Urban Utilities Planning: Water Supply, Sanitation and Drainage

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Module - 01
Urban Utilities Planning: Introduction
Lecture - 03
Planning Strategies (Contd.)

Welcome back. In lecture 3, discussion regarding Planning Strategies will be continued.

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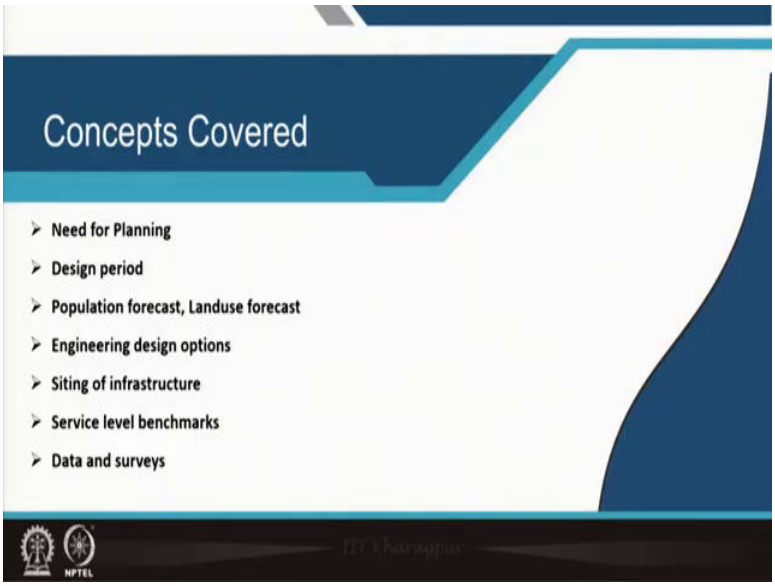

The concepts explaining the need for urban utilities and infrastructure planning were discussed in the previous lecture. The different design periods for different utilities and infrastructure, population forecast and the different methods are also discussed. Land use forecast will be discussed in detail in this lecture.

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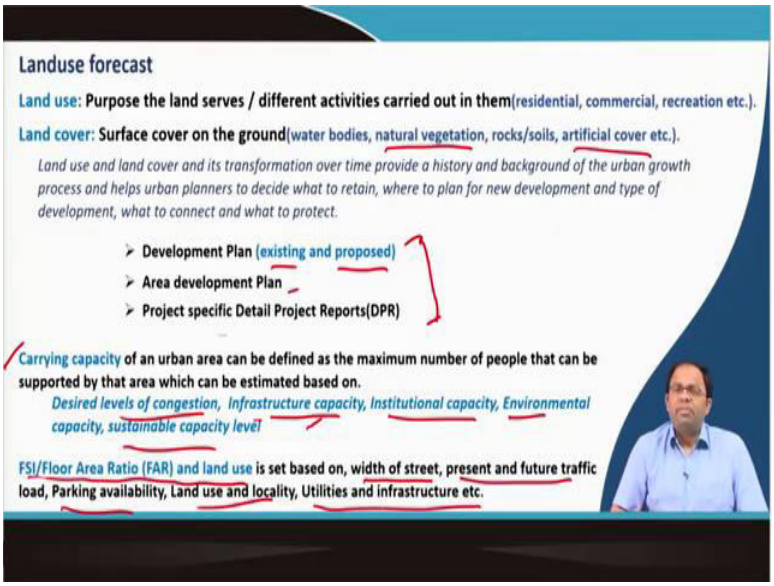

Land use forecast

Similar to population forecasting, land use forecast is a requirement. Land use is the purpose the land serves or the different activities that are carried out in them such as residential, commercial, recreation whereas land cover is the surface cover on the ground like water bodies, natural vegetation, what kind of rocks and soils are present or any artificial cover.

Land use and land cover and its transformation over time provide a history and background of the urban growth process and helps urban planners to decide what to retain, where to plan for new development and type of development, what to connect and what to protect. This also helps planners to decide on which parts they need to intervene and make changes and also how to plan for the new development such that it is more sustainable.

For example, if the vegetation cover is increasing or decreasing and what has to be done to correct it? If the artificial cover of an area is increasing or decreasing and what are its possible implications?

