Urban Landuse and Transportation Planning
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Lecture – 18
Demographic Models – 2

Welcome back. In lecture 18, the second part of demographic models will be covered.

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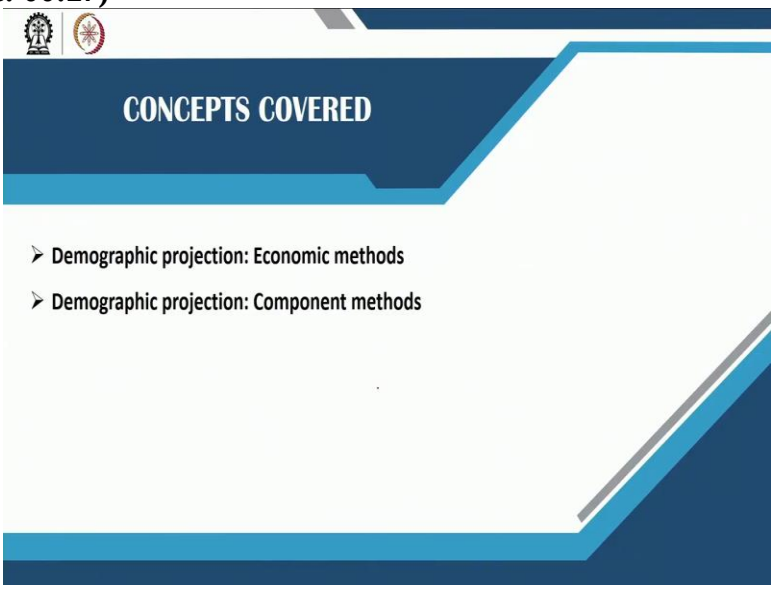

Economic methods and the component methods of demographic projection will be covered in this lecture.

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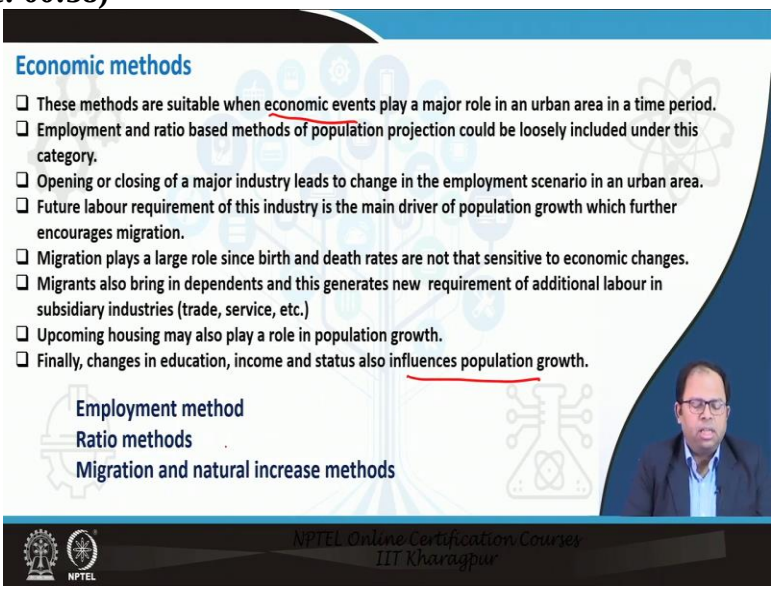

Economic Methods

Economic methods are suitable when economic events play a major role in an urban area during a time period. Economic events could be a new housing development program, opening of a new steel plant etc. These events attract a lot of investments which in turn will change the number of jobs in a particular area and leads to migration and other changes in that area. Employment and ratio based methods of population projection could be loosely included under this category. Ratio based methods refers to adopting the population growth ratio of a larger area to explain the growth of a smaller area if the economic growth of the larger area and the smaller area matches to an extent.

Opening or closing of a major industry leads to change in employment scenario in an urban area. Future labor requirement of such an industry is the main driver of population growth which further encourages migration. Migration plays a large role since birth and death rates are not highly sensitive to economic changes. The birth rate and death rate for a particular urban area are dependent on many factors such as the structure of society, age structure, culture and so on. Thus, if an industry opens, it creates new jobs and will change the migration pattern to that particular area and do not change the birth and death rates to a large extent. Migrants also bring in dependents and this generates new requirement of additional labor in subsidiary industries like trade, services, etc. They will also participate in buying of goods from the urban area or participate in trade and as a result of that, further new jobs are also gets created. Additionally, construction of new housing takes place resulting in population growth and creation of new jobs. Finally, changes in education, income and status for a particular area also influences population growth. Thus, migration greatly influences different kinds of events in an urban area.

