Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 12
Drainage and Recharge
Lecture - 60
Urban Flood Management and Drainage Plans Part III

In lecture 60, we Urban Flood Management and Drainage Plans Part III will be covered.

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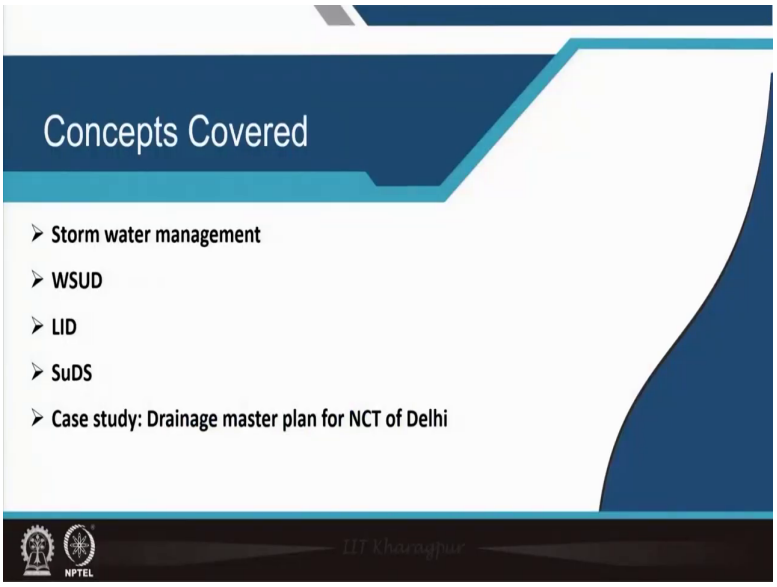

The different concepts that will be covered are storm water management, WSUD or Water Sensitive Urban Design, LID or Low Impact Development and SuDS. Also, a case study of drainage master plan for NCT (National Capital Territory) of Delhi will be discussed.

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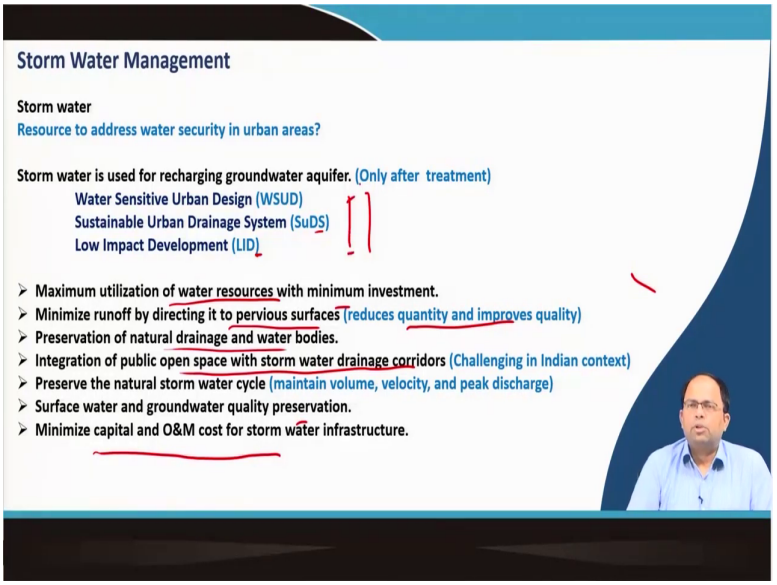

Storm Water Management

Sustainable urban drainage system, water sensitive urban design, and low impact development are the different strategies have already been discussed in Module 1. These are the final strategies whenever we are designing a drainage plan for particular area drainage.

We need to follow certain strategies to make sure that we not only improve the drainage of a particular area i.e., we reduce flooding, but also need to increase the recharge. We also need to improve the reuse of water in that particular urban catchment. All these strategies that we are considering along with design of infrastructure will help us to plan for drainage and sewerage infrastructure.

In some places where there is flooding, we also see incidences of water scarcity. So, can storm water be used as a resource to address water security in urban areas.

That means, we are trying to manage storm water and also utilize it in a certain way, so that it will actually reduce the water scarcity or improve the water security of a particular urban area. So, storm water could be used for recharging the ground water or groundwater aquifers after treatment. And there are several strategies like WSUD, SuDS and LID which could be utilized for this kind of purposes.

This will lead to maximum utilization of water resources with minimum investment. So, these strategies are primarily low cost strategies. This minimizes runoff by directing it to

pervious surfaces, so it reduces quantity and improves quality. Preservation of natural drainage and water bodies; that means, we try to not only preserve and restore as well as preserve this natural drainage channels and water bodies.