These are important to determine hydrological aspects such as runoffs and recharge areas. Therefore, the land cover plays a role in determining the hydrology of a particular area.

Similarly, land use determines what kind of activities are carried out in them, the population density and such. Development plans constitute both existing as well as proposed plans for a particular area. Area development plan is a more detailed plan for a particular area where the infrastructure layouts are specified. Project specific detailed project reports (DPR) where the detailed specifications of a particular project are listed. These are the different levels of plans which are available for a particular area which helps us plan for the utilities for that particular area.

Consider a proposed development plan and there are new areas where government is targeting to increase the city or expand the city. We have to provide some amount of utilities infrastructure over there that will encourage people to move into that particular area. This is how land use forecasting is related with infrastructure planning or utilities planning.

Carrying capacity

Carrying capacity of an urban area is an important concept in urban planning and infrastructure provision as it is directly related to infrastructure availability. Carrying capacity of an urban area can be defined as the maximum number of people that can be supported by that area and this is based on many criteria such as the levels of congestion, road infrastructure, overall infrastructure capacity, institutional capacity, environmental capacity, sustainable capacity levels etc. Infrastructure capacity determines the extent of carrying capacity which in turn determines the land use and the amount of population it can support.

FSI / Floor Area Ratio (FAR)

FSI/ floor area ratio (FAR) determines the amount of development that can be proposed in a particular area or rather the maximum intensity of development possible for that area. FSI is primarily based on the width of streets, adjacent streets, present and future traffic load, parking availability, land use of that particular locality and utilities and infrastructure.

If there are not adequate utilities infrastructure, we cannot simply increase the FAR. Because higher the FAR, larger the number of people densely packed in a particular area. For e.g., if FAR is increased from 2 to 4 implies that we can build 4 times more in the

same amount of land space. This can be translated as double the population for that particular area and the infrastructure should have the capacity to supply that amount of demand of water, sewage and other utilities. Therefore, utilities and infrastructure are directly related with carrying capacity and the FSI or floor area ratio that we set for an urban area.

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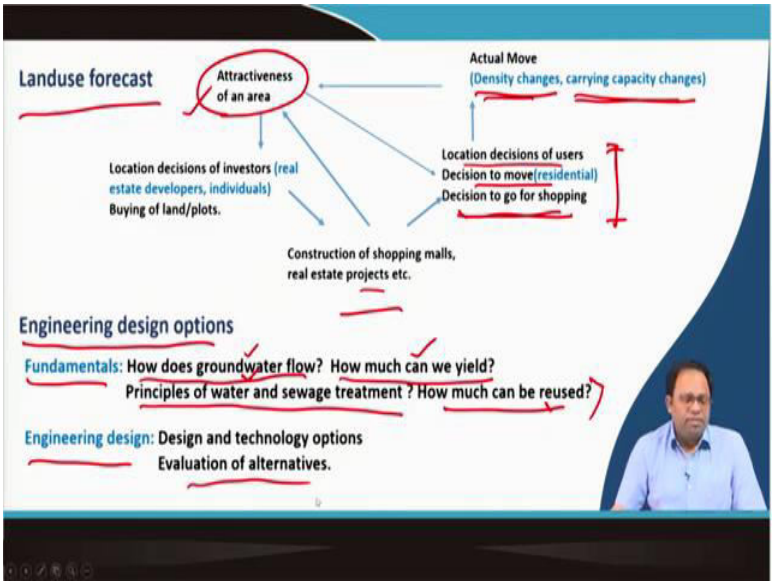

How does land use forecast work? We determine the attractiveness of an area for example a new area which the government wants to expand. Once the attractiveness of the area is determined, the real estate developers and investors will buy lands or plots. This is the first step. After this, when new infrastructure project comes up, for e.g., a new highway, these real estate developers start developing real estate projects like residences and shopping malls. This in turn attracts people to move in due to the presence of infrastructure projects such as highways, residences, shopping malls and such. All of these activities require supporting infrastructure.

If you plan to move to a new area, you will only move there if that particular area is attractive enough with adequate infrastructure. Shopping decisions will be influenced by its cleanliness, presence of toilets, adequate water supply and other amenities. Absence of these facilities will deter the people from going to such shopping malls.

