

# POPULATION FORECASTING

Design of water supply and sanitation scheme is based on the projected population of a particular city, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Changes in the population of the city over the years occur, and the system should be designed taking into account of the population at the end of the design period.

**Factors affecting changes in population** are:

- Increase due to births
- Decrease due to deaths
- Increase/ decrease due to migration
- Increase due to annexation.

The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city.

## ARITHMETICAL INCREASE METHOD

This method is suitable for **large and old city** with considerable development. If it is used for small, average or comparatively new cities, it will give lower population estimate than actual value. In this method the average increase in population per decade is calculated from the past census reports. This increase is added to the present population to find out the population of the next decade. Thus, it is assumed that the population is increasing at constant rate.

Hence,  $\frac{dP}{dt} = C$  ; **i.e.**, rate of change of population with respect to time is constant.

Therefore, Population after **n<sup>th</sup> decade** will be

$$P_n = P + n.C \dots\dots\dots(1)$$

Where,

**P<sub>n</sub>** is the **population** after ‘n’ decades, &

**‘P’** is **present population**.

## PROBLEM : 1

Predict the population for the year **2021, 2031, and 2041** from the following population data.

<b>Year</b>	1961	1971	1981	1991	2001	2011
<b>Population</b>	8,58,545	10,15,672	12,01,553	16,91,538	20,77,820	25,85,862

## SOLUTION

Year	Population	Increment
1961	858545	-
1971	1015672	157127
1981	1201553	185881
1991	1691538	489985
2001	2077820	386282
2011	2585862	508042

Average increment = 345463

Population forecast for year 2021 is,  
 Similarly,

$$P_{2021} = 2585862 + 345463 \times 1 = 2931325$$

$$P_{2031} = 2585862 + 345463 \times 2 = 3276788$$

$$P_{2041} = 2585862 + 345463 \times 3 = 3622251$$

**GEOMETRICAL INCREASE METHOD  
 (OR GEOMETRICAL PROGRESSION METHOD)**

In this method the percentage increase in population from decade to decade is assumed to remain constant. Geometric mean increase is used to find out the future increment in population. Since this method gives higher values and hence should be applied for a new industrial town at the beginning of development for only few decades. The population at the end of nth decade 'Pn' can be estimated as:

$$P_n = P (1 + I_G/100) \dots\dots\dots(2)$$

Where,

- $I_G$  = geometric mean (%)
- $P$  = Present population
- $N$  = No. of decades.

**PROBLEM : 2**

Predict the population for the years 1981, 1991, 1994, and 2001 from the following census figures of a town by different methods.

Year	1901	1911	1921	1931	1941	1951	1961	1971
Population: (thousands)	60	65	63	72	79	89	97	120

**S o l u t i o n**

Year	Population: (thousands)	Increment per Decade	Incremental Increase	Percentage Increment per Decade
1901	60	-	-	-
1911	65	+5	-	$(5+60) \times 100 = +8.33$
1921	63	-2	-3	$(2+65) \times 100 = -3.07$
1931	72	+9	+7	$(9+63) \times 100 = +14.28$
1941	79	+7	-2	$(7+72) \times 100 = +9.72$
1951	89	+10	+3	$(10+79) \times 100 = +12.66$
1961	97	+8	-2	$(8+89) \times 100 = 8.98$
1971	120	+23	+15	$(23+97) \times 100 = +23.71$
<b>Net values</b>	<b>1</b>	<b>+60</b>	<b>+18</b>	<b>+74.61</b>
<b>Averages</b>	<b>-</b>	<b>8.57</b>	<b>3.0</b>	<b>10.66</b>

**ARITHMETICAL PROGRESSION METHOD**

**Required Formula:  $P_n = P + ni$**

Average increases per decade =  $i = 8.57$

Population for the years,

- 1981** = population 1971 + ni, here n=1 decade  
 = 120 + 8.57 = **128.57**
- 1991** = population 1971 + ni, here n=2 decade  
 = 120 + 2 x 8.57 = **137.14**
- 2001** = population 1971 + ni, here n=3 decade

$$\begin{aligned}
 &= 120 + 3 \times 8.57 = \mathbf{145.71} \\
 \mathbf{1994} &= \text{population 1991} + (\text{population 2001} - \text{1991}) \times 3/10 \\
 &= 137.14 + (8.57) \times 3/10 = \mathbf{139.71}
 \end{aligned}$$

### G E O M E T R I C P R O G R E S S I O N M E T H O D

**Required Formula:  $P_n = P (1 + I_G/100)^n$**

Average percentage increase per decade;  $I_G = 10.66$

$$\begin{aligned}
 \text{✎ Population for 1981} &= \text{Population 1971} \times (1 + I_G/100)^n \\
 &= 120 \times (1 + 10.66/100), I_G = 10.66, n = 1 \\
 &= 120 \times 110.66/100 = \mathbf{132.8} \\
 \text{✎ Population for 1991} &= \text{Population 1971} \times (1 + I_G/100)^n \\
 &= 120 \times (1 + 10.66/100)^2, I_G = 10.66, n = 2 \\
 &= 120 \times 1.2245 = \mathbf{146.95} \\
 \text{✎ Population for 2001} &= \text{Population 1971} \times (1 + I_G/100)^n \\
 &= 120 \times (1 + 10.66/100)^3, I_G = 10.66, n = 3 \\
 &= 120 \times 1.355 = \mathbf{162.60} \\
 \text{✎ Population for 1994} &= 146.95 + (15.84 \times 3/10) = \mathbf{151.70}
 \end{aligned}$$

### P R O B L E M : E X E R C I S E & A S S I G N M E N T

The population data for *Uttara Model Town, Dhaka* is given below. Find out the population in the year **2021, 2031, 2038** and **2041** by (a) arithmetical (b) geometric methods.

Year	<u>1971</u>	<u>1981</u>	<u>1991</u>	<u>2001</u>	<u>2011</u>
<b>Population</b>	84,000	1, 15,000	1, 60,000	2, 05,000	2, 50,000

**Ans:**

Population in the year **2021, 2031** and **2041**

**(a) Arithmetical increase method** : 291,500; 333,000; 374,500

**(b) Geometrical progression method** : 327,500; 429,025; 562,023