Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 01
Urban Utilities Planning: Introduction
Lecture - 02
Planning Strategies

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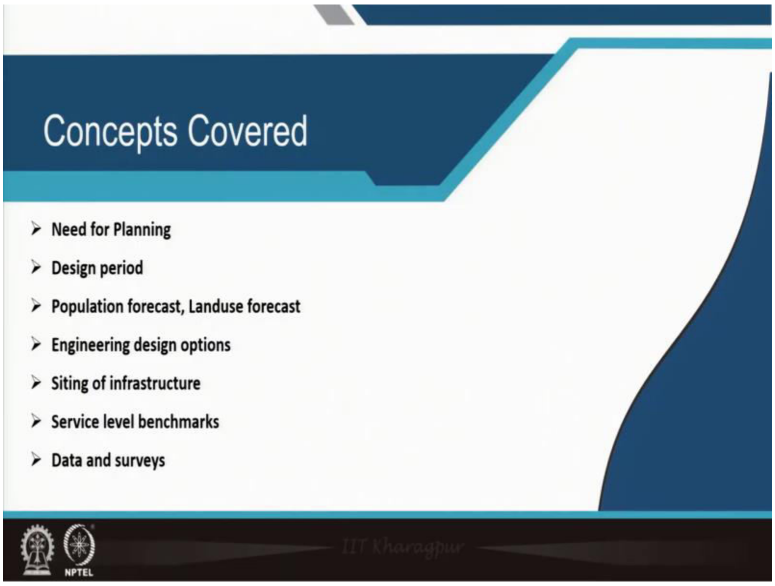

Concepts covered

Welcome back! in lecture 2, different planning strategies for urban utilities will be discussed. The different concepts that will be covered in this lecture are need for planning, design period for utilities, population forecast and landuse forecast, engineering design options, siting of infrastructure, service level benchmarks and data and surveys.

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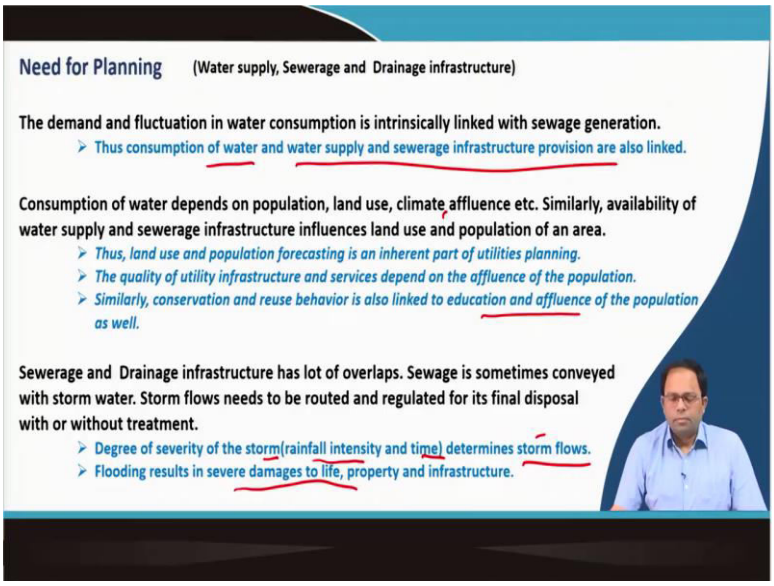

Need for planning

Some of the most important concerns in this context are the need to plan for water supply, sewerage and drainage infrastructure, and the primary needs that has to be addressed during planning of urban utilities and infrastructure. It is evident that the demand and fluctuation (variability) in water consumption by a given society/population group/region is - intrinsically linked with sewage generation. Thus, the consumption of water, water supply and sewerage infrastructure provision are linked.

The variability in water consumption depends on the nature of the population living within a given region. In addition, the nature of landuse affects variability of water consumption. Some areas may have more proportion of green spaces that requires comparatively more water. In a similar way, climate of a particular area affects the same. For instance, the dry region, cold region, coastal region have different water consumption patterns. The affluence of the society also affects the water consumption. The more affluent a society is, more amount of water is consumed by a given household is more.

As variability of water consumption is affected by nature of landuse and population, the availability of water supply and sewerage infrastructure influences land use and population of an area. Thus, the infrastructure needs to be provided based on the demand.