Then, integration of public open space with storm water drainage corridors has been tried in many foreign countries successfully, but in Indian context, it would be challenging. Because, there is lack of space, there is lot of illegal encroachments.

Then, there is preservation of the natural storm water cycle that is maintaining the volume, velocity and peak discharge. We need to maintain the pre-development values.

Then, surface water and groundwater quality preservation and minimizing the capital and operation maintenance cost for storm water infrastructure.

So, these are the targets that need to be achieved. We need to reduce the size of storm water drains or we need to reduce the number of drains. There are three approaches that can achieve that.

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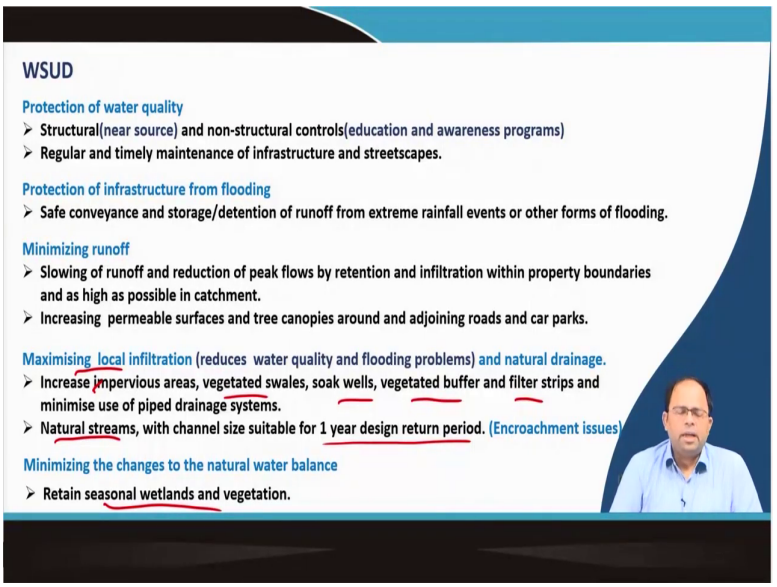

WSUD

All these three approaches are more or less similar with lot of overlaps. WSUD involves protection of water quality, structural (near source) and non-structural controls (via education and awareness programs).

Structural controls are done by putting certain kind of methods to protect water quality. Regular and timely maintenance of infrastructure and streetscapes also protects water quality. Then, protection of infrastructure from flooding is considered because extreme rainfall events are increasing. So, we need to be very careful and we need to prevent floods in urban area, because that leads to lot of monetary losses. Then, we need to minimize the runoff volume.

We need to slow down the runoff and reduce the peak flows by retention and infiltration within property boundaries and also within the overall catchment. Then we want to increase the permeable surfaces and tree canopies that will increase the infiltration. And finally, we want to maximize the local infiltration and natural drainage by increasing pervious, and by decreasing impervious areas.

Then, there should be provision of vegetated swales, soak wells, vegetated buffers and filter strips. Natural streams with channel size suitable for 1 year design return period can also maximize the local infiltration. WSUD can also be achieved by minimize the changes in the natural water balance by retaining seasonal wetlands in vegetation. These are the key strategies that we follow in WSUD.

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LID

Similarly in LID or low impact development, approaches are modelled based on nature. It manages runoff at the source through distributed decentralized micro-scale controls, so there is flow control, then there is detention, retention, filtration, infiltration into the ground and then the treatment. Treatment could be either by phytoremediation or bacterial action to metabolize contaminants in the storm water run-off.

LID talks about reducing impervious surfaces, disconnecting impervious areas tofrom the storm water drainage network and managing them separately. Then, conserving natural resources using cluster or consolidate development and using xeriscaping and water conservation practices. So drainage becomes part of the landscape.

