residential facilities at large scale. Today, the scenario is changed and densities in urban areas are exceeding the ideal range at many instances. In present work for Surat also, authors anticipate the density limits into day's scenario to be in range of 300 to 500 ppha for healthy atmosphere and infrastructure facility (to be observed through *Development Regulations*) easily to be available with high-rise residential facilities. Here, the consideration of higher density is based on geographical restrictions of Surat such as the Arabian Sea on the West, Industrial Complex and the Mindhola River in the South, Railway lines and National Highway in the North and the East. Land available for development is scarce and very precious in case of Surat making population densities to go up. As per records of the Surat Municipal Corporation, total count of tenement is 15,27,792 out of which 10,80,638 are being used as residences wherein citizens are accommodated with a family size ranging between four to five.

Application of density restriction is based on location and past growth of areas. For SMC, three different zones are worked out and different density restrictions are applied where in 102 wards are divided in 3 categories with restricted density at 500 ppha, 350 ppha and 300 ppha. (1) CBD area central zone density 500 ppha; (2) Periphery ward of CBD density 350 ppha and; (3) Outer periphery ward of SMC boundary density 300 ppha.

However, for areas under SUDA such divisions are not applied as the population growth and spread are observed to be very low compared to that of SMC. Some specific villages are identified having higher growth rate and for such villages, the population density is restricted to 300 ppha. RCM is so applied as such interventions are established leading to reliable population projection however, this method needs detailed data of population at micro level.

### 5.1 Procedure

Following are the methodological steps applied while using RCM for projection of population in Surat:

- Calculate decadal growth rate (at least four decades) for all wards and villages (the constituencies) and obtain average growth rate for individual constituency.
- Classify constituencies as per growth rate in categories say, A-1, A-2, A-3, A-4, B, C, D, E, F in different 9 categories (Refer Table 4). Here, Group A has four sub-categories due to variation in growth rate below 100% was comprising of more constituencies where in a uniform rate based on 100% would not be applicable and justified. For projection, the growth rates are used as coefficient of projection for each of the groups containing number of constituencies.

**Table 4: Growth Rate classification groups**

| Group | Growth Rate | Range (Coefficient) |
|-------|-------------|---------------------|
| A     | <100        | <1                  |
| B     | 100<x<200   | 1<x<2               |
| C     | 200<x<300   | 2<x<3               |
| D     | 300<x<400   | 3<x<4               |
| E     | 400<x<500   | 4<x<5               |
| F     | 500<x       | 5<x                 |
| A-1   | x<25        | x<0.25              |
| A-2   | 25<x<50     | 0.25<x<0.50         |
| A-3   | 50<x<75     | 0.50<x<0.75         |
| A-4   | 75<x<100    | 0.75<x<1.00         |

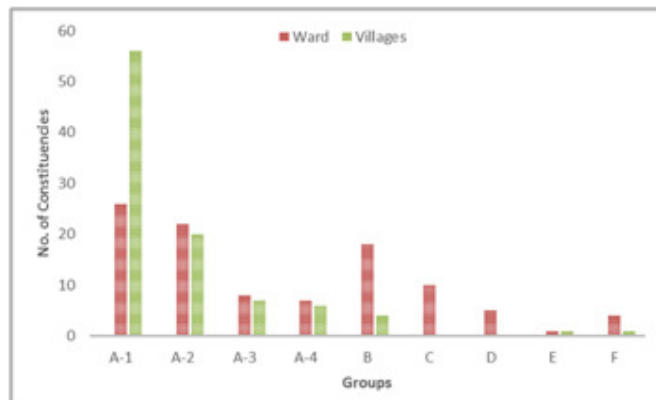
- The constituencies are arranged as per growth rate in categories based on the range and again an average of each group is obtained whereas this average growth rate is applied for projection for constituencies individually in the group.

Table 5 below show the number of constituencies distributed in different groups based on steps described above and Figure 3 show the volumetric comparison of constituencies in each of the group in support of the table below.

