Urban Utilities Planning: Water Supply, Sanitation and Drainage

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Module - 01
Urban Utilities Planning: Introduction
Lecture - 01
Urban Utilities Planning Issues

Hello, I am Dr. Debapratim Pandit and we will start our course today. The course is on Urban Utilities Planning: Water Supply, Sanitation and Drainage. Today's lecture will cover Introduction to Urban Utilities Planning and Urban Utility Planning Issues related to drainage, water supply, and sanitation. The concept of water security and hydrology will also be covered.

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Urban Utilities Planning issues: Drainage

Examples of recent flood events reveal the severity of Urban Utilities Planning issues associated with drainage. The first example is based on flooding in Gurugram, where Ghata lake is reported as becoming a dumping ground and urbanization is cited as a possible reason. Such activities tamper the natural drainage systems and topography, and the water bodies holding runoff water after heavy rainfalls does not serve its purpose. The second image shows the heavy floods which have occurred in Kerala. Ecologists cite unplanned development as a reason for such repeated flood occurrences in Kerala during the monsoon.

Development considerations:

1. Land use
2. Hydrology
3. Infrastructure

The linkages between landuse, infrastructure and hydrology have to be carefully considered while planning for new development. Interaction of landuse with the hydrology of a location and the infrastructure required to manage hydrology etc., has to be thoroughly analyzed to manage such hazards.

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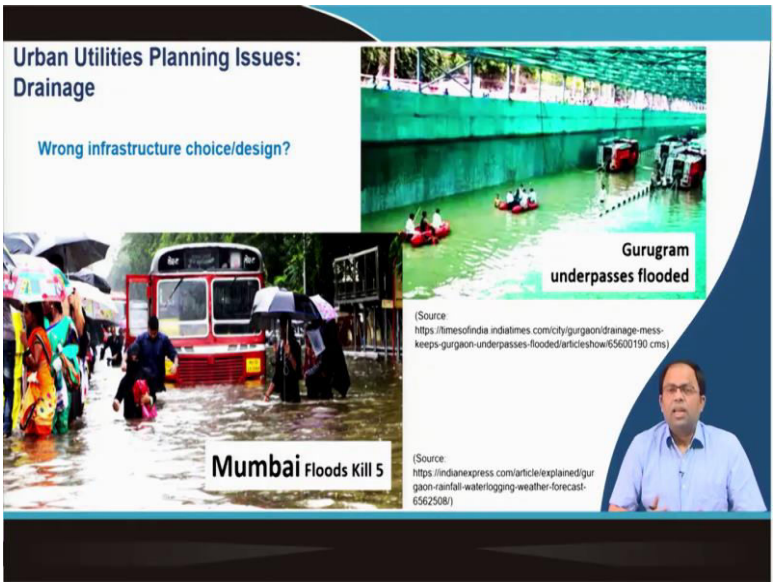

Also, In Gurugram, the flooding over infrastructure such as underpasses may indicate either wrong infrastructure choice or design. Such occurrences reinforce the need for consideration of hydrology, such as calculating the volume of water that a location can collect from the surrounding catchment during rainfall, the slope of the area, and the upstream area from where water can drain into a particular catchment. Flood events in Mumbai indicate that flood events not only causes damage and loss of property and livelihood and can result in loss of life.

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Similarly, the need for evacuating people when there is a flood risk can also incur a cost.

In the case of Assam floods during Covid-19, 70 lakh people were reported to be affected. Similarly, in Chennai, flood insurance claims almost touch around 5000 crore rupees, indicating the extent of flood damage. Also, there are other issues such as that involving Jurisdiction. For instance, it was reported that Delhi and Haryana fight over drainage related issues as an effect of the Gurugram flood.

Jurisdiction and Decentralization of Utilities: Deciding on who manages specific infrastructure demands a lot of coordination among the different agencies involved. It is also difficult to segregate such responsibilities; physical boundaries may overlap, and water from one area can move to another location and flood that area. So, even though decentralization of utilities can effectively manage infrastructure such as an urban local body or municipal body managing a particular area, a lot of coordinated functioning is essential.

India's flood zone map shows that the flood-prone areas include river basins such as the Ganges river basin and coastal areas, including locations in Kerala, Mumbai, West Bengal, etc.