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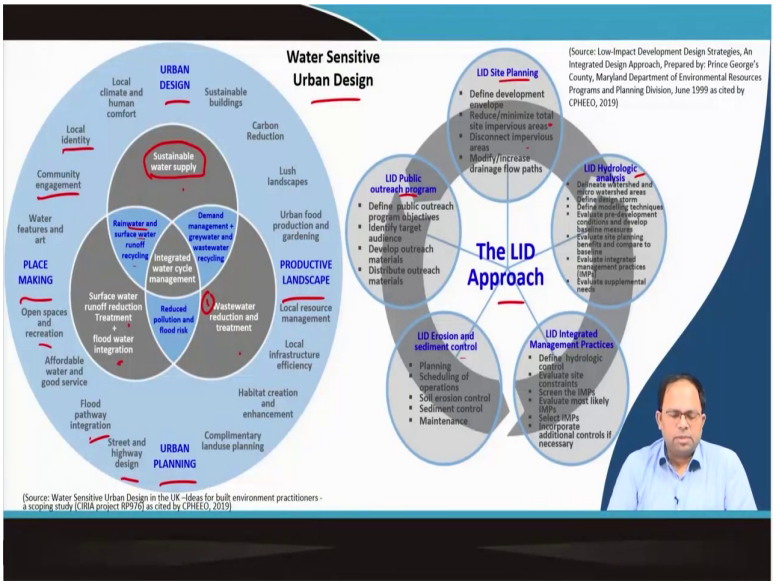

Water sensitive urban design and the LID approach have various overlaps. For example, when we talk about water sensitive urban design, there are urban design part, productive landscape design part, urban planning part, place making that are important.

The main goal is integrated water cycle management. One main direction of this is waste water reduction and treatment. Whereas, in sustainable water supply, we increase the water supply sources by using rain water and surface water runoff. Additionally, increased recycling, demand management along with grey water and wastewater recycling will increase the sustainable water supply.

Then, there is surface water runoff reduction and their treatment and flood water integration. Thus, these things are part of water sensitive urban design. These can be integrated by engaging the community and creating local identities.

Then, we can create new places, open spaces and recreational areas and can integrate flood pathways and finally consider street and highway designs, etc.

That is how we can plan for water sensitive design. The LID approach talks about almost similar concepts like site planning where the development envelope is defined, reduction of

total site impervious area, disconnecting impervious areas etc. Detail hydrologic analysis of the given areas can be conducted considering the above.

Then, we can have erosion and sediment control and then LID public outreach programs. More or less these are similar approaches and different cities have adopted these different approaches.

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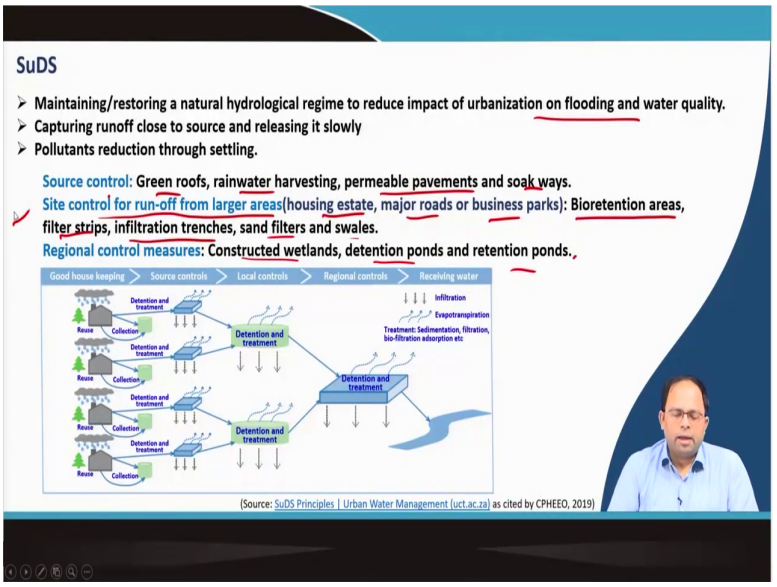

SuDS

SuDS involve maintaining and restoring a natural hydrologic regime to reduce impact of urbanization on flooding and water quality. Then, we capture run-off close to the source and then release it slowly; that means, we will capture it at the building level, at the locality level, then at the catchment level. Pollutants also could be reduced through settling.

At source control that is at the local level, we can use green roofs, rainwater harvesting, permeable pavements and soak ways within residential plots.

At site control for run-off from larger areas like housing estate, major roads or business parks, we can have bioretention areas, filter strips, infiltration trenches, sand filters and swales. Similarly, we have regional control measures where we can have constructed wetlands, detention ponds and retention ponds as shown in the Figure.

It leads to reduction of the storm water and that will reduce flooding and improve water quality. That is the basic approach that we want to follow. We need to do detail planning to estimate how much amount of recharge volume is required and where we need to put in the recharge.

Though these are broad policies, but to make them happen, we need to follow various detailed steps. To implement these policies on ground, considerable amount of integration work, and modelling work has to be done at the background.

