Population Forecasting

Prior to the design of a water treatment plant, it is necessary to forecast the future population of the communities to be served. The plant should be sufficient generally for 25 to 30 years. It is difficult to estimate the population growth due to economic and social factors involved. However, a few methods have been used for forecasting population. They include

- Arithmetic increase method
- Geometrical increase method
- Incremental increase method
- Decrease rate of increase method
- Simple Graphical method
- Comparative graphical method

Arithmetic increase method

- This method is suitable for large and old city with considerable development.
- 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, $dP/dt = C$ i.e. rate of change of population with respect to time is constant.
- Therefore, Population after n^{th} decade will be

$$Pn = P + n.C$$

- Where, Pn is the population after n decades and P is present population.

Example:

Arithmetic increase method

year	Population	increment
1961	858545	-
1971	1015672	(1015672-858545)=157127
1981	1201553	185881
1991	1691538	489985
2001	2077820	386282
2011	2585862	508042

Avg. increment per decade, C, =345463

Population in year 2021 =P2021=2585862+345463 x 1= 2931325
Population in year 2031 =P2031=2585862+345463 x 2= 3276788
Population in year 2041 =P2041=2585862+345463 x 3= 3622251

Geometric Increase 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 n^{th} decade 'Pn' can be estimated as:

$$Pn = P\,(1 + IG/100)^{n}$$

  - Where, IG = geometric mean (%)
  - P = Present population
  - n = no. of decades.

Example:

Geometric increase method

year	Population	increment	Geometric increase (rate of growth)
1961	858545	-	
1971	1015672	157127	(157127/858545)=0.18
1981	1201553	185881	(185881/1015672)=0.18
1991	1691538	489985	(489985/1201553)=0.40
2001	2077820	386282	(386285/1691538)=0.23
2011	2585862	508042	(508042/2077820)=0.24

Avg. Geometric mean per decade, IG, $=(0.18 \times 0.18 \times 0.4 \times 0.23 \times 0.24)^{1/5}$

Avg. Geometric mean per decade, IG, =0.235

Population in year 2021 $=P2021=2585862(1+0.235)^{1}= 3193540$

Population in year 2031 $=P2031=2585862(1+0.235)^{2}= 3944021$

Population in year 2041 $=P2041=2585862(1+0.235)^{3}= 4870866$

Incremental Increase Method

- This method is modification of arithmetical increase method and it is suitable for an average size town under normal condition where the growth rate is found to be in increasing order.

- The incremental increase is determined for each decade from the past population and the average value is added to the present population along with the average rate of increase.

- Hence, population after n^{th} decade is

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

  - Where,
  - Pn = Population after nth decade
  - X = Average increase
  - Y = Incremental increase

Example:

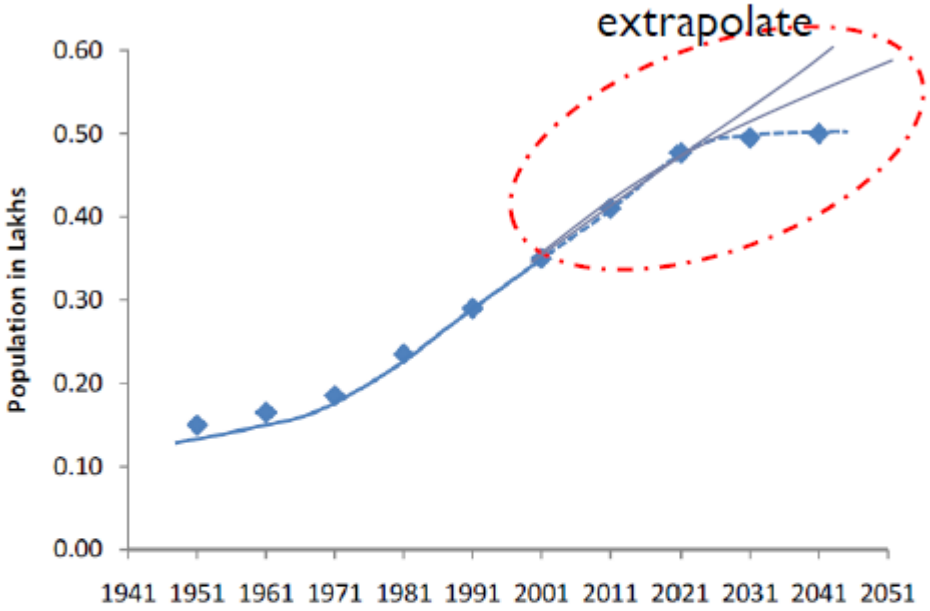
Increment increase method

year	Population	Increment (X)	Increment (Y)
1961	858545	-	-
1971	1015672	157127	-
1981	1201553	185881	(185881-157127)=28754
1991	1691538	489985	304104
2001	2077820	386282	-103703
2011	2585862	508042	121760
	Total	1727317	350915
	Avg.	345463	87729