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Issues and considerations associated with Urban Utilities Planning (Drainage):

- Infrastructure design: has to be done with careful considerations. Maintenance and Operation are also as important as the design. These considerations can avoid choked drains, ill-equipped diversions etc.

- Geography: involves the consideration of landslide occurrences or erosions, natural contour, watershed, vegetation etc.

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- Climate change: Uncertainty in rainfall events such as long periods of no rain or occurrence of heavy rainfall in a very short period etc., has to be considered for infrastructure planning. Built structures such as embankments on water bodies have to be designed appropriately as it may prevent water flow to water bodies leading to flooding

- Excessive cementing of ground: leads to the generation of more runoff which can result in flooding.

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- Encroachment of water bodies: natural sinks, natural detention basins or retention basins by real estate development or other needs has to be avoided or minimized.

- Improper landuse policies

- Jurisdiction and management issues

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- Ineffective flood warning system: or absence of flood warning system may lead to enormous damage.

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Urban Utilities Planning issues: Water Supply

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Besides While, places like Chennai gettings flooded by the occurrence of heavy rainfall over a short period, these placesit also report groundwater shortages and thusother several issues associated with water supply. Other cities including Delhi, Bengaluru, Hyderabad also reports similar issues. People struggle to get water to meet their daily requirements and rely on water tanker facilities in many areas of the country. Also,

40 percent of India's population will face drinking water scarcity issues by 2030. Water shortage is getting severe whilewith the drying of rivers, water bodies and wetlandsis happening.

On the one hand, floods are occurring, and on the other hand, drying of water bodies and water shortage is also being reported. This may lead to dependance upon on desalination of seawater to meet water requirements. The cause of this crisis may be because of

a gap in infrastructure and utilities planning. So, proper utilities planning can be a solution.

Coping cost: Apart from the cost of the supplied water, there are other costs involved related to the need to carry water from a source and the occurrence of diseases due to the use of contaminated water. So, Water scarcity is one of the biggest challenges in India.

In this context of increasing water shortage, drying of water sources etc., the Government of India is planning to supply piped water or tap water into every house.

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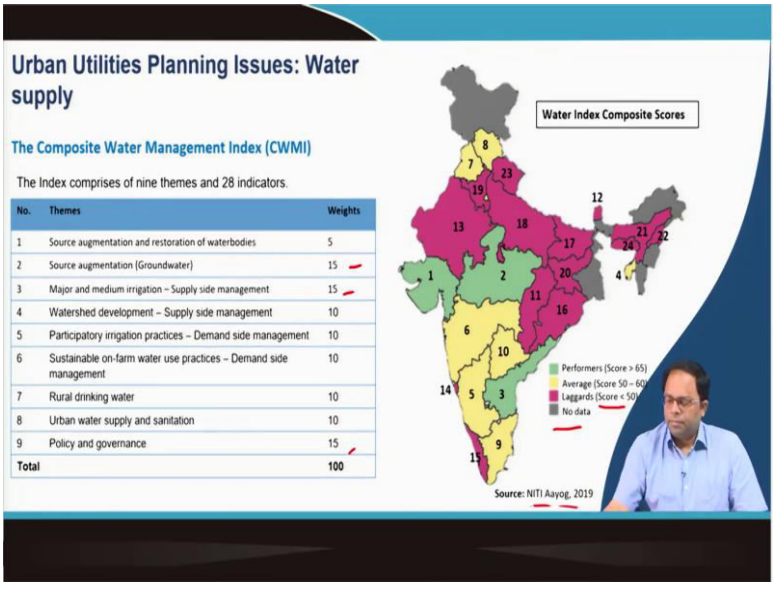

Composite Water Management Index

In 2019, Niti Aayog created Composite Water Management Index (CWMI) for India; It indicates the performance of different states with regard to water management and related aspects. From the map, it is observed that different states are classified and colour coded as

laggards (e.g., Rajasthan*,* Uttar Pradesh), which have a score of less than 50, *average*, which has a score between 50 and 60, *performers* (e.g., Gujarat, Madhya Pradesh) which has a score more than 60; States shaded in grey has no data for evaluation. This

index comprises 9 broad themes and 28 indicators covering rural issues as well. The themes cover rural issues as well. The different themes include Source augmentation and restoration of water bodies, Source augmentation (Groundwater), Watershed development – Supply-side management, Participatory irrigation practices – Demand-side management, Sustainable on-farm water use practices – Demand-side management, Rural drinking water, Urban water supply and sanitation, and Policy and governance. Different themes are given different weights. Policy and governance being the most important, is given the highest weightage of 15.

