FOCASTING POPULATION OR POPULATION ESTIMATION

Prof. Dr. Jabbar H. Al-Baidhani

FORECASTING POPULATION OR POPULATION ESTIMATION

In the design of any waterworks project it's necessary to estimate the amount of water required. This involves determining the number of people who will be served and their per capita water consumption, together with an analysis of the factors that may operate to affect consumption.

Forecasting Population :

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.

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- **It is usual to express water consumption in liters or gallons per capita per day, obtaining this figure by dividing the total number of people in the city into the total daily water consumption. For many purposes the average daily consumption is convenient. It is obtained by dividing the population into the total daily consumption averaged over one year.**

It must be realized, however, that using the total population may , in some cases, result in serious inaccuracy, since a large proportion of the population may be served by privately owned wells. A more accurate figure would be the daily consumption per person served.

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Since population is always a relevant factor in estimating future water use, it is necessary to predict, in some manner, what the future population will be. The date in the future for which the projection is made depends on the particular component of the system which is being designed.

FORCASTING POPULATION

Estimation population in the future is another matter. It is certain that estimate will be wrong in some degree and we can only to be as reasonable as possible in selecting an appropriate technique. Through knowledge of the community and external factors which may affect its growth are very important in such analysis.

Elements of the system which are relatively easy to expand tend to have shorter design lives, hence population projection periods may range from as little as 5 to as many as 50 years.

Factors affecting population :

- increase due to births
- decrease due to deaths
- increase/ decrease due to migration
- increase due to annexation.

Population Forecasting Methods :

1- Arithmetic 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, $\frac{dP}{dt} = \mathbf{K}$, $\mathbf{K} = \frac{\Delta P}{\Delta t}$

In which $\frac{dP}{dt}$ is the rate of change of population with respect to time and $\mathbf{K}$ is constant.

Therefore, The Population is estimated from:

$$P_t = P_o + K\Delta t$$

$\frac{dP}{dt}$: rate of change of population

P_t : population at some time in the future

P_0 : present or initial population

Δt : period of the projection in decades

K : population growth rate (constant)

Example: 1

The population of a town is obtained from the following population data as follows, estimate the population of the town on 1992 by using Arithmetic method:

Year	1957	1967	1977	1987
Population	58000	65000	73000	81000

Solution :

Year	Population	K
1957	58000	-
1967	65000	700
1977	73000	800
1987	81000	800

$$K = \frac{\Delta P}{\Delta t} \rightarrow K_1 = \frac{65000 - 58000}{10} = 700 \text{ capita}$$

$$\rightarrow K_2 = \frac{73000 - 65000}{10} = 800 \text{ capita} \qquad \rightarrow \qquad \boldsymbol{K_{ave}} = \frac{\mathbf{700+800+800}}{\mathbf{3}} = 767 \text{ capita}$$

$$\rightarrow K_3 = \frac{81000 - 73000}{10} = 800 \text{ capita}$$

$\boldsymbol{\Delta t}$ = 1992 – 1987 = 5 years , Population forecast for year 1992 is :

$\boldsymbol{P_t = P_0 + K\Delta t}$, $\boldsymbol{P_{1992}}$ = 81000 + 767 x 5 = 84835 capita

2- Uniform Percentage Method :

This method assumes uniform rate of increase, that is the rate of increase is proportional to population.

$$\frac{dP}{dt} = K' \quad , \quad \ln P_t = \ln P_o + K'\Delta t \quad , \quad K' = \frac{\ln P - \ln P_o}{\Delta t}$$

$\frac{dP}{dt}$: rate of change of population

P_t : population at some time in the future

P_o : present or initial population

Δt : period of the projection in decades

K' : population growth rate

Example 2:

For the same data given in example 1 , estimate population on 1992 using logistic method :

$$K' = \frac{\ln \Delta P}{\Delta t} \rightarrow K'_1 = \frac{\ln 65000 - \ln 58000}{10} = 0.0114$$

$$\rightarrow K'_2 = \frac{\ln 73000 - \ln 65000}{10} = 0.0116$$

$$\rightarrow K'_3 = \frac{\ln 81000 - \ln 73000}{10} = 0.0104 \qquad \rightarrow \quad K'_{ave} = 0.0111$$

$$\ln P_t = \ln P_o + K'\Delta t \qquad \rightarrow \ln(P_{1992}) = \ln(81000) + 0.0111 \text{ x } 5 = 11.3577$$

$$\therefore P_{1992} = 85622 \text{ Capita}$$

3- Logistic method :

This method has an S-shape combining a geometric rate of growth at low population with a declining growth rate as the city approaches some limiting population. A logistic projection can be based on the equation:

$$P = \frac{P_{sat}}{1 + e^{a + b\Delta t}}$$

$$a = \ln \frac{P_{sat} - P_o}{P_o} \quad , \quad P_{sat} = \frac{2P_o P_1 P_2 - P_1^2 (P_b + P_2)}{P_o P_2 - P_1^2} \quad , \quad b = \frac{1}{n} \ln \frac{P_o (P_{sat} - P_1)}{P_1 (P_{sat} - P_o)}$$

Where $\frac{dP}{dt}$ **:** rate of change of population

P_t **:** population at some time in the future

P_{sat} **:** population at saturation level .

P_o **:** Initial population.

P_1, P_2 **:** population at time periods.

Δt **:** number of years after base year

n **:** period time (Time interval)

K' **:** population growth rate

Example 3:

In two periods each of 20 years a city has grew from 18000 to 58000 and then to 75800, Determine the extended population for the next 20 years :

Solution:

$$P_{sat} = \frac{2(18000)\,(58000)(75800)\ -\ (58000)^2\,(\,18000 + 75800\,)}{(18000)(75800)\ -\ (58000)^2} = 77582 \text{ capita}$$

$$a = \ln\frac{77582 - 18000}{18000} = 1.197 \quad , \quad b = \frac{1}{20}\ln\frac{18000\,(77582 - 58000\,)}{58000\,(77582 - 18000\,)} = -0.114$$

$$P = \frac{77582}{1 + e^{1.197 - 0.114(60)}} = \mathbf{77308\ capita}$$

4- Declining growth method :

This technique, like the logistic method, assumes that the city has some limiting saturation population, and that its rate of growth is a function of its population deficit:

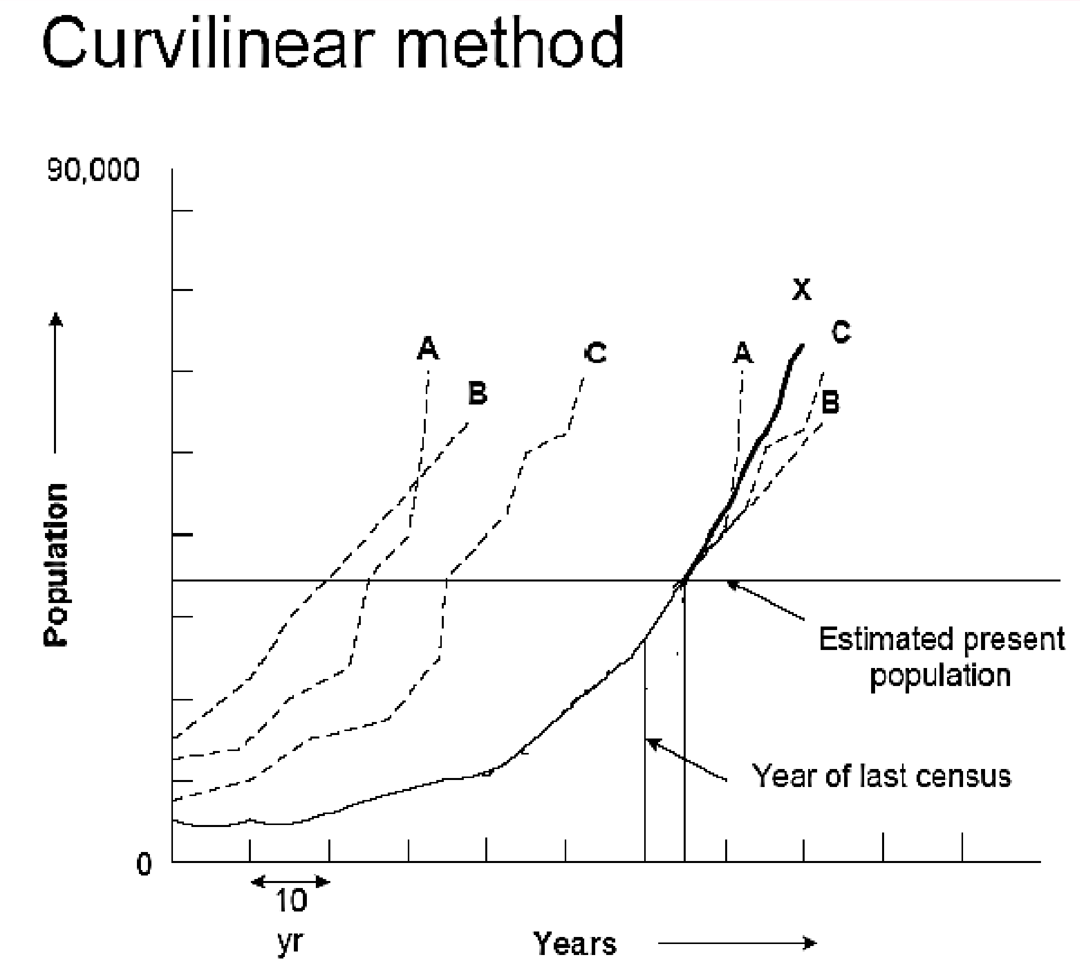
$$\frac{dP}{dt} = K''\,(P_{sat} - P\,) \quad , \quad K'' = \frac{1}{n}\ln\frac{P_{sat} - P}{P_{sat} - P_o}$$

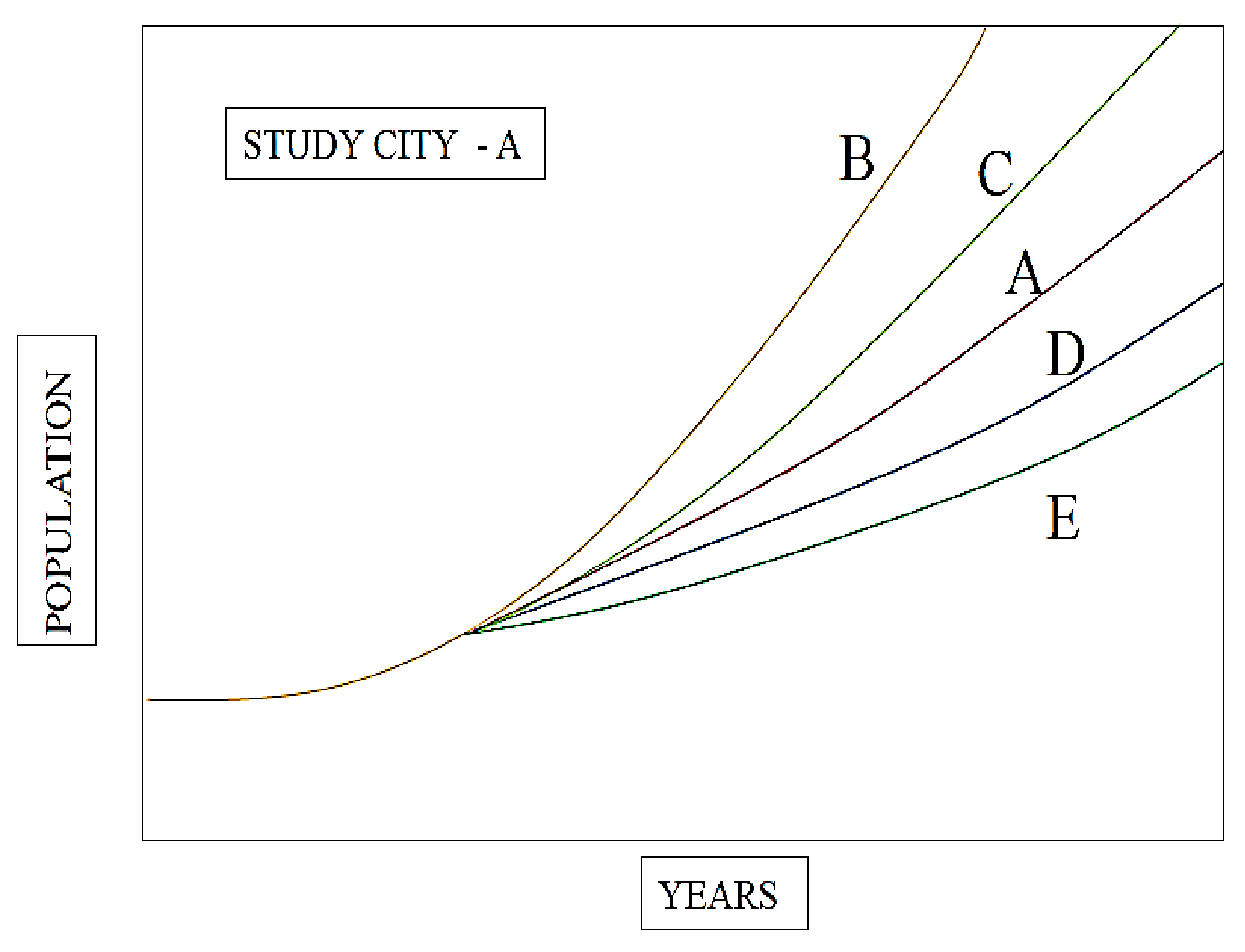
$$P = P_o + (P_{sat} - P_o)(1 - e^{K''\Delta t})$$