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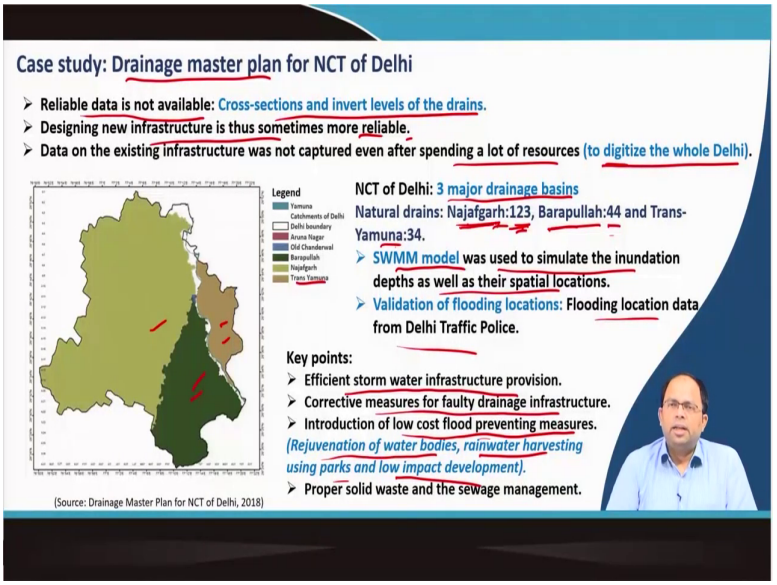

Case study: Drainage master plan for NCT of Delhi

Figure shows the drainage master plan for the NCT (National Capital Territory) of Delhi as a case study. This drainage master plan has been gradually developed using aforementioned approaches.

The practical issues are also discussed when certain kinds of drainage master plans are implemented in our country.

For example, in this case, the survey was conducted by IIT and it was found that the biggest problem was the reliability of the data and non availability of the data. Cross-section and

invert levels of the drains were not available in many cases. Even though detailed surveys have been conducted, data was not that reliable.

Sometimes instead of finding out old drains or the old infrastructure, it is reliable to lay new infrastructure. In many cases the records are not maintained in our country, but we can design new infrastructure with proper records.

So, in case of Delhi, the entire Delhi's storm water and sewerage infrastructure was digitized in this project. However, after spending a lot of resources, it was not properly captured that was the main drawback of this particular plan. The NCT of Delhi has 3 major drainage basins as shown in the image. These are Trans-Yamuna, Barapullah, and Najafgarh.

There are 123 natural drains in Najafgarh, 44 in Barapullah and 34 in Trans-Yamuna.

The team used the SWMM model to simulate the inundation depths as well as the special locations in this particular area. It was done for each of this catchments separately. Flooding location were validated. This data was obtained from Delhi Traffic Police. Some of the key points for this plan were to provide efficient storm water infrastructure provision so that flooding does not happen.

Then, corrective measures for faulty drainage infrastructure were implemented. In some areas, the drainage infrastructure was wrong. To correct that, low cost flood prevention devices were introduced. Rejuvenation of water bodies, rain water harvesting using parks and low impact development strategies were implemented.

Proper solid waste and sewage management was also stressed upon. As this is one of the reasons why drains get blocked and leads to flooding.

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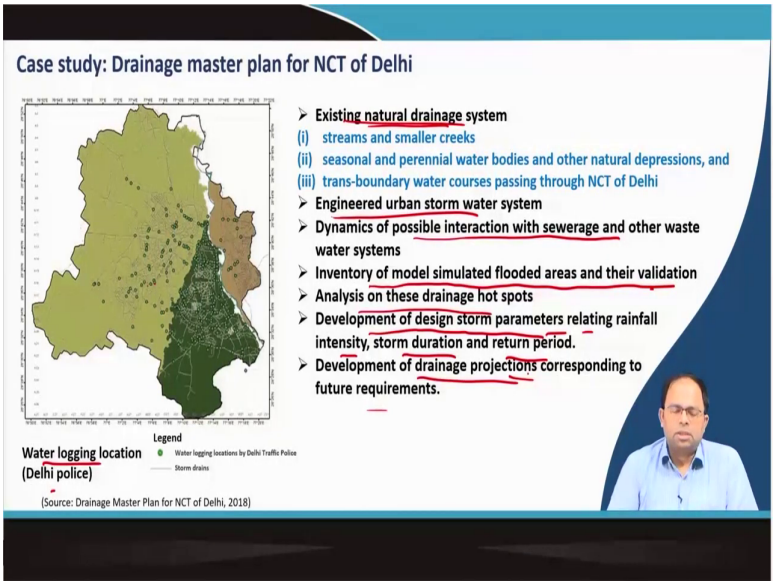

The work started with first identification of the existing drainage channels, streams and smaller creeks. Seasonal and perennial water bodies and other natural depressions and trans boundary water courses passing through NCT of Delhi were determined. Also, trans boundary water courses which are coming from outside the area and may be entering into some parts were also considered. In addition to the natural drainage systems, all the engineered urban storm water systems were considered. Dynamics of possible interaction with sewerage and other waste water systems were also considered.