These location choices or decision to travel are related with the kind of developments coming up in that particular area. Actual move is when people decide to locate and they

actually move into that area. Then the density of that area changes which in turn changes the carrying capacity of that area. The carrying capacity remains same, but the capacity that has been already covered will change. So, there is just the remaining capacity where you can only have a few more people who wish to come there. This increases the price of that particular area and so on. These density changes and the capacity changes are all related with infrastructure that is available. If you want more people to move there and if you want the carrying capacity to be changed, we need to provide more infrastructure. When we provide more infrastructure, it will become more attractive, more people will try to acquire land over there and more people will start moving in.

This is how land use forecasting also needs to be done. These are events which happens simultaneously and if there is always a supply and demand difference, prices of that area will vary based on this. All of these ultimately depends on the kind of infrastructure that is present. Infrastructure includes road infrastructure, parking infrastructure, water supply, sanitation, and drainage infrastructure which actually decides on the attractiveness of an area and the subsequent development of that area. This is how land use forecasting is connected with infrastructure planning.

Engineering design options

So, in addition to population forecast and land use forecast, we also need to understand the different engineering design options and there are two parts to it, one is the fundamentals and the other is the actual engineering design.

Fundamentals

Fundamentals refer to basic physical processes so that we can understand how to actually deal with that particular background process and the kind of infrastructure that has to be provided to deal with that. This helps us decide on the best possible engineering design to for that particular kind of infrastructure.

Consider how groundwater flows in a particular area and based on that we can determine how much amount of water could be yield from that particular well or a deep tube well. So, amount of water available from deep tube well depends on how groundwater flows in a particular area. This is the physical process and it serves the water demand for a particular area.

Principles of water and sewage treatment; how much can be reused? Based on what kind of sewage treatment you adopt you can determine how much of that water could be reused. If the treatment is basic, then you cannot reuse the water. If the treatment is thorough, we can re-use it for different purposes depending upon the degree of treatment. If it is partially treated, then we can use it in the for augmenting the green infrastructure or recharging the water bodies or some streams in that area.

Engineering design

The design and technology options are there for any kind of infrastructure. We have to evaluate the different alternatives in terms of their cost, efficiency and performance. This helps us to take a call on which is the most appropriate for a particular area. These are the different aspects that needs to be considered when planning for urban utilities.

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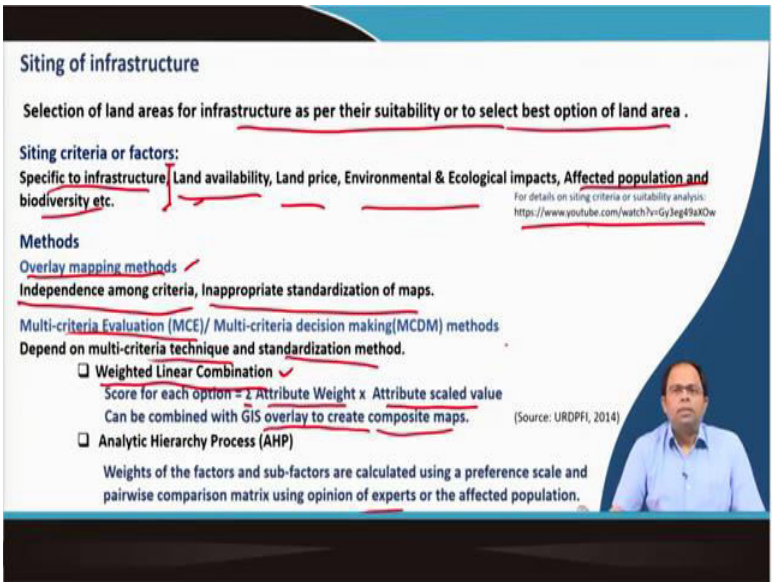

Siting of infrastructure

Siting of infrastructure is another dimension, usually considered in most planning problems, which is a little different in utilities planning. Consider the following question: Where do we decide to construct a particular infrastructure? Where do we locate an overhead tank? Where do we locate a water treatment plant? Where do we locate a sewage treatment plant? Siting of infrastructure refers to selection of land areas for infrastructure as per the suitability of the land area. We select the land area which is the

most suitable for a particular infrastructure and specific to the infrastructure that is planned for.