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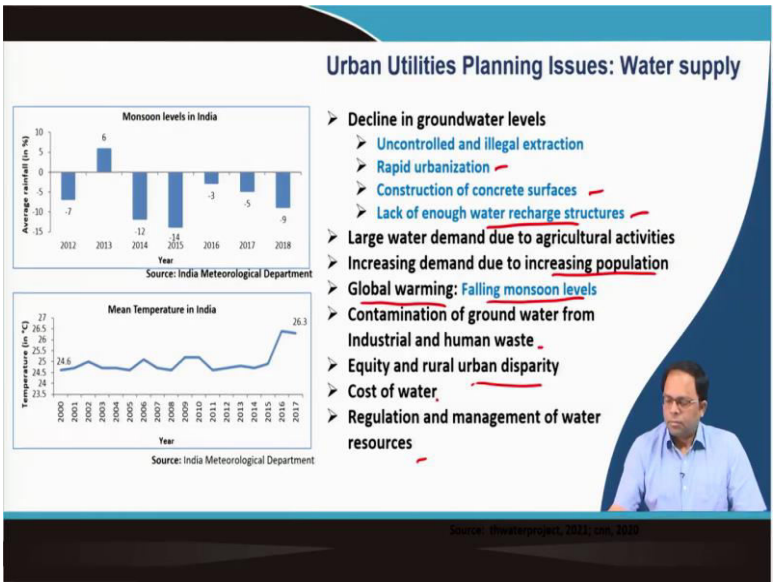

Issues and considerations associated with Urban Utilities Planning (Water Supply):

- Decline in groundwater levels: Uncontrolled and illegal extraction of groundwater is a cause; For instance, there is a lack of a system framework for accounting for water cost, such as registration of wells.

- Rapid urbanization, Cconstruction of concrete surfaces, lack of enough water recharge structures, etc., also contribute to the decline of groundwater.

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- Large water demand is also due to agricultural activities: maybe because of wrong choices of crops with regard to its water requirement and availability of water in that area.

- Increasing demand due to increasing population.

- Global warming: Resulting in falling monsoon levels; The graph in the above figure indicates that rainfall during monsoon is declining. The rate of reduction is also increasing.; I

- n 2014, 12 percent reduction was noted while in 2015, it is observed as a 14 percent reduction from average and in 2018, it was 9 percent and so on. Also, an increase in mean temperature (26.3 degrees centigrade presently) is another serious issue. These issues

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- may be attributed to global warming, and its effects will become increasingly challenging to address.

- Contamination of groundwater from industrial and human waste: Improper treatment of wastewater, sanitary sewage, or industrial sewage gradually reaches the ground, increasing chances of mixing with groundwater and contaminating the entire groundwater sources.

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- quity and rural disparity: Equity issues do not stop being among rural and urban. It can be observed even within the urban areas, such as lack of piped water or limited availability of its supply for people living in slums. Also, it is to be noted that government cannot provide piped water supply at slums that are not notified.

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- Cost of water: involves the payment cost, whether it is just for the quantity of the water or for allied services, companies involving in water supply etc.

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- Regulation and management of water resources in a more integrated manner.

Urban Utilities Planning issues: Water Supply

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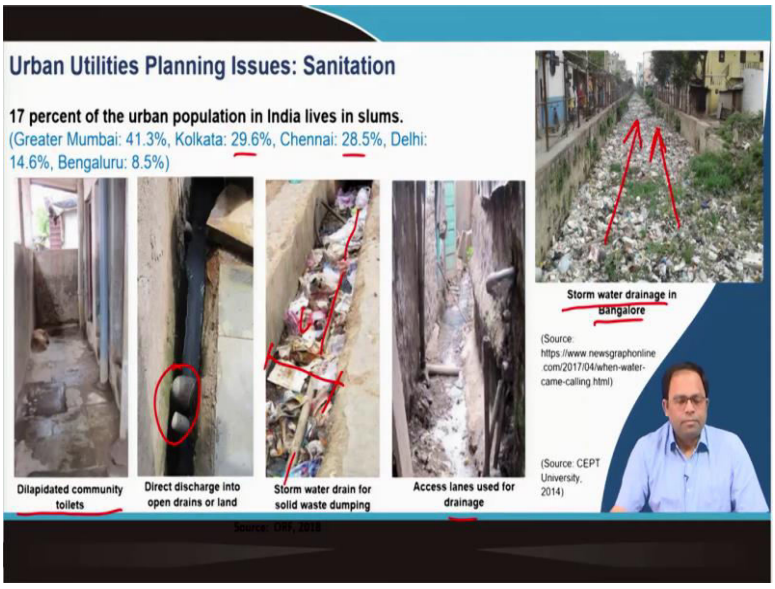