The Figure shows the water logging areas (as nodes) as provided by Delhi police. The basic data was entered in SWMM and the model was run. The inventory of model simulated flooded areas were determined and they were validated with the Delhi police data set.

Analysis of each of these drainage hot spots were also conducted wherever there was flooding incidence. The next step was to determine the design storm water parameters relating to rainfall intensity, storm duration and return period. These determine the intensity of rainfall and accordingly the amount of runoff that would be generated.

Then, development of drainage projections was done corresponding to future requirements. That means future population and other related calculations were done to determine the overall drainage projections.

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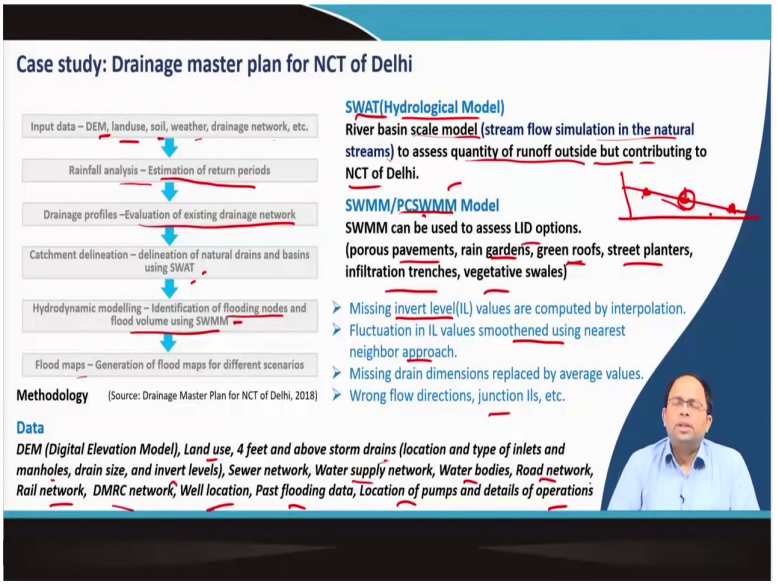

The methodology given in the master plan is discussed. Input data was DEM data, land use data, soil, weather, drainage network data, etc.

Rainfall analysis was done to estimate the return periods. Drainage profile of existing drainage network was evaluated. Then the catchment was delineated that involves delineation of natural drains and basins using the SWAT software. This was primarily for the drains that are outside the boundary.

Then, hydrodynamic model was created where identification of flooding nodes and flood volume using SWMM was conducted. Finally, flood maps were generated for different scenarios.

The SWAT model is a hydrological model. It is a river basin scale model where stream flow simulation in the natural streams was conducted to assess the quantity of runoff outside, but contributing to the national capital territory of Delhi.

All the different channels which were bringing water to the NCT were estimated using the SWAT hydrological model. Then SWMM and PCSWMM model was used. The PCSWMM model is added with SWMM model for flood modeling.

SWMM model can be used to assess the LID options like porous pavements, rain gardens, green roofs, street planters, infiltration trenches and vegetated swales.

These could be introduced in the SWMM model as different open drain profiles could be introduced in the SWMM model. New infrastructure could be provided in form of green infrastructure or low impact development options and could be evaluated by the SWMM model.

The missing invert level values were computed by interpolation. For example, there is a profile of the sewer section with nodes. Sometimes the fluctuation in the IL values were observed during survey. These are smoothened using the nearest neighbour approach. missing drain dimensions where replaced by average values, wrong flow direction, junctions and invert levels etc. were rectified or put in as required.

The required data are DEM data, land use data, 4 feet and above storm drains, location and type of inlets and manholes, drain sizes and invert levels, overall sewer network, water supply network, water bodies, road network, rail network, DMRC network, metro rail network, well location, past flooding data, location of pumps details of all operations. Thus, huge quantity of data is required for these drainage plans.