If a given area does not have required infrastructure or utilities, people will not choose to locate in that area. The status of infrastructure and nature of landuse/population is a two way link right. Thuas, land use and population forecasting is an inherent part of utilities planning. There is a need to understand the pattern of evolution of landuse

for a particular area. and population forecasting.

The quality of utility infrastructure and services, technology of the infrastructure, and engineering design depends on the affluence of population and willingness to pay for the services. Similarly, conservation and reuse behaviour is also linked to education and affluence of the population. More affluent/educated people are more prone to conservation or reuse the water resources as they can understand the challenges and regarding the scarcity of water.

Sewerage and drainage infrastructure has lot of overlaps. Sewerage can be conveyed with storm water as well asseparately. Thus, either a combined sewerage system or a separate system can be designed. In case of separate system, the storm flow needs to be routed separately and regulated before its final disposal (with or without treatment) to avoid the flooding in the area.

The severity of a storm (rainfall intensity and duration of rainfall) determines the amount of storm water that is being generated. If rainfall is intense, the greater amount of water will be generated in a short period that might not be able to get drained as the drainage system is not designed accordingly. The water will over flow and will create floods that eventually results in severe damages to life, property and infrastructure. Thus, , this needs to be considered while designing the infrastructure.

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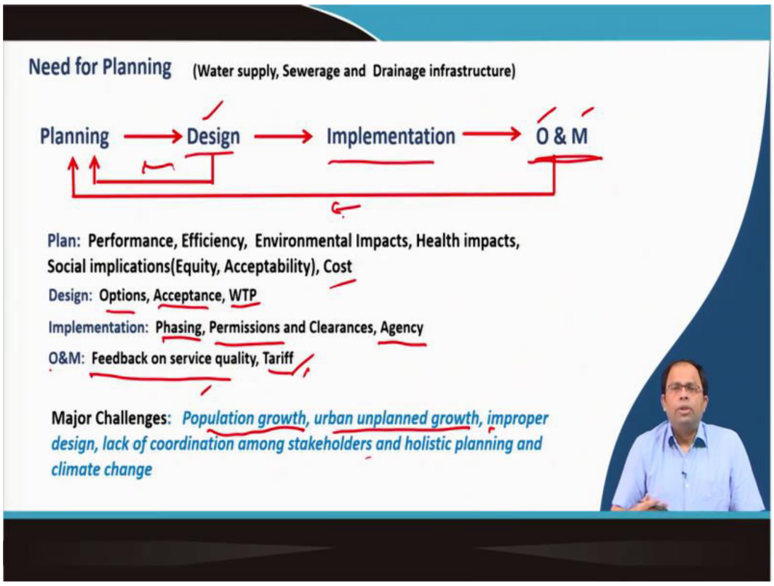

There is a fundamental difference between the standard landuse planning of and utilities planning. The utilities planning encompass four steps: planning, design, implementation and operation/maintenance. Planning includes consideration of the performance of the plan (area coverage of the plan and kind of demand the plan is going to get satisfied),

efficiency of the plan (ratio of the amount of storm water drained to the amount generated, for instance: 80% or 90% efficiency), environmental impacts of the plan, health impacts of the plan, the social implications such as equity (if the water supply is available to everyone in the city?) and acceptability (is a particular infrastructure acceptable?) , and the cost of provision of these services or utilities.

Design includes the engineering design of a given utility infrastructure. A given infrastructure can be designed using different alternatives that are associated with their pros/cons and cost. There would be some benefit to certain designs, however, the cost will be higher. Therefore, the right design must be chosen that are suitable for a certain climate and certain geographical characteristics.. If a sophisticated system is provided in an area where there is no appreciation for the given system, there is no need to provide the system. Apart from technological options, design also include acceptance of the design, and willingness to pay for the design is important.

Implementation includes phasing that ensures adequate funds in every phase for construction. Phasing is linked with land use growth. Implementation also includes involves permissions/clearances and the agency (government, private company, PPP model, etc.) who will implement the given project.

Operation and maintenance (O&M) is a crucial part of the utilities planning. After construction, the utility will run for a long period. Thus, during that period, there is a need for operation and maintenance. O&M also include feedback on service quality.