For e.g., if we are planning for intake points for water supply, it should be close to the intake source. In case of pump location, it should be either close to the overhead reservoir or the water treatment unit.

Therefore, siting of infrastructure depends on different technical criteria. In the case when two or more sets of land satisfies all the technical requirements, then we need to take a call on which land to choose and the other factors come into play. These include land availability, land price, environmental & ecological impacts, affected population and biodiversity of that particular area etc.

First step is to make sure that all the design criteria for a particular infrastructure is met and then we can evaluate the best possible alternative. There are different ways to go about this which is explained in detail in this lecture.

The two primary methods are overlay mapping method and the multi-criteria evaluation or multi-criteria decision-making methods.

Overlay mapping method

Firstly, we prepare a map for land availability for a particular infrastructure, only marking the land parcels which are available. Then the land price is marked based on band categorisation with higher and lower price bands which reduces the number of choices. Then environmental and ecological impact each of these are overlapped on to the map. This helps us determine which among those are available with a certain band of land price and an acceptable amount of environmental impact.

This will reduce our options making it easier to take decision. In a nutshell, in overlay mapping method we will map different layers of decisions or decision criteria and we will select the one where all the criteria are fulfilled.

The first drawback is the assumption of independence among the criteria. We are taking each layer or each criterion one after the other and not taking them as an integrated measure. The other is inappropriate standardization of the maps. Each criterion will have different units and hence standardization will be different.

Multi-criteria evaluation or multi-criteria decision-making methods

Multi-criteria evaluation or the multi-criteria decision-making methods include several methods depending on the multi-criteria technique and standardization methods.

Weighted linear combination

The first technique is weighted linear combination where we give a score to each of the options that are available to us and take a summation of the attribute weight and the attribute scaled value.

$$\text{Score for each option} = \Sigma \text{ Attribute Weight x Attribute scaled value}$$

For each attribute or each criterion based on which we are taking a decision, there is a score attached to it based on that particular plot of land and a weight indicating the importance of that particular criteria.

These values are multiplied and added up to get an overall score for each option and whichever has the highest score will be chosen. This can be combined with a GIS overlay to create composite maps.

Analytical hierarchy process

In analytical hierarchy process, weights of factors and sub-factors are calculated using a preference scale and pairwise comparison matrix composed using opinion of experts and the affected population.

Two of those factors are taken and compared to decide which one is preferred over the other and this is repeated for all the different criteria. Based on the opinion of experts and the affected population, we determine the weights and then determine which option is the best one.

Analytical hierarchy is more or less the same as weighted linear combination with the exception in the method adopted for the determination of weights; in the latter, weight is directly given by some expert or based on some cost parameter whereas in the former, weight is based on pairwise comparison.

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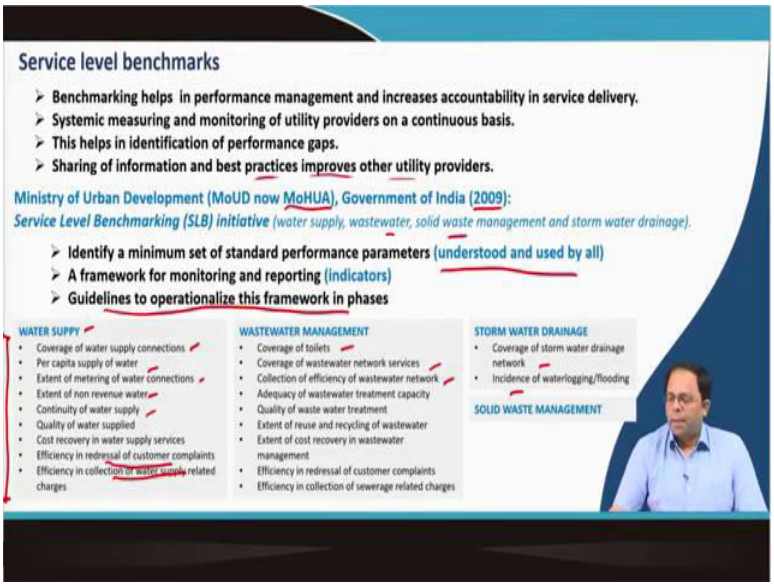

Service level benchmarks

Service level benchmarks helps us to determine what kind of services is appropriate for a certain population. There are several service providers and this necessitates the need to create standards which everybody has to follow. These standards should be designed such that it satisfies the people in terms of particular services.