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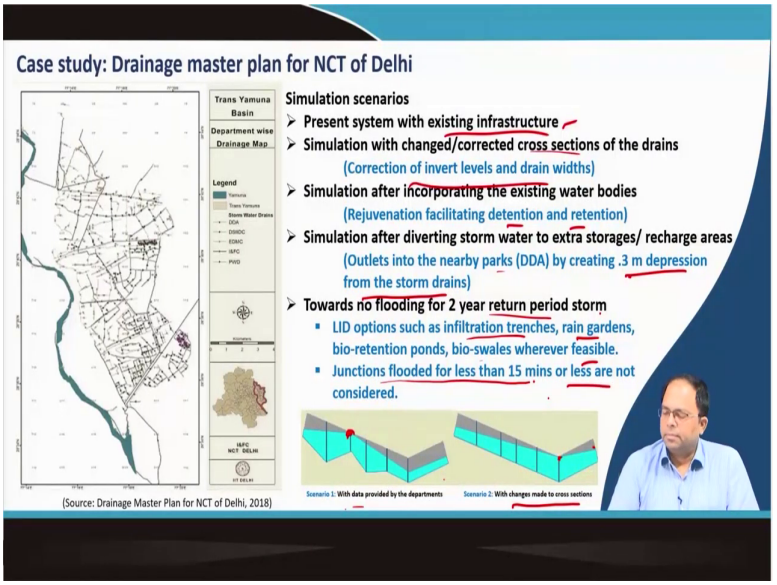
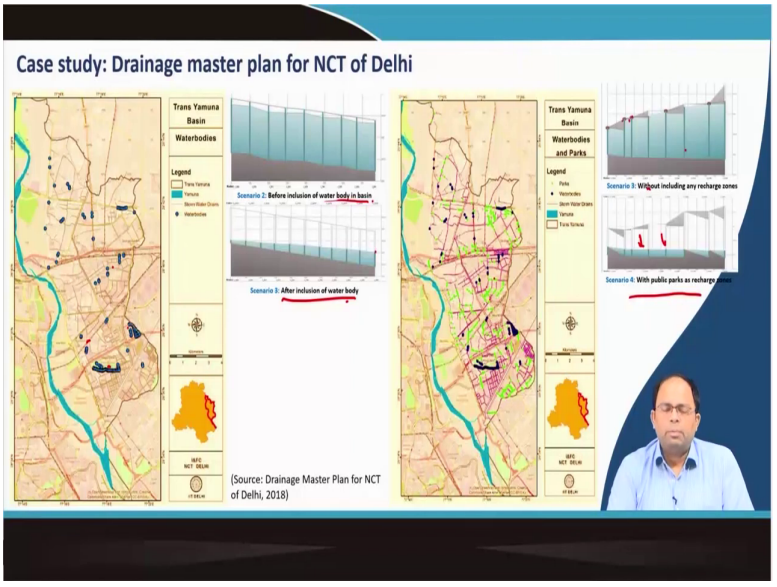


Once the basic estimation was done, then several scenarios were simulated. The first simulated scenario was the present system with existing infrastructure. This represents the simulated sewer section using data provided by the different departments. The computation are done and checked if the flooding is happening. Simulation was done again with changed/ corrected cross sections. Corrections are done in invert levels and drain widths.

Simulation was done after incorporating the existing water bodies, so that rejuvenation facilitating detention and retention could be studied. So, some of the water bodies was also incorporated into the network which could be used for detention or retention of water.

Then, simulation was done after diverting storm water to extra storage or recharge areas. Some of the outlets were taken into nearby parks by creating 0.3 meter depression from the storm drains. It means that some amount of water would be stored here and gradually it will percolate down. So, this was also introduced into the model.

Then, towards no flooding for 2 year return period LID options such as infiltration trenches, rain gardens, bio retention ponds were introduced wherever feasible and the results were modelled. Another simulation was done considering 15 minutes of flooding at the junctions as acceptable. (Refer Slide Time: 23:59)



As shown in the image, like in scenario 2 before inclusion of water body in the basin, this was the kind of profile of water in the drains. Whereas, after inclusion of water bodies, the water level in the drains have reduced significantly.

Similarly, without the parks flooding was happening at nodes. After introduction of parks, the flow value reduced and there was no flooding. This is where the section profiles have been analysed. As explained earlier, in SWMM we can determine water level at the different sewers and in the manholes. ifferent parks have been introduced into the network or the storm water network where some amount of water can be stored.

