CHAPTER 2

POPULATION FORECASTING

Since the water supply systems are designed for a certain design period, instead of present population, population expected in the design period must be considered in the design of water supply systems.

Forecasting of population can be accomplished with different mathematical methods by using present and past population records that can be obtained from local census office. These methods are generally classified under 2 categories:

A) Short term methods (1-10 years)

- Arithmetic progression
- Geometric progression
- İller Bankası method
- Decreasing rate of increase
- Graphical extension

B) Long term methods (10-50 years)

- Comparative method
- Ratio & correlation method
- Component method
- Logistic method (mathematical curve fitting)

A) SHORT TERM METHODS

- <u>ARITHMETIC PROGRESSION</u>

Rate of population increase is constant and expression is $\frac{dP}{dt} = Ka$

where K_a is an arithmetic constant.

The formula is

$$P\_future = P\_last + \overline{(Ka)}\,(t\_future - t\_last)$$

and

$$\overline{Ka} = \frac{\sum_{i=1}^{x} Kai}{x}$$

Where x = number of past records time intervals.

- GEOMETRIC PROGRESSION

Rate of population is proportional with the population and expression is $\frac{dP}{dt} = Kg.P$

where K_g is a geometric constant and P is population Kg is calculated as

$$Kg = \frac{Ln\, P_2 - LnP_1}{t_2 - t_1}$$

to calculate the future population, the equation is

$$Ln\, P\_future = Ln\, P\_last + \overline{(Kg)}\, (t\_future - t\_last\,)$$

and average Kg

$$\overline{Kg} = \frac{\sum_{i=1}^{x} Kgi}{x}$$

- İLLER BANKASI METHOD

It is a geometric increase method but calculation of Kg is different. In this method Kg = Ç

$$Ç = \left(\sqrt[a]{\frac{P2}{P1}} - 1\right) x100$$ where a = t_2 - t_1

If Ç < 1 then Ç = 1

If 1 < Ç < 3 then Ç = $Ç_i$

If Ç > 3 then Ç = 3

To calculate Ç average

$$\bar{Ç} = \frac{\sum_{i=1}^{x} Çi}{x}$$

where x = number of past record interval

The future population is calculated as

$$P_{future} = P_{last}\left(1 + \frac{\bar{Ç}}{100}\right)^n$$

where n = t_{future} - t_{last}

- <u>DECREASING RATE OF INCREASE</u>

City has some limiting saturation population, and that its rate of growth is a function of its population deficit.

$$\frac{dP}{dt} = Kd\ (S - P)$$

Where Kd is constant, S is the saturation population and P is the population.

Kd is calculated as

$$Kd = \frac{-Ln\ (\frac{S-P2}{S-P1})}{t_2 - t_1}$$

Kd average is calculated as

$$\overline{Kd} = \frac{\sum_{i=1}^{x} Kdi}{x}$$

At last, future population is calculated as

$$P_{future} = P_{last} + \ (S - P_{last})(1 - \ e^{\overline{-Kd}(t_{future} - t_{last})})$$

- <u>GRAPHICAL EXTENSION METHOD</u>

Graphical projection of the past population growth curve continuing whatever trends the historical data indicate.

B) LONG TERM METHODS

- <u>COMPERATIVE METHOD</u>

The future population can be predicted by plotting the population of other cities.

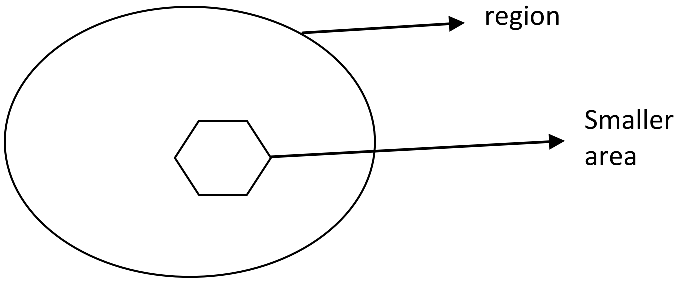
Cities to be compared should be as similar as possible to city being studied. Factors to be considered i) geographical proximity, ii) likeness of economic base, iii) access to similar transportation systems.

Population of the city is expected to grow in a similar manner to cities used for comparison.

- RATIO & CORRELATION METHOD

The method is based on the assumption that ratio of the population of the city being studied to that of the larger group will continue to change in the future in the same manner that has occurred in the past.

In other words, the growth of a smaller area is closely related to the growth of the population of the region in which the smaller area is situated.



$$\frac{Pf}{Pf'} = \frac{Pi}{Pi'} = k$$

K is constant and

P_f = population forecast for the area under study

$P_{f'}$ = future population for the region

P_i = population of the area under study at the last census

$P_{i'}$ = population of the region at the last census

- COMPONENT METHOD

Main reasons of the population change are birth, death and migration. Where information regarding births and deaths is available, the natural increase can be easily estimated. When calculating, net migration should be calculated first, otherwise it will not affect the number of births and deaths recorded.

It is a useful method when migration is not the main factor in population change.

- LOGISTIC METHOD (MATHEMATICAL CURVE FITTING)

Assumption of the method is geometric rate of growth at low population with a declining rate as the city approaches some limiting population.

P.S = last 3 census is important for this procedure.

Population is calculated as

$$P = \frac{S}{1 + m.e^{c.\Delta t}}$$

S is the saturation population and m and c are constants.

$\Delta t = t_{project} - t_0$

Calculation of saturation population

$$S = \frac{2.P_0P_1P_2 - P_1^{\ 2}(P_0 + P_2)}{P_0P_2 - P_1^{\ 2}}$$

Here P_2 is the population at the last census, P_1 is the population one before the last census and P_0 is the population one before P_1.

$$m = \frac{S - P_0}{P_0}$$

$$c = Ln\frac{P_0(S - P_1)}{P_1(S - P_0)}$$

where $n = t_2 - t_1$