The benchmarking process helps in performance management and increases accountability in service delivery. They help measure the performance of utility service providers to assess if they are performing adequately or if a particular urban local body is efficient. There can be some performance measures based on which we can rate and compare different agencies and accordingly take appropriate decisions. This involves systematic measuring and monitoring of utility providers on a continuous basis. This forms a big part of implementation and maintenance as these operators will tend to only look into its own profit. Service level benchmarks will ensure the performance of these providers and the provision of good quality services.

It also helps in the identification of performance gaps. If we notice that certain areas are not well maintained, we have to overcome this by sharing of information on best practices which improves other utility providers. So, if somebody does good, others will be able to know about it and then, they can perform better.

In India, Ministry of Urban Development now renamed as Ministry of Housing and Urban Affairs in 2009, started the service level benchmarking initiative for water supply, wastewater, solid waste management and storm water drainage. They identified a minimum set of standard performance parameters for each of this particular service utilities which can be understood and used by all the different service providers. They also formulated a framework for monitoring and reporting of these indicators and guidelines to operationalize this framework in different phases.

There are different sets of indicators for different services. Consider water supply; the different indicators include coverage of water supply connections, per capita supply of water, extent of metering of water connections, extent of non-revenue water, continuity of water supply. Other things include efficiency in redressal of customer complaints, efficiency in collection of water supply related charges. These indicators give an extent about the different things we need to improve for a particular service. Similar to water supply, the service level benchmarks of wastewater management will be discussed in detail in the subsequent lectures.

For wastewater management, many of the parameters are same like redressal of customer complaints, efficiency in collection of sewage related charges, then coverage of toilets, coverage of wastewater network services, collection efficiency etc. These are different parameters based on which we can evaluate service provision for a particular area.

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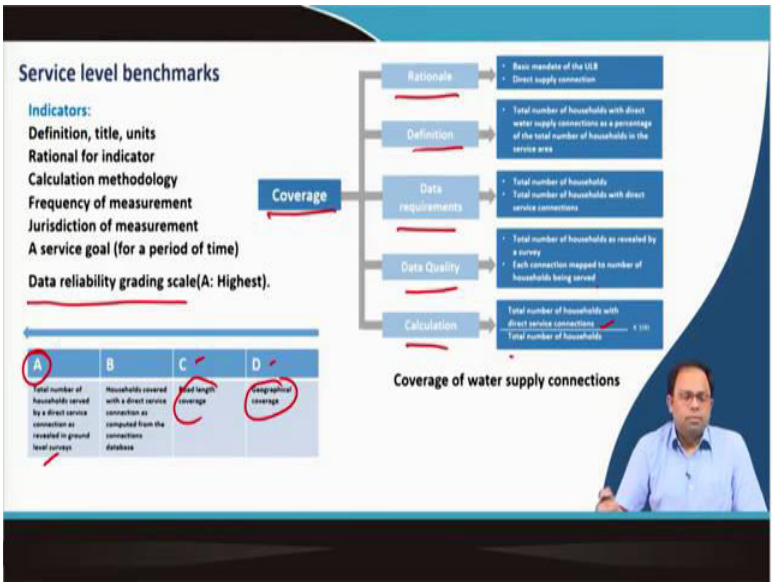

Indicators

Indicators help define the different service level benchmarks. Consider the indicator of coverage of supply connections under water supply. There is a rationale for considering this particular indicator. The definition explains what coverage means in this particular case and the data requirement, data quality and the calculation.

Calculation refers to the method i.e., the number of service connections divided by total number of households(percentage of households covered by the direct service connections). The data required are the number of total number of households and total number of households with direct service connection. The total number of households could be revealed by survey or through a map of households being served.

The data quality issues imply how the data has been collected. There is a data reliability grading scale to assess its quality. If we are getting the data directly from a survey, it is of reliability level A which is the best possible reliable data. If it is based on average values based on geographical coverage or connections per road lengths, it is of C and D level of reliability.