**Table 5: Classification of constituencies**

|                      | Group          |             |             |          |           |           |          |          |          | Total       |           |
|----------------------|----------------|-------------|-------------|----------|-----------|-----------|----------|----------|----------|-------------|-----------|
|                      | A-1            | A-2         | A-3         | A-4      | B         | C         | D        | E        | F        |             |           |
| Range (coefficients) | <0.25          | 0.25<x<0.50 | 0.50<x<0.75 | 0.75<x<1 | 1<x<2     | 2<x<3     | 3<x<4    | 4<x<5    | 5<x      |             |           |
| SMC Ward             | 26             | 22          | 8           | 7        | 18        | 10        | 5        | 1        | 4        | 101*        |           |
| <b>Total-A</b>       | <b>26</b>      | <b>22</b>   | <b>8</b>    | <b>7</b> | <b>18</b> | <b>10</b> | <b>5</b> | <b>1</b> | <b>4</b> | <b>101*</b> |           |
| SUDA Village         | Chorasi        | 25          | 8           | 4        | 3         | 2         | 0        | 0        | 1        | 1           | 44        |
|                      | Kamrej         | 8           | 5           | 2        | 2         | 0         | 0        | 0        | 0        | 0           | 17        |
|                      | Olpad          | 13          | 4           | 0        | 0         | 0         | 0        | 0        | 0        | 0           | 17        |
|                      | Palsana        | 10          | 3           | 1        | 1         | 2         | 0        | 0        | 0        | 0           | 17        |
|                      | <b>Total-B</b> | <b>56</b>   | <b>20</b>   | <b>7</b> | <b>6</b>  | <b>4</b>  | <b>0</b> | <b>0</b> | <b>1</b> | <b>1</b>    | <b>95</b> |

\* Note: A ward named “Kadifaliya” is excluded due to unavailability of population data in various sources



**Figure 3: SMC wards and SUDA village classified as per growth rate**

Population projection using RCM avails a control as projection depends on density. The method is more reliable as it brings in effect of influence of physical characteristic and capacity of city areas. The constituencies are situated in different locations and hence, density restriction criteria is different for each as identified. Table below show wards and villages accumulated in groups based on locations for which the density restrictions are to be applied while projecting population of each constituency.

**Table 6: Constituency in group based on location**

| Sr. | Wards / Villages  | No. |
|-----|---|-----|
| 1   | <b>SMC Density Group – I (restricted to 500 ppha)</b>   | 13  |
|     | Wadifalia, Mahidharpura, Haripura, Sonifalia, Begumpura, Gopipura, Saiyadpura, Shahpor, Salabatpura, Nanavat, Nanpura, Sagrampura, TPS - 2 Nanpura  |     |
| 2   | <b>SMC Density Group – II (restricted to 350 ppha)</b>  | 40  |
|     | Rander, Athwa, TPS – 1, Rampura, Laldarwaja, Nanavarachha Water Works, Ved, TPS - 3 Katargam Gotalawadi, TPS - 8 Umarwada, TPS - 4 Ashvanikumar Navagam, TPS - 6 Majura – Khatodara, TPS - 5 Athwa – Umara, Bhedvad, Utran, TPS - 7 Anjana,, Limbayat, Udhana, Fulpada, Bharthana – Vesu, TPS - 9 Majura, Karanj, Adajan, Umara, Dabholi, Piplod, Nanavarachha, Dindoli (Part), Katargam, Singanpor, Dumbhal, Althan, Bhatar, Tunki, Parvat, Majura, Magob (Part), Bamroli (Part), Godadara, Kapadra, Pandesara, Sarthana, Amroli,  |     |
| 3   | <b>SMC Density Group – III (restricted to 300 ppha)</b>   | 31  |
|     | Vanta, Dumas, Bhimpur, Budiya, Abhava, Sarsana, Khajod, Sultanabad, Gaviyar, Bhimrad, Rundh, Variyav, Jahangirpura, Magdalla, Bhestan, Gabheni, Jiyav, Motavarachha, Pal, Pisad, Vesu, Kosad, Chhapara Bhattha, Jahangirabad, Vadod, Unn, Palanpor, Simada, Sonari, Puna, Kandi Faliya (Dumas)  |     |
| 4   | <b>SUDA Density Group – I (restricted to 300 ppha)</b>  | 95  |
|     | Asarma, Bhattha, Bhatia, Bhatpor, Bhesan, Bonand, Chichi, Deladva, Eklera, Kachholi, Kapletha, Khambhasla, Kharvasa, Lajpor, Malgama, Mahoni, Popda, Ravla Alias Vaktana, Samrod, Saniya Kanade, Timbarva, Umber, Vanakala, Vanz, Vihel, Abrama, Bhada, Kathodara, Kosamadi, Kosmada, Ladvi, Oviyan, Umbhel, Ambheta, Balkas, Gothan, Kunkni, Sarol, Saroli, Segwachhama, Segwasyadla, Sonsak, Sherdi, Talad, Vadod, Vaswari, Antroli, Erthan, Karan, Kharbhasi, Lingad, Niyol, Talodara, Tantzaghda, Taraj, Vadadala, Bhanodra, Dakhkhanvada, Devadh, Goja, Ichchhapor, Kumbharia, Saniya Hemad, Saroli, Kholvad, Pasodara, Valak, Valthan, Vav, Ariyana, Jothan, Kanad, Kosam, Haripura, Sedhav, Vankaneda, Bharthana Kosad, Pali, Chhedchha, Khadsad, Karala, Vedchha, Karadva, Okha, Kansad, Laskana, Talangpor, Navagam, Chalthan, Kavas, Sachin, Pardi Kanade, Kadodara, Vareli, Sabargam |     |