The amount of sewage or sullage that is generated depends on the amount of water supplied in that area.

In addition, the runoff water during rainfall has to be dealt with separately.

17 percent of the urban population in India lives in slums without having access to proper infrastructure and rely on community toilets. Slums are very densely packed urban settlements; there is also an issue of lack of space to provide infrastructure.

So, it is essential to understand the different facilities to be provided, including the number of toilets that must be provided, the distance at which they must be provided, etc. Another issue associated with lack of infrastructure is the absence of a sewerage network or even an on-site treatment facilityies such as a Septic tank. This leads to such untreated waste water to be drained in open land or *nalas* causing unhygienic and unhealthy conditions. This may also interfere with water supply systems increasing the occurrence of diseases. Similarly, lack of proper solid waste management systems leads to dumping of waste on undesignated locations, including storm water drains; this creates unhealthy conditions and chokes the drain and blocks runoff water flow, eventually leading to flooding. Other problems include water contamination because of leakage due to lack of maintenance and the absence of proper space for service pipelines. These issues can be addressed through behavioural changes, which can be achieved with awareness campaigns, social engineering etc., and technological improvements.

Hence, it is imperative to address these issues in the context ofconsidering the fact that, 17% of India's urban population living in slums (Greater Mumbai: 41.3%, Kolkata: 29.6%, Chennai: 28.5%, Delhi: 14.6%, Bengaluru: 8.5%).

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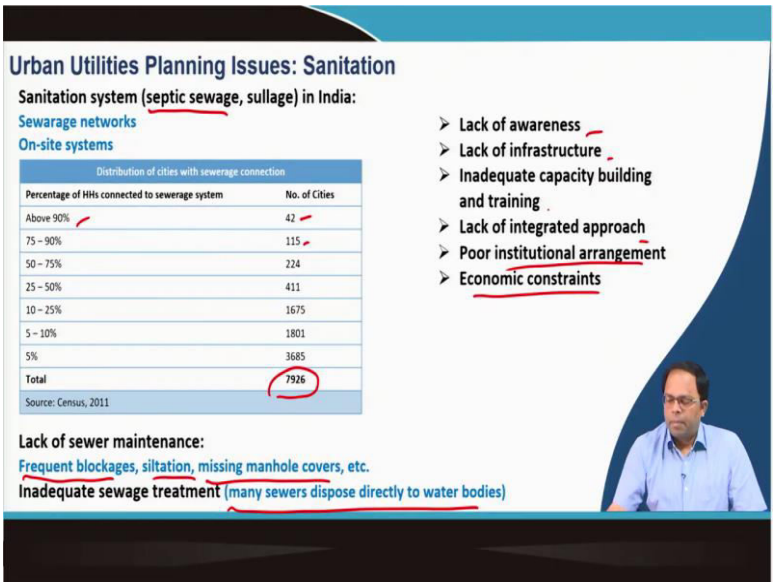

Sanitation system (septic sewage, sullage) in India:

Sanitation system involves both septic sewage and sullage. Septic sewage is the waste from the toilets and sullage from bathrooms or kitchens. This waste can be treated locally or using an on-site treatment facility such as the septic tanks. Local treatment methods are sometimes ineffective or inconvenient because of the requirement for periodic cleaning of septic tanks, issues of local flooding, issues associated with the improper design of such facilities etc. However, suppose if a sewerage network is in place. In that case, this waste can be conveyed to the municipal sewer network with pipelines eliminating the need for local treatment. Thus, a FFlushing system ensures the availability of water to carry such sewage along sewers as in water carriage systems.