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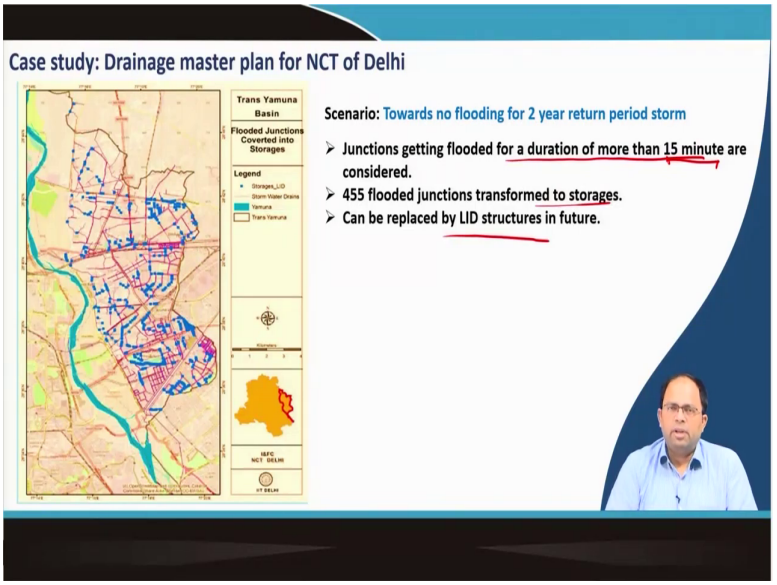

Then towards no flooding for 2 year return period. It was seen that junctions getting flooded for a duration of more than 15 minutes were considered. As shown in the image, 455 junctions were flooded and these were transformed to storages. That means, they were designed to store water. As they store water for only 15 minutes, that is considered as an acceptable solution.

This can be replaced by LID structures in future; that means, if some amount of LID structures like swales could be provided, this kind of flooding can be avoided.

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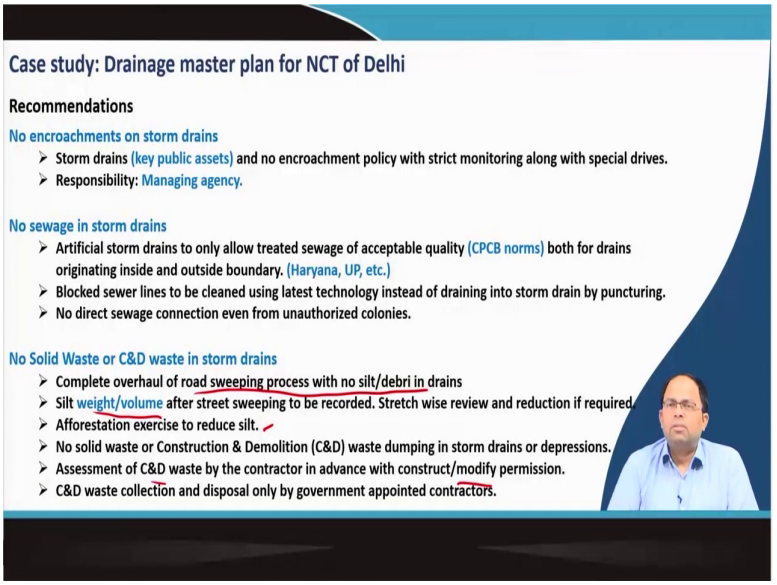

The final recommendations from the drainage plan for NCT of Delhi are provided. There should be no encroachment on storm water drains because storm water drains are key public assets.

There has to be special monitoring and special drives to remove those encroachments and some agency has to be given this responsibility. Then, no sewage should be added to storm drains and artificial storm drains should allow only allow treated sewage of acceptable quality.

Untreated sewage cannot be introduced into the storm drains because these are used for recharge in parks/gardens. Blocked sewer lines should be cleaned using latest technology and there should be no direct sewage connection even from unauthorised colonies. There should be no solid waste or construction and demolition waste in the storm drains.

There should be a complete overhaul of road sweeping process and no silt or debri in the drains. Silt has to be weighted or their volume needs to be determined after street sweeping and these needs to be recorded. So that we can keep track of how much amount of silt is collected and are taken to the landfill. Afforestation exercise along the roads will reduce silt further.

There should be no solid waste or construction demolition waste in the storm drains and there has to be assessment of C and D waste as well as their removal has to be done with permission. This has to be done only by specific contractors appointed by the government that will actually prevent unauthorized disposal of this particular kind of waste in the storm water drains.