The different economic methods of population projections of a particular urban area are;

- Employment methods,
- Ratio methods and
- Migration and natural increase methods

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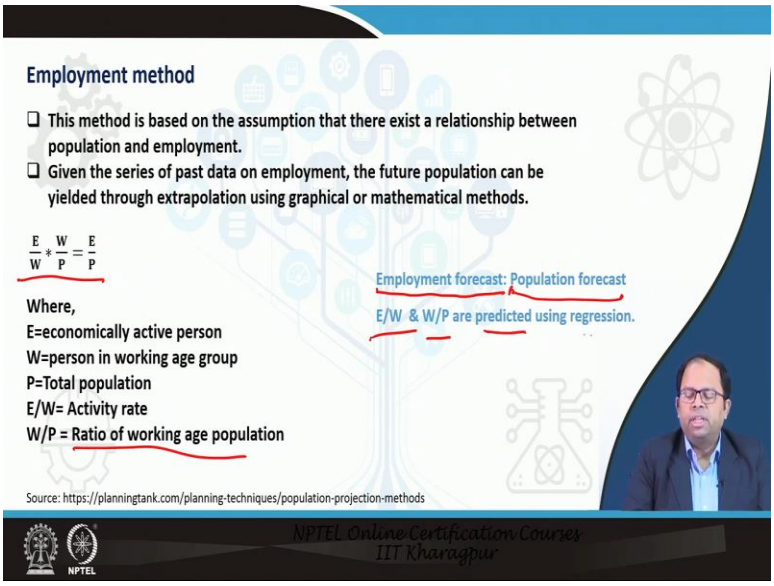

Employment Method

In employment method, it is assumed that there exists a relationship between population and employment ie, if there is certain amount of change in employment, it will relate to certain amount of population increase. Hence, if there is certain amount of population growth and if there is past data on employment, future population can be yielded through extrapolation using graphical or mathematical methods. Similarly, if there is past data on employment and data on current population then based on the employment pattern and the population pattern earlier, prediction can be done. Future employment can influence the future population. So, in many cities employment forecasts are conducted for future year or periods in order to do the population forecast for that particular time period. The equation is given as:

$$\frac{E}{W} * \frac{W}{P} = \frac{E}{P}$$

Where, E is economically active person, W is person in working age group, P is total population, E/W is the activity rate, i.e., the number of people engaged in work and W/P is the ratio of working age population. Also, if E is known P can be predicted based on the equation. E/W and W/P can be predicted using regression based on past historical data. So predicting both of them helps in estimating E / P.

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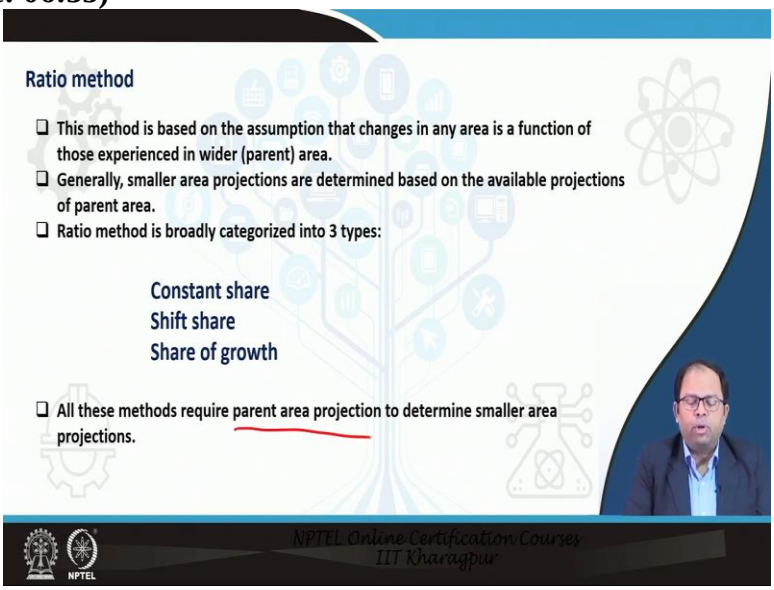