Operators or utility providers take feedback from people to see if they are happy with the services, what are the service aspects that are lagging that has to be improved, and setting of tariffs. However, the determination ofof cost of services, ways to improve service quality, operational management plan, engineering design, etc. is more technical and out of the domain of urban planning.

One of the major challenges for utilities planning include population growth because in developing countries, the urban population is growing at a very rapid pace. Thus, the infrastructure planning should not only consider current population

but also future population. Urban unplanned growth is also one of the crucial challenge as certain areas of the city may develop with proper planning while others may develop without proper planning.

In addition, addition, improper design, lack of coordination among stakeholders and absence of holistic planning and climate change are also some of the major issues that needs to be dealt for utilities planning.

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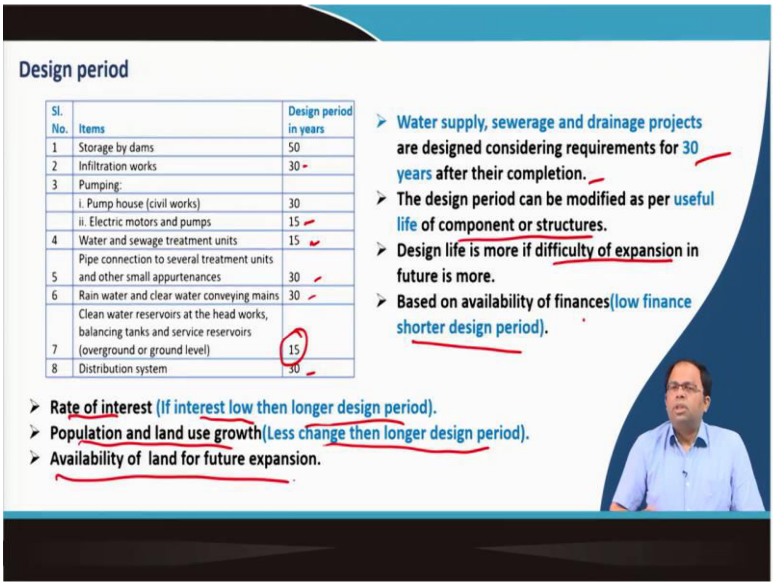

Design period

Design period is one of the crucial considerations of the utilities planning. For these projects, a big capital investment is required and thus a careful consideration of design period becomes important. Usually, water supply, sewerage and drainage projects are designed for around 30 years. Though not all parts of the infrastructure is designed for 30 years, but most of it is designed for 30 years after completion.

Thus, the design period can be modified as per useful life of component and structures. Some of the components and structures can have a lower life while some can have comparatively larger. For example, pumps, electric motors and mechanical units of water and sewage treatment plant have a life of approximately 15 years. In addition, the overhead and service reservoirs have a life of 15 years. On the other hand, infiltration works pipes, connections to several treatment units, rainwater and clear water conveying mains, etc. have a life of 30 years. Thus, the design period helps to determine the kind of plan.

The design period is more if the difficulty in expanding a particular project is more.

The design period is also affected by the availability of the finances. The lLow finances leads to the shorter design period because shorter design periods leads to lessower capacity/size of infrastructure (drains, treatment units, etc.) that require less capital investment.

The rate of interest also plays an important role to decide the design period. The low interests leads to a longer design period.

In addition, the population and land use growth also affects the design period. If the changes in population and land use growth are less, the design periods are longer because of lesserfew areas being newly planned and lesslower risk of design failure.

The availability of land for future expansion also plays a role in deciding the design period.