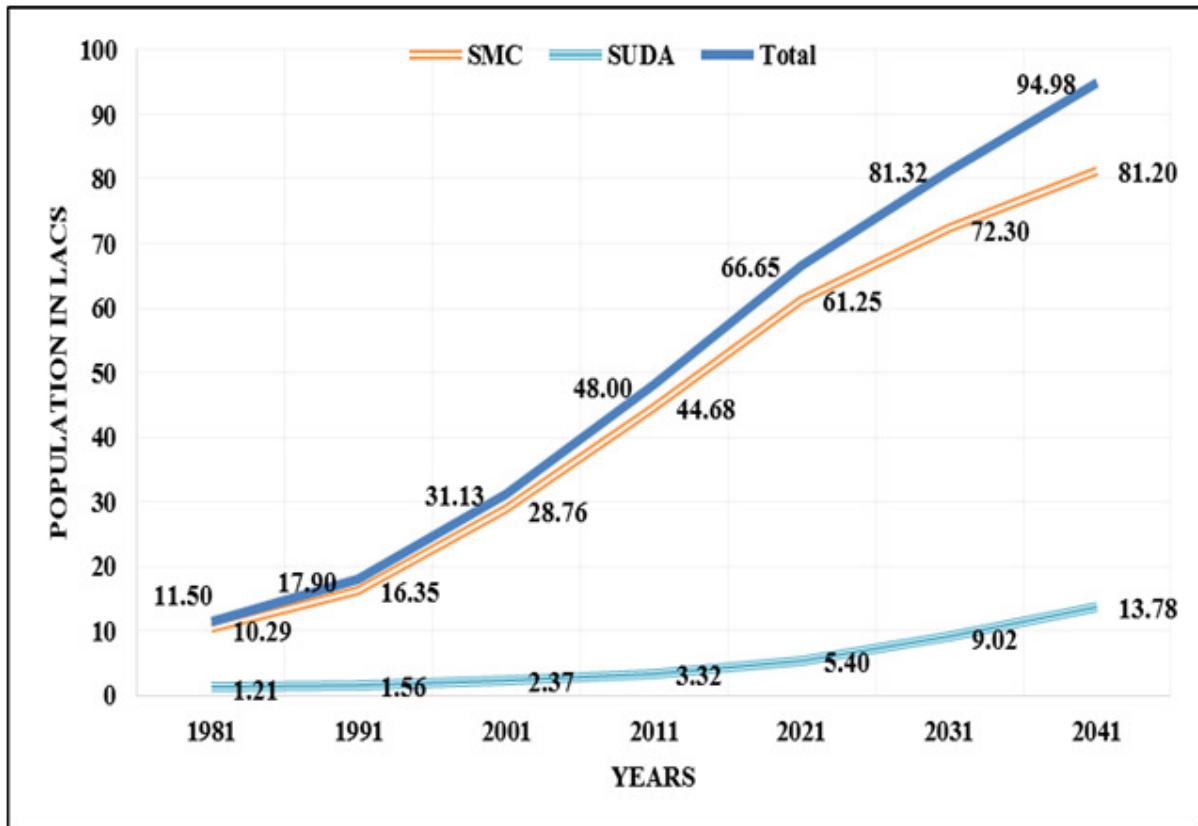
Population projections with application of density restrictions in location groups obtained as below. It was interestingly observed that density restriction was required to be applied to only six constituencies of SUDA for projection in year 2041.

**Table 7: Projection using RCM(Population in Lacs)**

| Year               |      | 1981           | 1991         | 2001         | 2011         | 2021         | 2031         | 2041         |              |
|--------------------|------|----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Population         | SMC  | Group-1        | 4.48         | 4.33         | 4.14         | 4.09         | 4.04         | 4.00         | 4.19         |
|                    |      | Group-2        | 5.08         | 10.95        | 21.12        | 31.54        | 36.99        | 39.37        | 40.55        |
|                    |      | Group-3        | 0.72         | 1.07         | 3.51         | 9.05         | 20.22        | 28.93        | 36.46        |
|                    |      | <b>Total-A</b> | <b>10.29</b> | <b>16.35</b> | <b>28.76</b> | <b>44.68</b> | <b>61.25</b> | <b>72.30</b> | <b>81.20</b> |
|                    | SUDA | Group-1        | 1.21         | 1.56         | 2.37         | 3.32         | 5.40         | 9.02         | 13.78        |
|                    |      | <b>Total-B</b> | <b>1.21</b>  | <b>1.56</b>  | <b>2.37</b>  | <b>3.32</b>  | <b>5.40</b>  | <b>9.02</b>  | <b>13.78</b> |
| <b>Grand Total</b> |      | <b>11.50</b>   | <b>17.91</b> | <b>31.13</b> | <b>48.00</b> | <b>66.65</b> | <b>81.32</b> | <b>94.98</b> |              |

(Source: Authors)

Table above shows the projected population with support of below graphical representation wherein the trends can be well observed with effect of restriction in density. For SMC, the growth is observed to be lowering in 2031 and 2041 which is the result of population saturation whereas the SUDA constituencies, there was no such requirement of applying density restriction except for six villages as mentioned earlier. The projection trend reveals that there will be 14.50% of total population will be occupying SUDA areas by citizens of Surat metropolitan. In addition, it is observed that by 2041, Surat will averagely accommodate citizens with density of 249 ppha within SMC areas itself.