Ratio method

This method is based on the assumption that changes in any area is a function of those experienced in a wider or parent area, which is also the larger area. Generally smaller area projections are determined based on the available projections of parent area. It is assumed that the kind of growth that parent area experiences will be eventually passing on to the smaller area. The ratio method is broadly categorized into 3 types. They are as follows:

- Constant share method
- Shift share method and
- Share of growth method

All these methods require parent area projection to be adopted to the smaller area i.e., only after the population data of the parent area is projected, population data for the smaller area can be projected.

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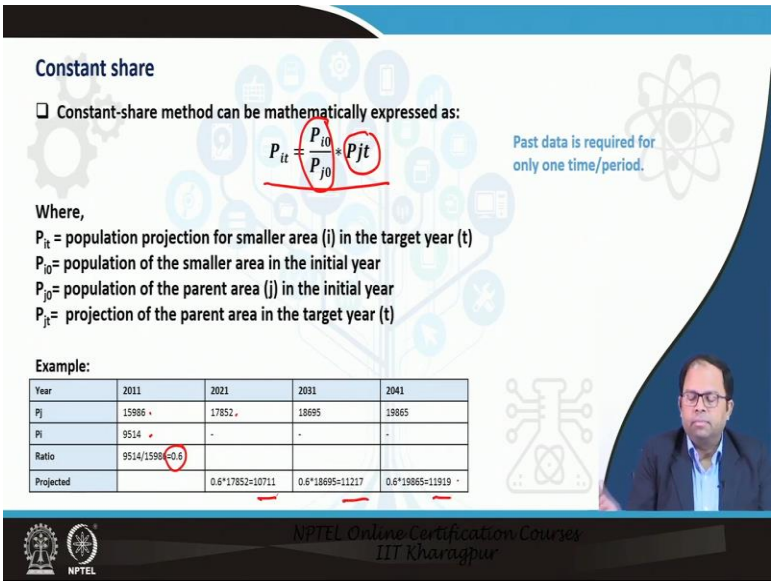

Constant share method

Constant share method is based on the assumption such that, the same rate of a previous year is considered for the future years. It is mathematically expressed as:

$$P_{it} = \frac{P_{i0}}{P_{j0}} * Pjt$$

Where, P_{it} is the population projection for smaller area (i) in the target year (t), P_{i0} is the population of the smaller area in the initial year, P_{j0} is the population of the parent area (j) in the initial year and P_{jt} is the projection of the parent area in the target year (t). In this method, the same ratio is being extended.

In the example, Pj corresponds to the larger area and Pi corresponds to the smaller area for the year 2011. The ratio can be estimated from the given data and using that ratio and the projected population of the larger area, the projected population of the smaller area can be estimated as shown in the above figure.

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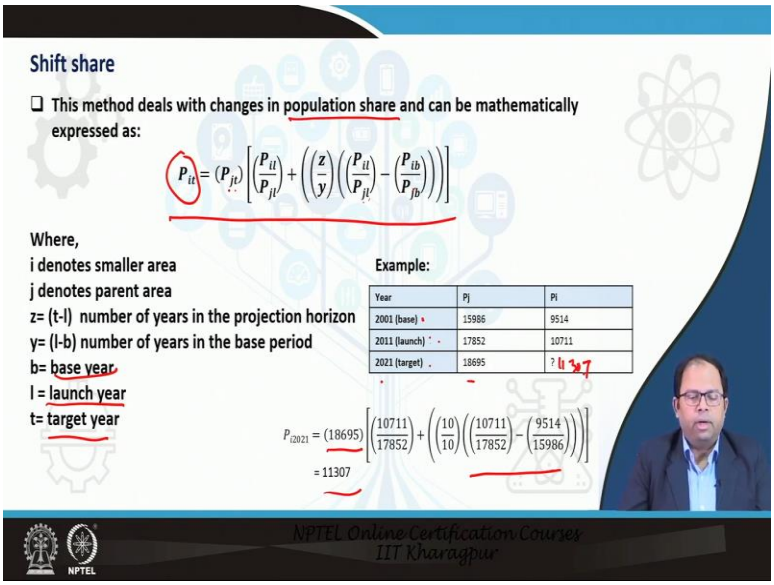