5- Curvilinear method (Comparative graphical extension method) :

This technique, involves the graphical projection of the past population growth curve, continuing whatever trends the historical data indicate. This method includes comparison of the projected growth to the recorded growth of other cities of larger size. The cities chosen for the comparison should be as similar as possible to the city being studied.

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 absence of some of the past census report





5- Ratio method:

Ratio method of forecasting is based on the assumption that the population of a certain area or a city will increase in the same manner to a larger entity like a province, or a country. It requires calculation of ratio of locals to required population in a series of census years. Projection of the trend line using any of the technique and application of projected ratio to the estimated required population of projected ratio to the estimated required population in the year of interest.

Example :

A community has an estimated population in a period of 25 years ahead which is equal to 40000 capita. The present population is 30000 capita and the present average daily water consumption is 20000 m^3/day. The existing water treatment plant has a design capacity of 46800 m^3/day. Assuming an arithmetic rate of population growth , determine for how many years the existing water treatment plant will reach its design capacity for maximum daily consumption ?

Solution :

$$k = \frac{40000 - 30000}{2.5} = 4000$$

$$consumption\ rate = \frac{maximum\ daily\ \ water\ consumption}{population} = \frac{1.8\ x\ 20000\ m^3/d}{30000\ capita} = 1.2\ m^3/d.c$$

$$population = \frac{capacity}{consumption\ rate} = \frac{46800\ m^3/d}{1.2\ m^3/d.c} = 39000\ capita$$

$$pt = \ po + k\ \Delta t$$

$$39000 = \ 30000 + 4000\ \ \Delta t$$

$$\Delta t = \ 2.25\ decade = 22.5 years$$

Problems :

1- The recent population of a city is 30000 inhabitant. What is the predicted population after 30 years if the population increases 4000 in 5 years .

2- The recent population of a city is 30000 inhabitant. What is the predicted population after 30 years if the growth rate is 3.5% .

3- The population of a town as per the senses records are given below , estimate the population of the town as on 2040 by all methods.

Year	Population
1957	58000
1967	65000
1977	73000
1987	81000
1997	95000
2007	115000

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For listening