Therefore, it is not just how we estimate and define parameter, but also depends on the reliability of data and how the calculations are carried out. These are important for service level benchmarks.

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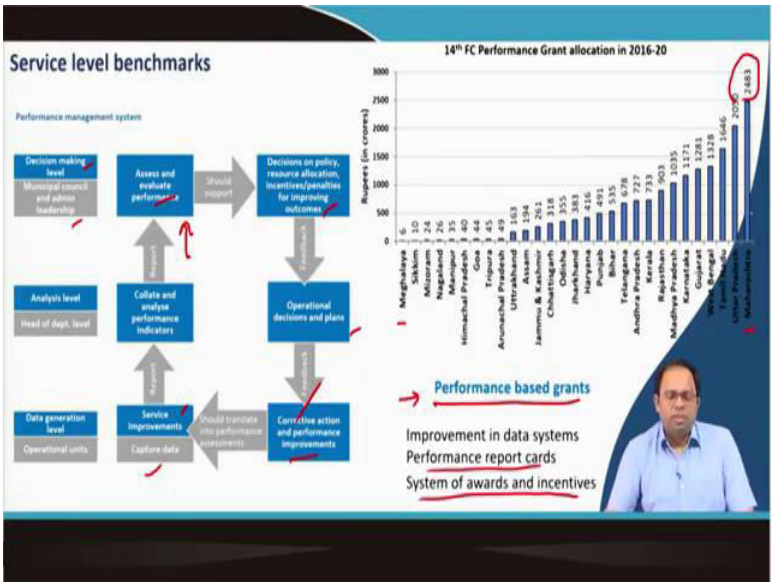

Service level benchmarks are used to assess and evaluate performance of a particular service provider. So, the decision-making level of the municipal council assess the performance and based on that, they take decisions on policy, resource allocation, incentives or penalties for improving outcomes.

So, ultimately, they can either choose to penalize them to improve the outcome or give them a price to motivate them. The operational decisions and plans, corrective actions and performance improvements have to be decided based on this. We have to collate and analyse the performance indices based on our SLBs which then goes for reporting.

This is the process in which decisions are taken in a municipal area. Firstly, they assess the performance of service and then based on those corrective measures would be taken. Currently, in India, performance-based grants are provided, in addition to the normal grants, if a municipality is performing well. Different cities get different performance-based grants based on their performance and size. Maharashtra got the highest performance-based grant of Rs. 2483 crores while the least amount was given to Meghalaya and Sikkim. These grants are based on the performance report cards and acts as an award system for the states so that they get motivated to further improve their services.

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Data and Surveys

The final aspect to be covered is the different data and service that are required in utilities planning which includes data for social aspects, physical aspects and engineering aspects.

Therefore, the data requirement is considerably large compared to other planning activities as we require raw data, primary data, survey data, experimental data as well as secondary data from published sources, maps, reports and regulations.

In order to get socio economic data, user perception of service quality, choice, willingness to pay for particular services, surveys can be conducted. Details regarding the different surveys will be explained in the subsequent lectures.

In the case of raw data, primary data, survey data, experimental data and secondary data, it has to be collected for various aspects such as physical characteristics, rainfall characteristics, and waterway characteristics.

Physical characteristics

Data regarding physical characteristics such as topographical details, slope of catchment, streams, canals, number of outfall points, intake points for water, outfall points for sewage are required. Details of road network, railway network, bridges, culverts, railway crossing are required. Existing land use, land price, land cover these are also required. Data on inflows from contiguous upper region, this inflow of water from the upper regions of catchment how water flows from those regions to a particular area, soil characteristics which in includes permeability, porosity, run off coefficients, soil bearing capacity are also required.

Sometimes, not all of the data would be required; a subset of the data would suffice. We will see that for different estimates and calculations these data is a prerequisite and hence it is better to have this data ready whenever we start infrastructure planning.

Data regarding groundwater tables along with the seasonal variations, rainwater harvesting, groundwater recharge structures in the landscape, solid waste, and pollution sources are augmented by Survey of India topographical maps, satellite images, aerial

photographs and also, the existing master plans, development plans and area development schemes for that particular area.