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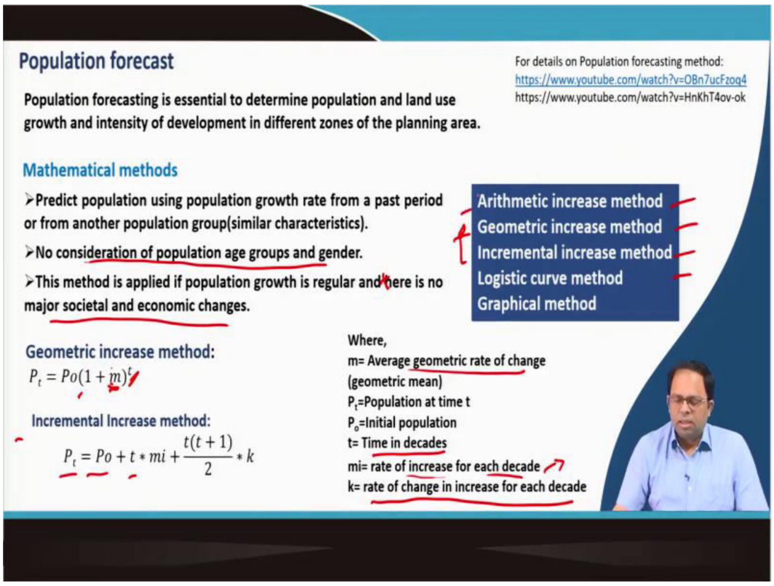

Population forecast

Population forecasting for a particular area is essential to determine population and land use growth and intensity of development in different zones of the planning area. It is also essential for utilities planning so that the infrastructure can be planned according to the predicted population and landuse patterns within the design period.

There are several methods of population forecasting such as mathematical methods, economic methods, etc. In this lecture, mathematical models and economic methods are discussed. Mathematical methods predict population using the population growth rate from a past period based on the available data or from similar kind of population groups with areas with similar characteristics. There is no consideration of age groups, gender and other population sub-groups also. In addition, this method is applied if population growth is regular and there is and there are no major societal and economic changes, for instance a disaster. Thus, these methods are used for short-term forecasting. Mathematical models include arithmetic increase method, geometric increase method, incremental increase method, logistic curve method, and graphical method. Each method has its pros and cons and thus the method should be selected based on the requirement.

Arithmetic increase method is the linear growth method that assumes the similar growth for all the years. Logistic curve method assumes a logistic curve instead of geometric curve. Graphical method forecast population based on observation.

The geometric increase method and incremental increase method are discussed in detail.

For geometric increase method,

$$P_t = P_0 (1 + m)^t$$

Where m = Average geometric rate of change (geometric mean), P_t = Population at time t, P_0 =Initial population, t = Time in decades or number of periods in decade

In this method, the geometric mean of change in population between each time period is determined.

For incremental increase method,

$$P_t = P_0 + t * mi + \frac{t\,(t+1)}{2} * k$$

Where mi = rate of increase for each decade, k = rate of change in increase for each decade

This method takes into account both the existing growth and the incremental growth for each time period.

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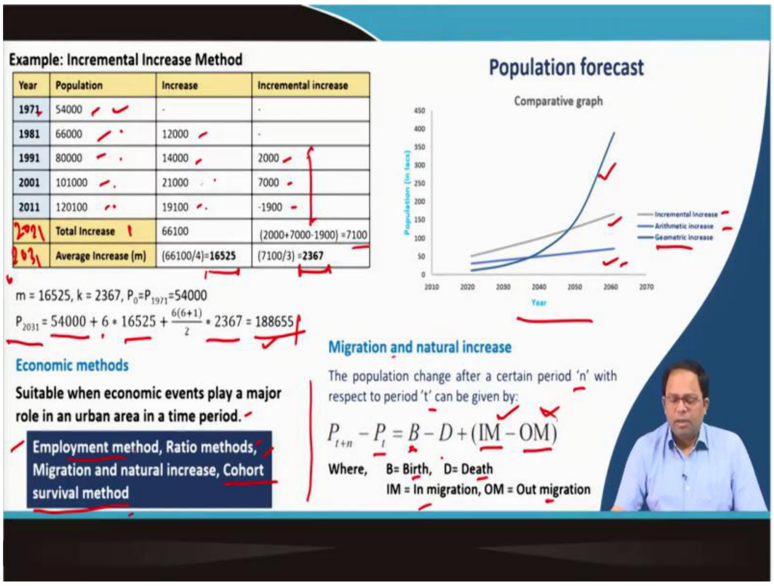

Incremental increase method

Let us consider an example of incremental increase method where the population for the year 2031 needs to be predicted based on the given data.

m = 16525, k = 2367, P0 = P_{1971} = 54000, t = 6

$$P_t = P_0 + t * mi + \frac{t\,(t+1)}{2} * k$$

$$P_{2031} = 54000 + 6 * 16525 + \frac{6\,(6+1)}{2} * 2367$$

$$P_{2031} = 188655$$

The comparative graph of predicted population using geometric increase, arithmetic increase and implemental increase method, it is observed that the population predicted by the incremental increase method lies somewhere between geometric and arithmetic method. Thus,

in case a city is growing at a slow pace, the arithmetic method should be used. If a city is growing exponentially and new businesses are growing, geometric method should be used. Else, incremental increase method should be used which is the most appropriate method.