Based on Census 2011 data, India, it can be observed that only 5% coverage of sewerage network is available in 3685 towns out of 8000 towns in India. Only 42 towns have above 90% coverage. The majority of the cities does not have a sewerage network. Also, there are maintenance and operational issues such as frequent blockages, siltation inside the pipes resulting in a reduction of bore size, theft of manhole covers etc. which are not addressed by the companies or agencies responsible for such managementservice provision.

Issues and considerations associated with Urban Utilities Planning (Sanitation):

The challenges involve:

- Lack of awareness
- Lack of infrastructure
- Inadequate capacity building and training
- Lack of integrated approach
- Poor institutional arrangement
- Economic constraints

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Water Security:

Water is both the source of life health, livelihoods, production, and prosperity; the more water you have, the more prosperous you are. Even though water is indispensable for living, the unpredictability associated with rainfall or its effect may lead to deaths, devastations and poverty. This is because of the occurrence of drought, flood, landslides, epidemic, erosion, inundation, desertification, contamination and disease. So, both the presence and absence of water is a threat or opportunity. For instance, civilizations have both harnessed the power of water and also have got destroyed by flooding.

Water is also a source of dispute and conflict. There can be conflict regarding the water demanded to meet the needs of agriculture or urban use. Sometimes, two governments may be involved in a water dispute concerning a river that flows across both states and countries.

Water security can be defined as the reliable availability of an acceptable quantity and quality of water for health, livelihood and production coupled with an acceptable level of water-related risk.

Infrastructure investment is required to counter the risk associated with the availability of good quantity and quality of water. Thus,

water security has to be evaluated against infrastructure investment. So, the considerations influencing water security include:

- The hydrologic environment and water resource availability: involves understanding of the catchment area, topography, amount of rainfall, groundwater resources, aquifer levels etc.

- Inter and Intra annual variability of rainfall and groundwater: Involves the understanding of the quantity of water available from rainfall from a particular source,

- etc.

- Spatial distribution of these resources

- Socio economic environment: which includes affluence, culture, behaviour and resulting policy choices. Affluent society would demand

- better quality and quantity of water and related services. The culture or behaviour of people determines whether the society willing to conserve water.

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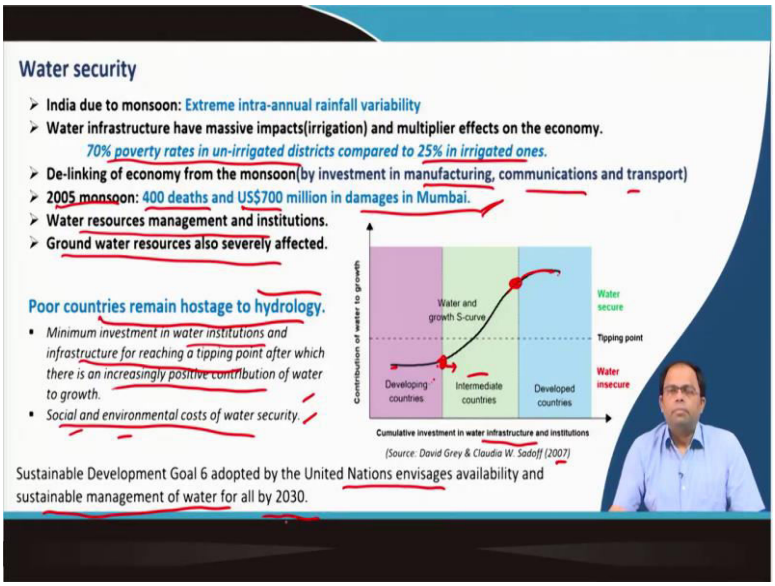

In India, occurs significant variability exists in intra annual rainfall. Infrastructure is essential such as for water storage during heavy rainfall and for irrigation.

Also, the presence of infrastructure has got a lot of multiplier effects on the economy. For instance, the construction of irrigation channels can create benefit direct benefits such as farming; the multiplier effect involves the persons involved in agriculture being able to spend money on buying goods and, hence, benefits the economy. In India, unirrigated districts have a 70% poverty rate while only 25 percent in irrigated districts it is only 25%. In short, the economy in India is linked with monsoons to a great extent. Hence, there is a need to delink this because of the variability in the economy due to monsoons' variability. This can be achieved by

investing in other sectors like manufacturing, communications, and transports instead of agriculture which is directly linked with irrigation and monsoon. However, these efforts cannot completely solve the negative effects of water. This becomes evident during extreme rainfall events. For instance, during the 2005 monsoon, 400 deaths and US dollars 700 million worth of damage was reported in Mumbai. However,

it is essential to invest in order to reduce the risk associated with water.