Shift share method

This method deals with the changes in population share and could be mathematically expressed using the following equation.

$$P_{it} = (P_{jt})\left[\left(\frac{P_{il}}{P_{jl}}\right) + \left(\left(\frac{z}{y}\right)\left(\left(\frac{P_{il}}{P_{jl}}\right) - \left(\frac{P_{ib}}{P_{jb}}\right)\right)\right)\right]$$

Where, i denotes the smaller area, j denotes parent area, z is (t-l) number of years in the projection horizon, y is (l-b) number of years in the base period, b is base year, l is launch year and t is the target year. Here, the factor differs from the previous method. The factor assumes change in the population share. 2 new variables are adopted such as the base year and the launch year. Launch year is from where the population projection is being launched. In the example given, the launch year is 2000, the target here is 2021 and the base year is 2001. z/y is the stickiness ratio and it indicates the number of years which is to be projected in future and in what ratio it is to the previous phase.

Using the equation, P_j and P_i values are determined as shown in the above figure. Once these values are determined, the target area value for target year, 2021 can be obtained based on the above equation. Hence, P_{i2021} is determined using the shift shared method.

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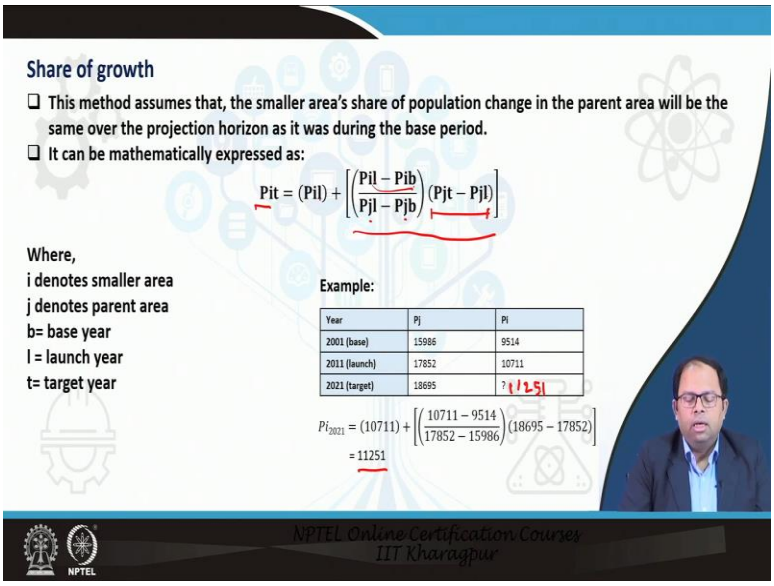

Share of growth method

In share of growth method, it is assumed that the smaller area's share of population change in the parent area will be the same over the projection horizon as it was during the base period. This could be mathematically expressed as

$$\mathbf{Pit} = (\mathbf{Pil}) + \left[\left(\frac{\mathbf{Pil} - \mathbf{Pib}}{\mathbf{Pjl} - \mathbf{Pjb}}\right)(\mathbf{Pjt} - \mathbf{Pjl})\right]$$

Where, i denotes smaller area, j denotes parent area, b represents base year, l is launch year, and t is the target year. In the example, using the given P_j and P_i values replaced in the above equation, an estimate of around 11251 is obtained for the future population.

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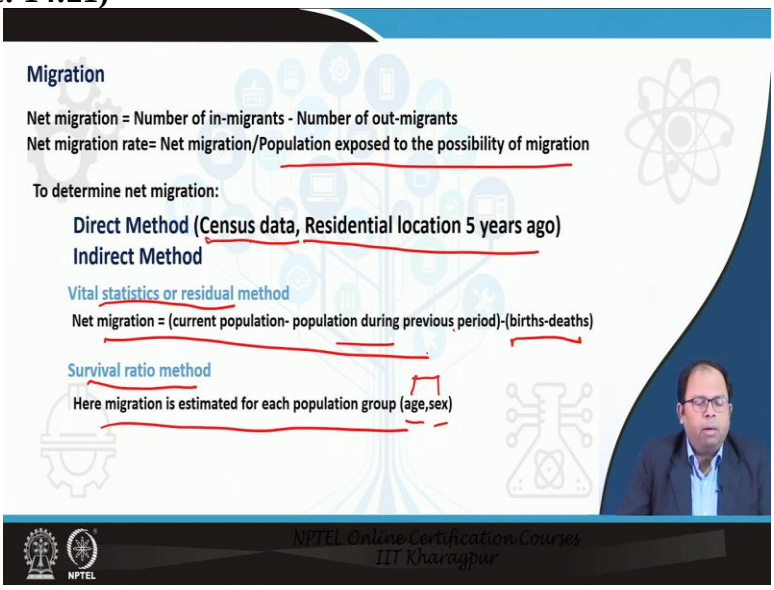