Population in year 2021 =P2021=2585862+(345463 x 1)+(1(1+1)/2)x 87729=3019054
Population in year 2031 =P2031=2585862+(345463 x 2)+(2(2+1)/2)x 87729=3539975
Population in year 2041 =P2041=2585862+(345463 x 3)+(3(3+1)/2)x 87729=4148625

Graphical Method

- In this method, the populations of last few decades are correctly plotted to a suitable scale on graph.
- The population curve is smoothly extended for getting future population.



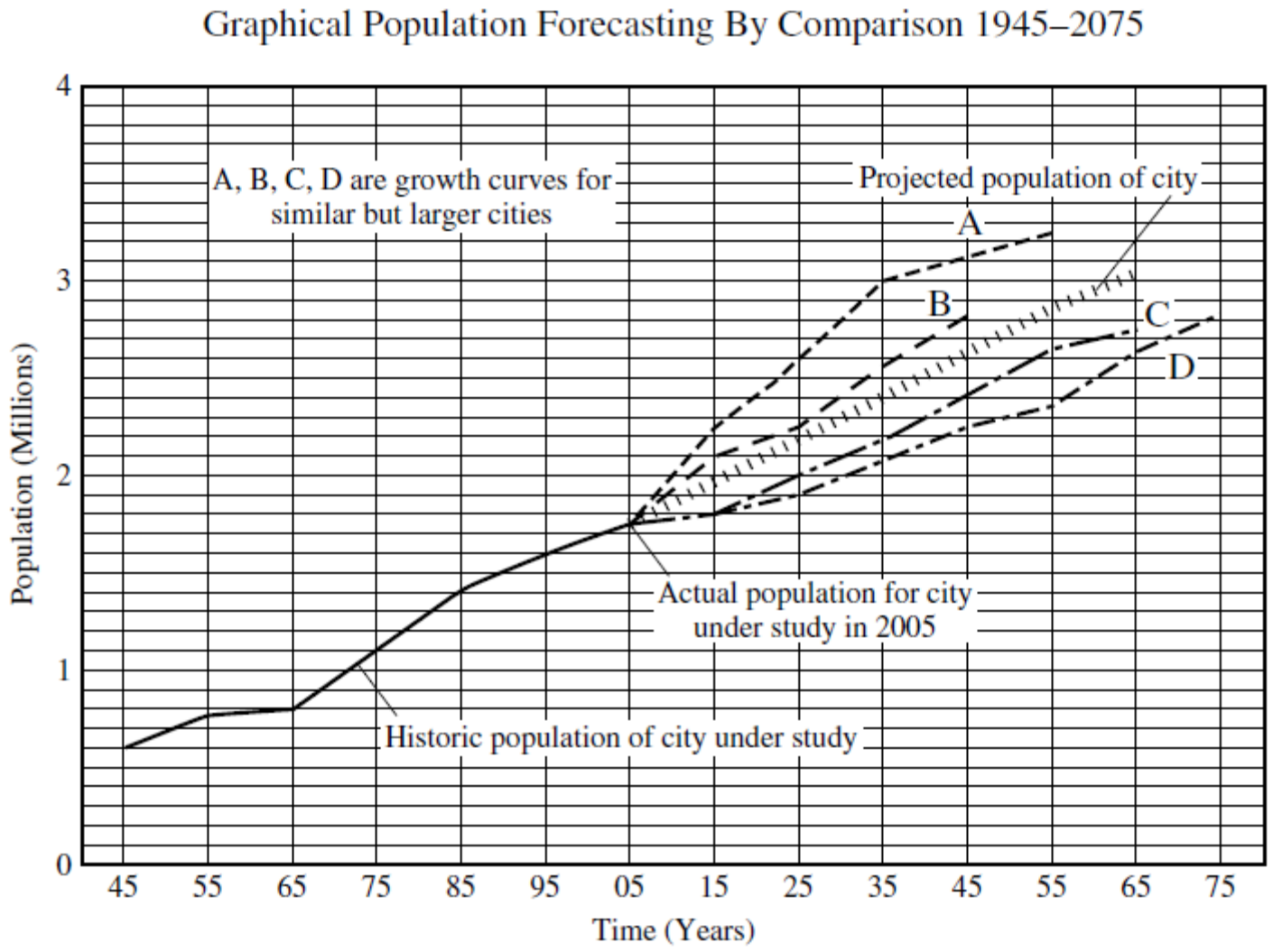
This extension should be done carefully and it requires proper experience and judgment.