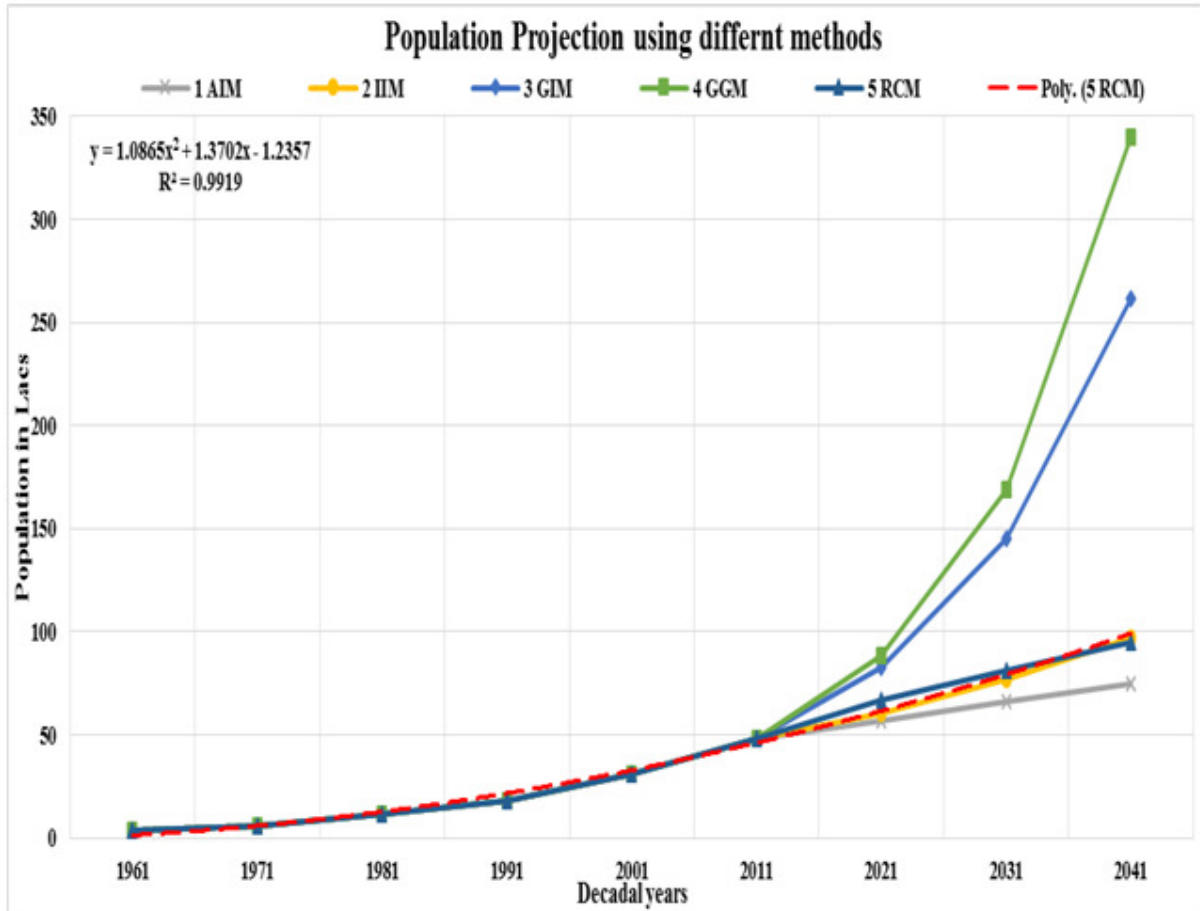


**Figure 4: Population projection by Ratio and correlation method**



## 6. CONCLUDING REMARKS

Above chart show a comparative trend for projected population of Surat (SMC and SUDA constituencies) wherein the method of RCM show the best fit through polynomial fitting having value of  $R^2$  (with observed



**Figure 5: Comparative population projection using different methods**

past and values of projection) as much near to 0.1 that justifies the development trends of city with population projection matching the past and future possibilities. This makes a decision to put population projection values in a fix and start working on service and social infrastructural planning as well as execution of works. Further details on priority areas are already available in terms of groups of constituencies to facilitate identification of phase of works and fund allotment.

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