Investment, water security and **C**ontribution to development:

As it is challenging to meet the monetary demand for infrastructure provision concerning water security, poor countries are more prone to the variability associated with rainfall or other characteristics related to hydrology. This is explained by the graph prepared by Grey and Claudia in 2007. It is observed that the initial investment to achieve water security may not yield much returns however, after a tipping point, there is an increasingly positive Ccontribution of water to economic growth with further investment. In developing countries, it is challenging for governments to make such investments that does not give monetary returns or other benefits soon. Social and environmental cost of water security should also be given consideration. The graph also reflects the association between the Ccontribution of water to development and cumulative investment in water infrastructure and institutions as expressed by the S-curve.

For developing countries, investments yield a positive contribution to growth and development. This also reaches a tipping point after which Ccontribution to development becomes stable(flat) with any further investment.

In this context, Sustainable Development Goal 6 adopted by the United Nations envisages the availability and sustainable management of water for all by 2030. Since this mandate is made, countries are trying to make sure its population gets adequate good quality water to adhere to the established development goals.

Hydrology

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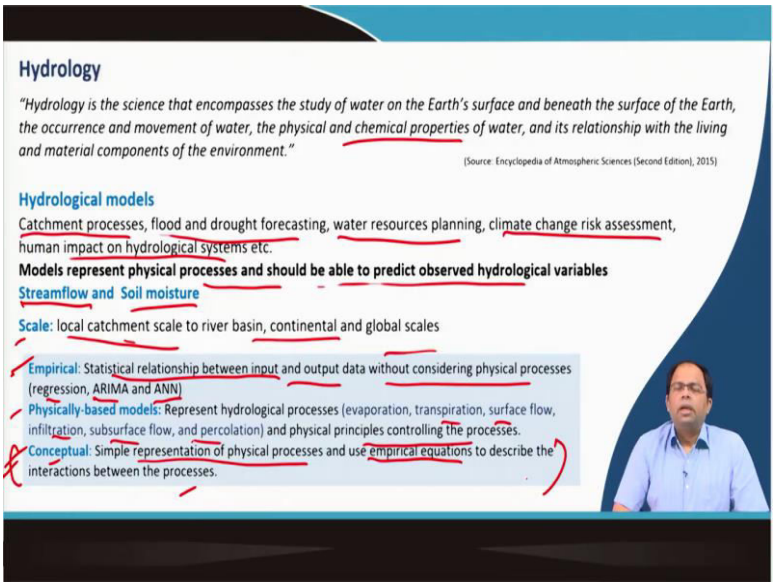

It is essential to understand hydrology to do sustainable utilities planning.

Hydrology is the science that encompasses the study of water on the earth surface and beneath the surface of the earth, the occurrence and movement of water, the physical and chemical properties of water and its relation with the living and material components of the environment. It is important to understand the different properties of water, characteristics of usable water, the relationship with different land use etc. This can be achieved by employing different

Models explaining various relationships. These models represent the actual physical processes. For instance, *Catchment models* explain the amount of water that percolates onto the ground, the movement of runoff within a catchment etc. Similarly, there are *flood and drought forecasting*, *water resources planning, climate change risk assessment, human impact on hydrological systems* etc.

Hydrological models: represent physical processes and should be able to predict observed hydrological variables. The two most important hydrological variables are

- *Streamflow*: The amount of water flowing in a stream; surface water availability.
- *Soil* moisture.

Scale is another critical consideration concerning hydrological models, such as whether these models represent a local catchment, river basin, continental scale, or global scale. There are different hydrological models such as Empirical, Physically-based models and Conceptual models.

Empirical models:

Statistical relationship between input and output data without considering physical processes; it is based on available data such as rainfall, ground water availability, etc. These are easier models. Examples - Regression, ARIMA and ANN

Physically-based models: Represent hydrological processes (evaporation, transpiration, surface flow, infiltration, subsurface flow, and percolation) and physical principles controlling the processes (hydraulic gradient)

Conceptual models are somewhere between empirical and physically based models where simple representation of physical processes are taken and then empirical equations are used to describe these interaction processes.