Migration studies

This is another type of economic method for determining future population. Natural increase could be determined from birth rate and death rates for a particular urban area. Usually, the details about the migration data for a particular area is not easily available. Net migration is the difference in number of in-migrants and the number of out-migrants. Net migration rate is the ratio of net migration to the population exposed to the possibility of migration. In order to determine net migration, there are two methods such as the direct and indirect method.

Direct method

Direct method requires census data. Using the census data how many people have migrated to a particular area can be determined. If there is data of 'residential location 5 years ago' available from the census for a particular household and for a particular area, then, one can automatically detect that how many people have moved into that particular area. Similarly, to determine the number of out migration that has happened from an area, data from other areas to where the people from the area under consideration has gone can be used. Thus, using a direct method, the total net migration for an area can be determined.

Indirect method

The two indirect, methods include the vital statistics or residual method and the survival ratio method.

Vital statistics / residual method - Net migration using the residual method can be determined by using the current population, population during previous period or previous census period, and total births and deaths that has happened during that particular period. So, using the direct method, the amount of migration that has happened from the last census period to the current period can be determined. The same net migration rate can be used both for the current year and for projecting the future population. In case data is available for a few time periods then, the trends can be determined and projection can be done to determine migration. However, as migration depends on a lot of economic factors like opening of a factory or any other event which has the potential for economic growth, this method may not be very accurate.

The survival ratio method - In the survival ratio method, the same procedure is followed as the residual method however, migration is estimated for each population group as per age and sex. This will be elaborated in the cohort survival method. Population growth for each cohort or population group is determined as per age and sex. Using the cohort method in a reverse order, the total amount of migration that has taken place in an area can be estimated.

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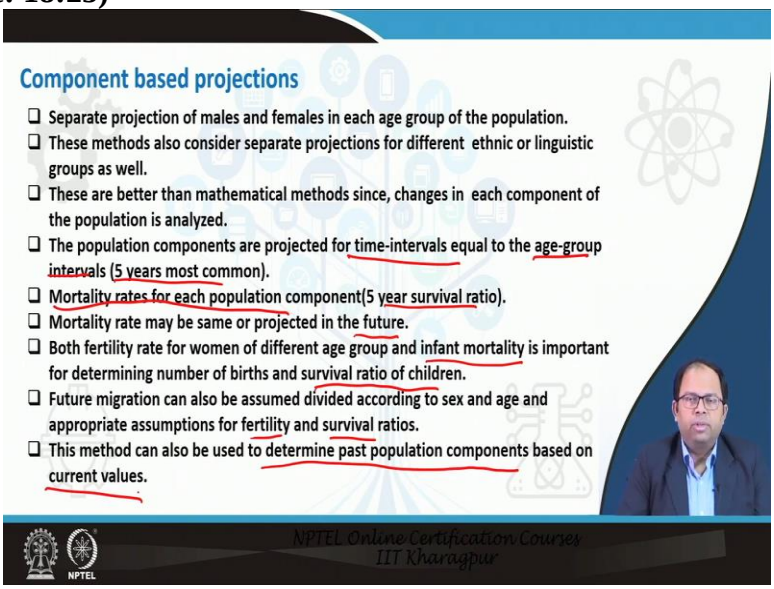

Component based projections

In this method, separate projection for males and females in each age group of the population is undertaken, i.e., the population is divided into different groups. It could be done for different ethnic or linguistic groups or any other population group as well. These are better than mathematical methods since changes in each component of the population such as the fertility rates, mortality rates etc.. So, if group wise analysis is done, then, more accurate estimates are obtained. The population components are projected for time intervals equal to the age group intervals that means that the age groups, i.e., if the time period for project projection is similar to the age group interval, then it can be considered that at the end of each time period, 1 age group could move on to the next age group. If the age group is 0 to 10 years and the projection period is for 10 years, it can be assumed that the entire age group will move on to the next age group, i.e., all the number of people in this particular age group will move to the next age group which is 10 to 20 years. This eliminates the need to do calculation based on every year or so. Hence, age

group interval is matched with the time interval of projection and is usually considered as 5 years.