Economic methods are suitable when economic events (generation of employment opportunities) plays a major role in an urban area in a time period. Economic methods include

employment method, ratio method, migration and natural increase method, and cohort survival method.

Employment method is based on the employment rates which help to forecast the population for an area.

Ratio method considers the ratio of growth between two decades from a similar area which shows similar kind of trends. Migration and natural increase method considers both migration (inmigration and outmigration) and natural change (births and deaths) of the population.

For migration and natural increase method,

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

Where P_{t+n} = Population at a time period after a period n, P_t = Population at initial time period, B = Births, D = Deaths, IM = Inmigration, OM = Outmigration

This method is still crude because the birth rate and death rate of entire population is assumed asto be same. A 90 year old person and a 35 year old person cannot have same chances of death.

Similarly, birth rates also varies as per the age group of the female population. For certain age groups, there is more chance for births. Thus, cohort survival method can be adopted where the population is predicted based on the survival of existing people and the number of births. In this method, the entire population is broken down into different age groups or gender groups (cohorts). Then, the birth, death and in migration and out migration for each cohorts is estimated and overall population for a particular urban area can be predicted.

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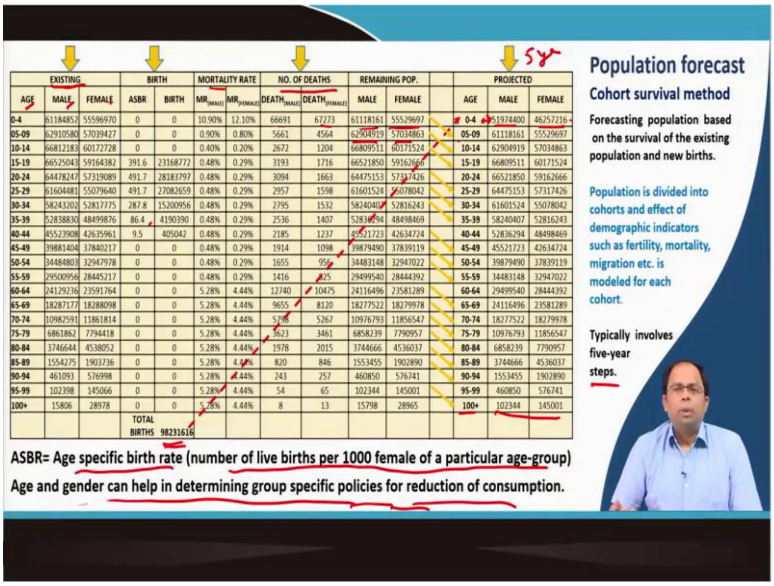

Cohort survival method

In the given example, the existing population is broken down as per different age groups and gender.

. The total number of births for each cohort is determined using ASBR (age specific birth rate or number of live births per 1000 female of a particular age group). The total number of deaths for each cohort is determined using mortality rate which helps to determine the total number of people survived or remaining in each cohort.

The total number of births are added and divided proportionately into male and female based on survey data/available data from medical records.

This proportion helps to determine the number of births in five years and thus, the predicted population in the 0-4 age cohort can be determined. The existing 0-4 age cohort becomes a part of 5-9 age cohort after 5 years. The population is similarly transformed into the next group and thus, the population can be predicted for each cohort. In this method, the inmigration and outmigration can also be considered and analysed in a similar way as that of the native population.

This method can help in determining group specific policies for reduction of consumption of utilities and services or policies as per the behavioural changes for each cohort. Thus, this method

is the most appropriate way to project the future population. However, based on the kind of policies and requirement, the projected population can be utilised for further analysis. For instance, if the total volume of water needs to be determined for a particular area, the overall projected population needs to be multiplied with the water consumption rate (liters per capita per day).