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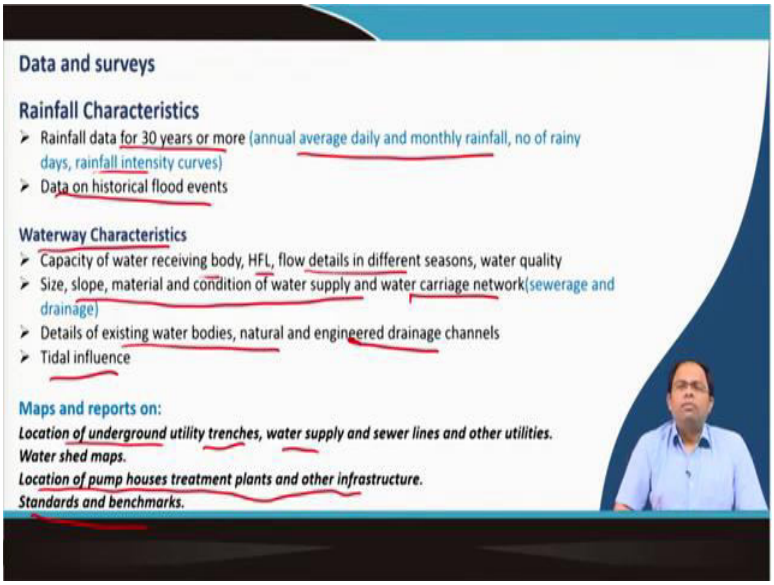

Rainfall characteristics

Rainfall data for 30 years or more in the form of annual average, daily and monthly rainfall, no of rainy days, rainfall intensity curves is required to estimate runoff. Data on historical flood events is also required.

Waterway characteristics

Waterway characteristics like capacity of water receiving body, high flood level, flow details in different season, size, slope, material, condition of water supply, water carriage networks, details of existing water bodies, natural and engineered drainage channels, tidal influences are some of the data requirements. These are augmented by secondary sources such as location of underground utility trenches, water supply and sewer lines in urban areas, watershed maps, location of pump houses treatment plants and other infrastructures, the standards and benchmarks for a particular area.

These are the different types of data that we require for utilities and infrastructure planning in any urban area.

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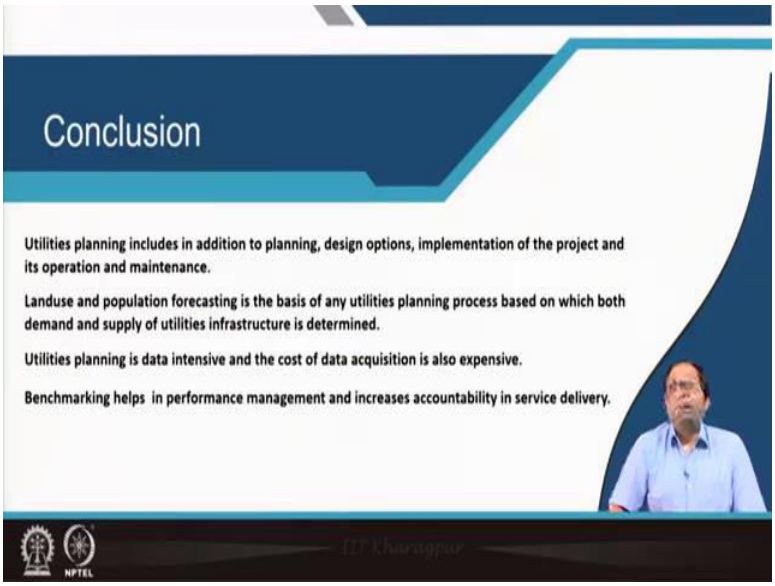

Conclusion

So, to conclude, utilities planning includes in addition to the planning aspect, the design options, the implementation of the project and its operation and maintenance. Land use and population forecasting is the basis of any utilities planning process based on which both demand and supply of utilities and infrastructure is determined. Utilities planning is data intensive, and the cost of data acquisition is also expensive. Benchmarking helps in performance management and increases accountability in service delivery.

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The references mentioned can be used for further understanding these concepts.

Thank you.