Most equations explaining groundwater, water movement, or water movement in pipes, etc., follow this conceptual model. These models are widely employed for Urban Utilities Planning

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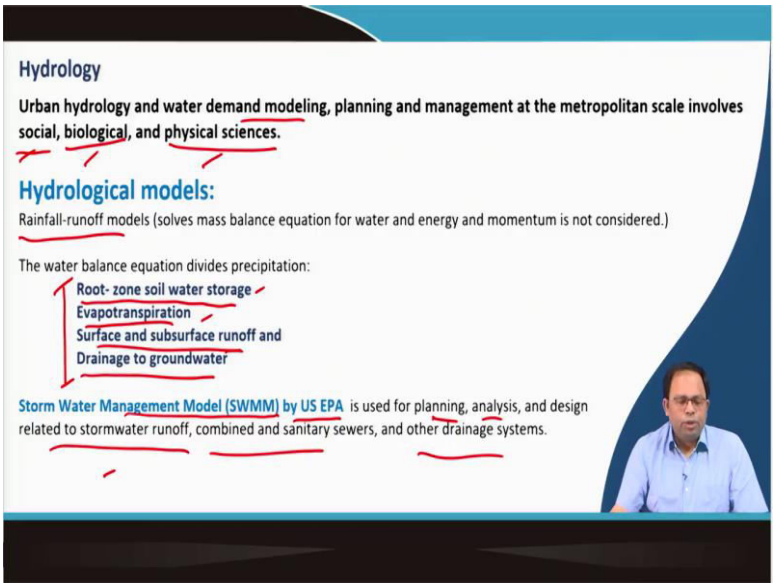

Urban hydrology and water demand modelling planning and management at the metropolitan scale involve not only physical processes, it involves biological, social and physical sciences as well.

Rainfall-runoff model: solves mass balance equation for water and energy, and momentum is not considered. This expresses how runoff is generated. The water balance equation divides precipitation into:

- Root- zone soil water storage: storage by soil at the root zone of the trees
- Evapotranspiration
- Surface and subsurface runoff and

- Drainage to groundwater: water that goes percolate inside the ground

Storm Water Management Model SWMM by US EPA (United States Environmental Protection Agency): This is used for planning, analysis and design related to stormwater, runoff, combined and sanitary sewers and other drainage systems. Such software is used to build the overall sewerage network.

Conclusion:

There is a need to understand the social processes, physical processes, and actual engineering design processes,(which can be solved using software applications).

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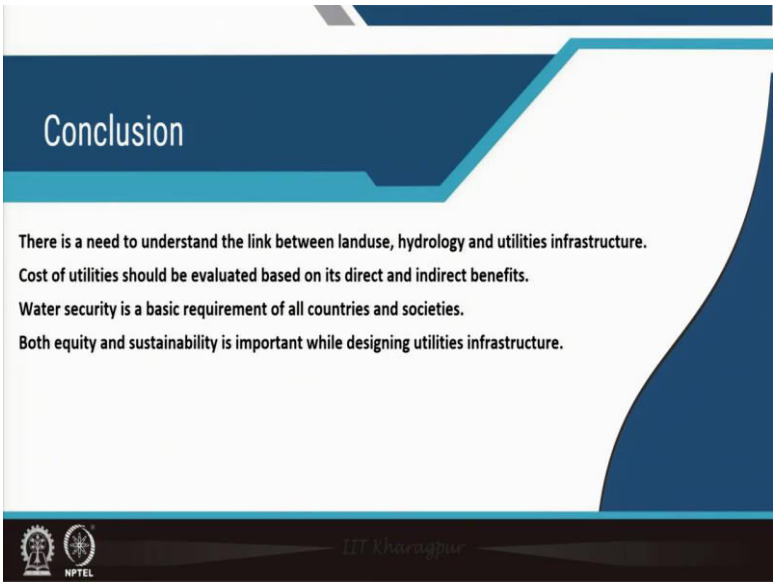

- There is a need to understand the link between land use hydrology and utilities infrastructure.
- Cost of utilities should be evaluated based on its direct and indirect benefits
- Water security is a fundamental requirement of all countries and societies
- Both equity and sustainability is important while designing utilities infrastructure.

References:

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