Mortality rates for each population component is required. This is also called the 5 year survival ratio. This data is required for each population group however, this data is not available always and in such cases, parametric models and semi parametric models can be used to determine the mortality rates. Certain tables can also be used to determine mortality rates. It can be considered the same as from previous projection previous years or could be projected for future years as well. Both fertility rate for women of different age groups and infant mortality rate is important for determining number of births survival ratio of children. Once there occurs births by a particular age group, using fertility rate, the number of births for different age groups can be determined. Also, using infant mortality rate, the number of infants who will survive can be understood.

Future migration can also be assumed divided according to sex and age and appropriate assumptions for fertility and survival ratios. This method can not only be used to determine future population but it could be also used to determine past population components based on current values.

In the migration method, the net migration that has happened in a previous period can be determined using birth rates, death rates, fertility rates, and mortality rates from existing periods. So one can backtrack; back calculate and hence estimate the migration rates as well.

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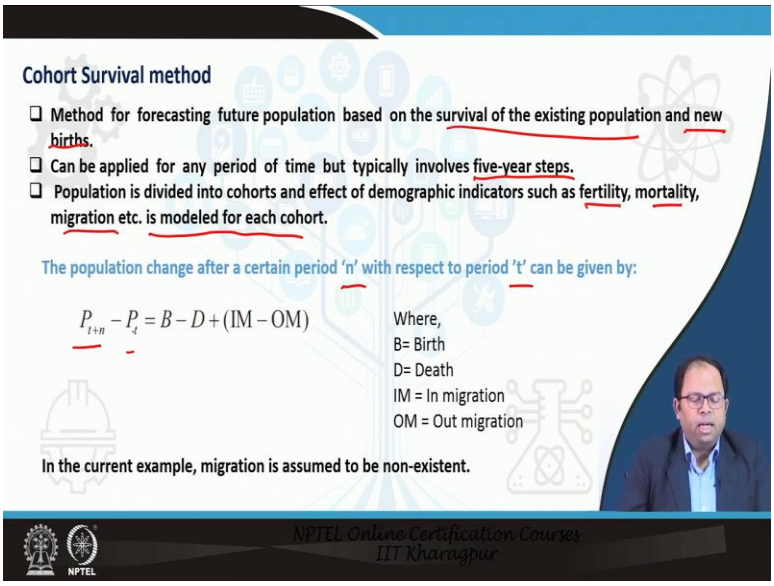

Cohort survival method

Cohort survival method is one of the methods which is based on different components of population where the entire population is divided into different groups. This is a method for forecasting population based on the survival of existing population and new births i.e., by estimating the survival rates of existing population groups along with the new birth for the different age groups, the future population can be estimated. While, this method can be applied for any period of time, usually 5 years steps are taken.

Population is divided into cohorts and the effect of demographic indicators such as fertility, mortality, migration etc. is modeled for each cohort. The population change after a certain period 'n' with respect to period't' can be given by

$$P_{t+n} - P_t = B - D + (\text{IM} - \text{OM})$$

Where, B is the Birth, D is Death, IM is in migration and OM is out migration.