The best way of applying this method is to extend the curve by comparing with population curve of some other similar cities having the similar growth condition.

Comparative Graphical Method

- In this method the census populations of cities already developed under similar conditions are plotted.
- The curve of past population of the city under consideration is plotted on the same graph.

- The curve is extended carefully by comparing with the population curve of some similar cities having the similar condition of growth.
- The advantage of this method is that the future population can be predicted from the present population even in the absent of some of the past census report.



Graphical prediction of population by comparison.

Comparative Graphical Method

- **Example:** Let the population of a new city X be given for decades 1970, 1980, 1990 and 2000 were 32,000; 38,000; 43,000 and 50,000, respectively. The cities A, B, C and D were developed in similar conditions as that of city X. It is required to estimate the population of the city X in the years 2010 and 2020.
- The population of cities A, B, C and D of different decades were given below:
  - (i) City A was 50,000; 62,000; 72,000 and 87,000 in 1960, 1972, 1980 and 1990, respectively.
  - (ii) City B was 50,000; 58,000; 69,000 and 76,000 in 1962, 1970, 1981 and 1988, respectively.
  - (iii) City C was 50,000; 56,500; 64,000 and 70,000 in 1964, 1970, 1980 and 1988, respectively.
  - (iv) City D was 50,000; 54,000; 58,000 and 62,000 in 1961, 1973, 1982 and 1989, respectively.

- Population curves for the cities A, B, C, D and X were plotted. Then an average mean curve is also plotted by dotted line as shown in the figure. The population curve X is extended beyond 50,000 matching with the dotted mean curve. From the curve the populations obtained for city X are 58,000 and 68,000 in year 2010 and 2020.

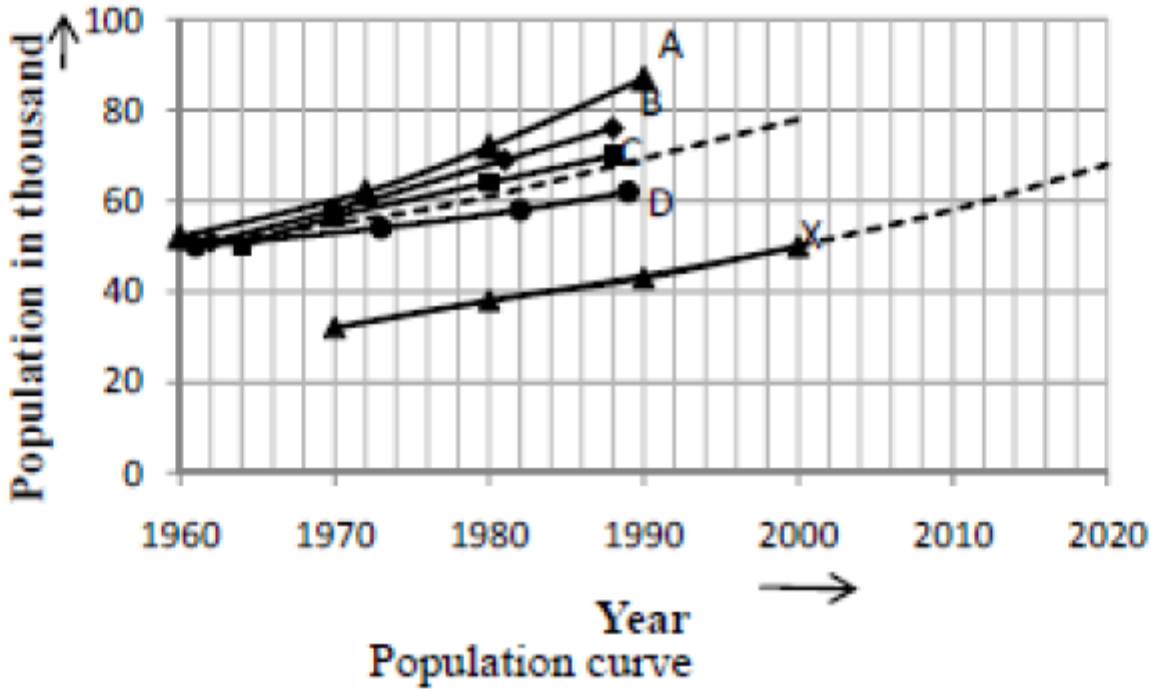


Figure: Comparative graphical method