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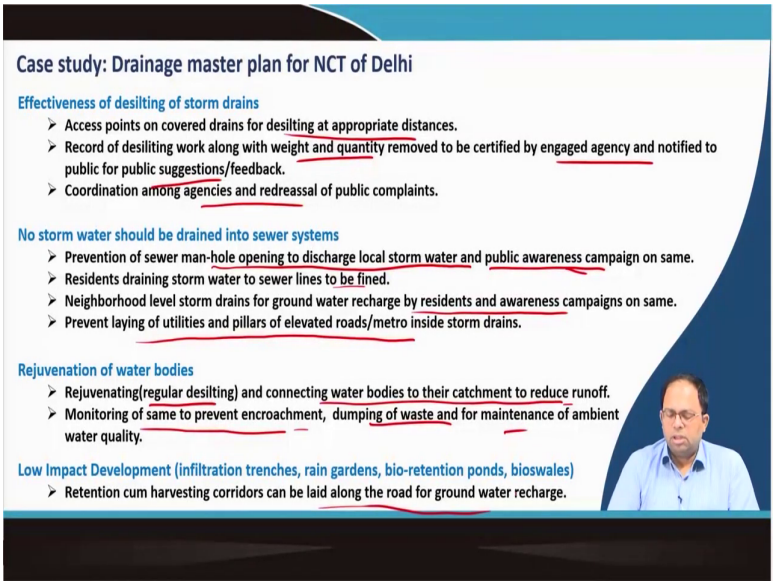

Effectiveness of desilting of storm water drains has to be checked. Access points should be made on covered drains for desilting at appropriate distances; that means, we have to make regular access points for regular desilting. There has to be record of the desilting work that how much has been carried, how much has been taken out and when it has happened, etc. There has to be some agency that has to be made responsible for this. Public suggestion has is to be taken for this as well. There has to be coordination among agencies for redressal of public complaints. No sewage should drain into storm water drains. Similarly, no storm water should drain into the sewer system.

So, prevention of sewer manhole openings to discharge local storm water and public awareness campaigns on the same.

Residents draining storm water to sewer lines can be fined and neighborhood level storm drains for groundwater recharge by residents and awareness campaigns on the same. There

should be prevention of laying of utilities and pillars of elevated roads metro inside storm water drains because in many cases we have observed that construction companies do not bother about drainage.

All the agencies have to be taken together and we have to check that each one of them is not hampering the work of another.

Finally, we also need to rejuvenate water bodies and rejuvenation could be done by regular desilting and connecting water bodies to their catchments to reduce runoff. At the same time monitoring has to be done, so that we prevent encroachment, dumping of waste and we also maintain this water quality in water bodies. Low impact development also has to be conducted. Retention cum harvesting corridors can be laid along roads for groundwater recharge.

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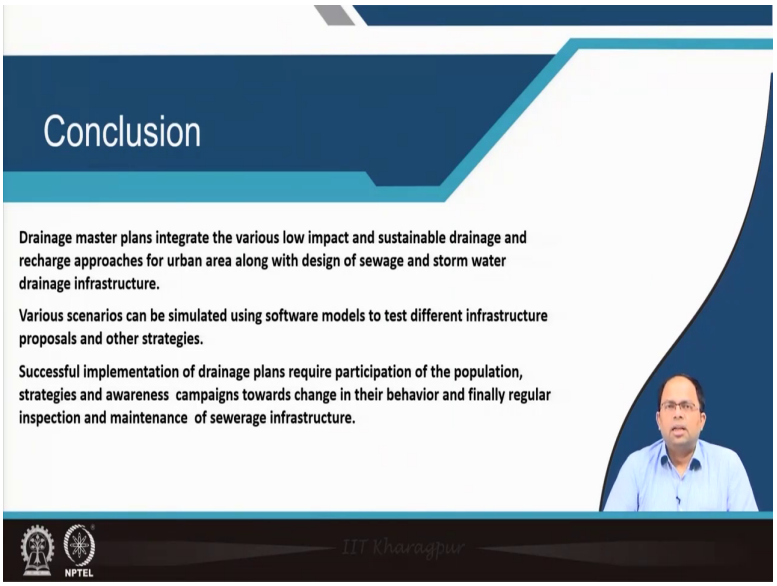

Conclusion

To conclude drainage master plans integrate the various low impact and sustainable drainage and recharge approaches for urban areas along with the design of sewage and storm water drainage infrastructure and that should be the approach that has to be taken.

Various scenarios can be simulated using software models to test different infrastructure proposal and other strategies. Finally, successful implementation of drainage plans require participation of the population, strategies and awareness campaigns towards change in their behavior and finally, regular inspection and maintenance of sewerage infrastructure.

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References

These are the references that can be followed.