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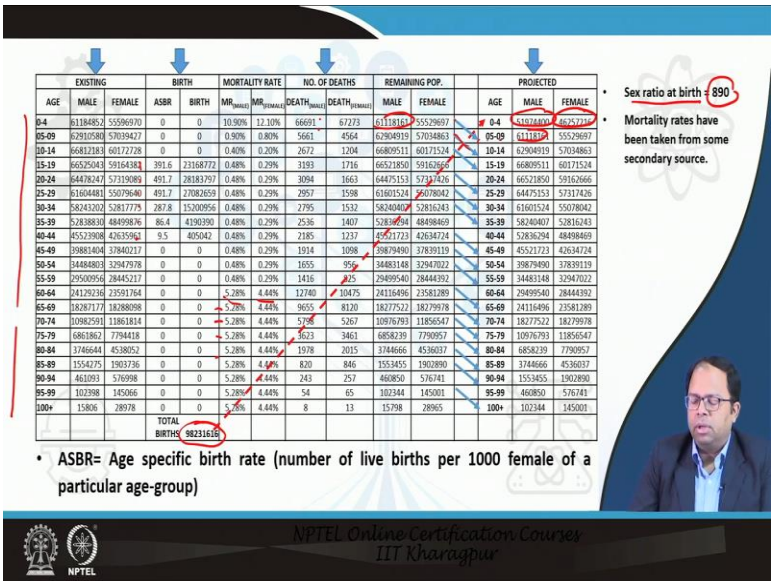

In the example given in the above figure, the entire population is divided into different age groups starting from 0 to 4, 5 to 9, 10 to 14, 15 to 19 and so on to the 100 plus interval. The table shows how the entire population is divided into groups based on age and gender.

Then, the birth rates in each of this group is determined. For female population of age from 15 to 45 years, which is the child bearing age, age specific birth rates (ASBR) are given. This rate gives the number of live births per 1000 female of a particular age group. Total births specific to different age groups can be determined using this rate as shown in the table. This could be per year or for a 5 year period. Hence, total births are determined by adding the births specific to age group. Mortality rate is considered and is different for male and female and also varies across the different age groups. As given in the table, for the 0 to 4 age group the mortality rate is observed to have a high value of 11% for male and 12% for female and then it is observed to drastically reduce and finally, it starts to increase with higher age groups. It can also be observed that the age group from '60 to 64' to the '100 plus; the same mortality rate has been adopted. This is done because of the lack of data. Based on the mortality rate, the total number of deaths from each of this age group is estimated separately for male and female. Using the mortality rate, the number of deaths is calculated which in turn is used to determine the surviving population. So for each age group, the total number of deaths is subtracted from the existing population corresponding to each age group to determine the final survival population for each of the groups.

Then, at the end of the simulation the remaining population value is shifted to the upper age group i.e., after 5 years, the population in the 0 to 4 age group is shifted to the 5 to 9 years category. It can be observed from the table that, each of the remaining population value is shifted one cell down. For the 100 plus group, the value is retained and added with the surviving population of the age group previous to '100 plus'. In order to have the projected population for the first group i.e., '0 to 4', number of births is considered along with the sex ratio at birth. The number of new births is divided into male and female based on the sex ratio. This completes one cycle and then if there is a need to project for a period of 10 years then, another cycle is run. So in that way, the projection can be done.

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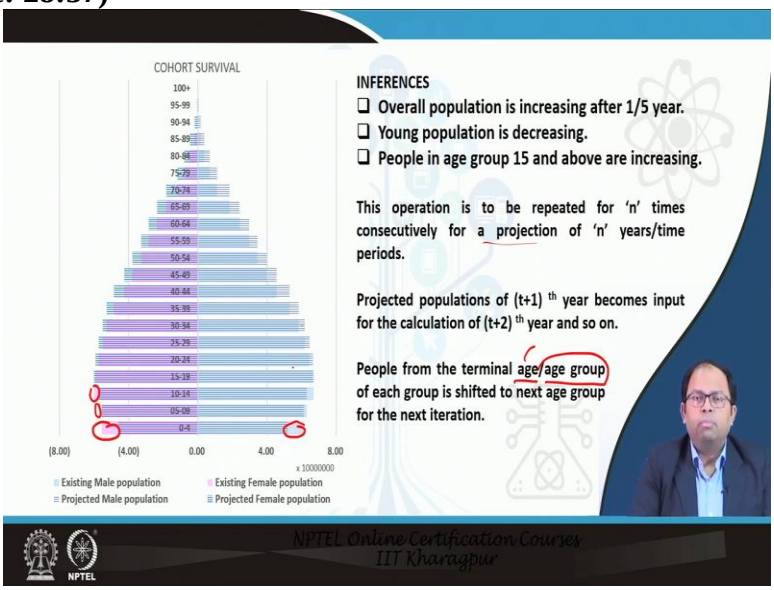

The above figure shows the age sex pyramid of the data given in the previous example. From the age sex pyramid, it is clear that the number of births has reduced. There is reduction in the lower age groups. Overall population is increasing, young population is decreasing and people in age group 15 and above are increasing. This operation is to be repeated for n times consequently for a projection of n years or other time period. So if it is done year wise, then for each age group, people in the terminal year of each age group will be shifted to the next age group for the next iteration. Projected populations of $(t+1)^{th}$ year becomes input for the calculation of $(t+2)^{th}$ year and so on.

This is how population can be projected. This is a very detailed method requiring lots of data. However, it is an accurate method. The age sex pyramid not only determines the total change in

population but also represents which age group shows a decline or increase. Accordingly, the effect on the societal growth and the economics of an area can be understood. It also helps in identifying policies and decision that would be appropriate as per the context.

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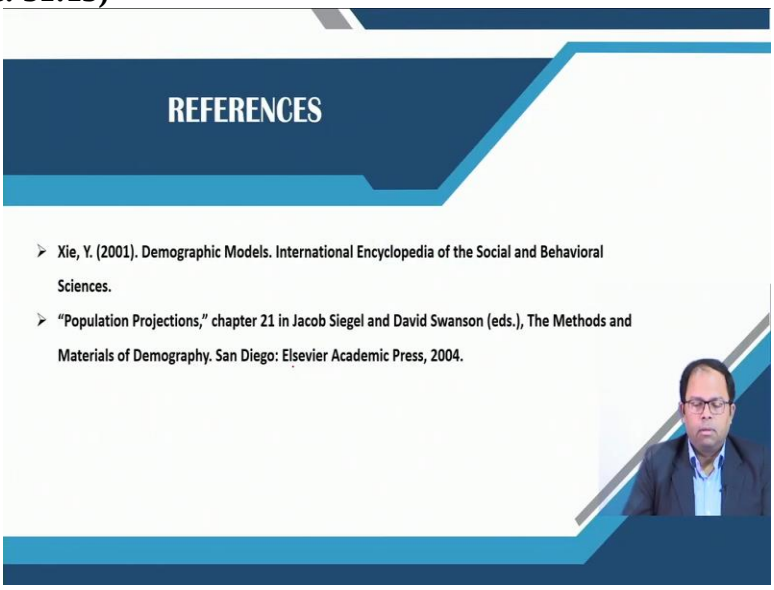

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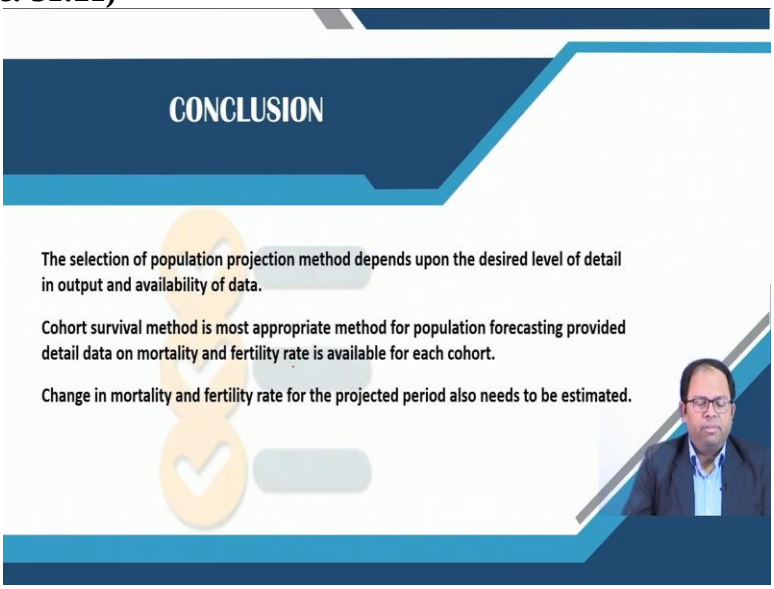

The references are listed.

Conclusion

It can be said that the selection of population projection method depends upon the desired level of detail in output and availability of data and that a cohort survival method is the most appropriate method for population forecasting provided detail data on mortality and fertility rate is available for each cohort. Also, change in mortality and fertility rate for the projected period also needs to be estimated.

Thank you.