Watershed Management
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Module No. # 08

Lecture No. # 34

Flood Control and Management

Namaste and welcome back to the video course on watershed management. We were discussing about storm water and flood management in module number eight.

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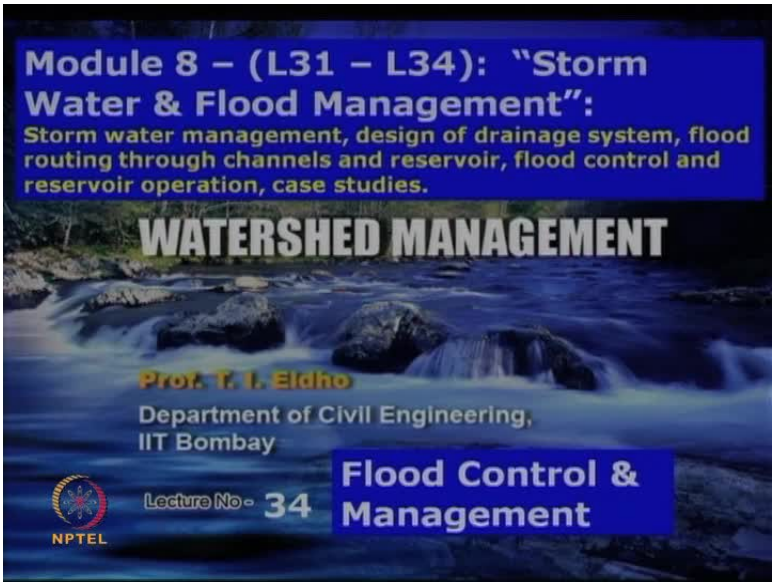

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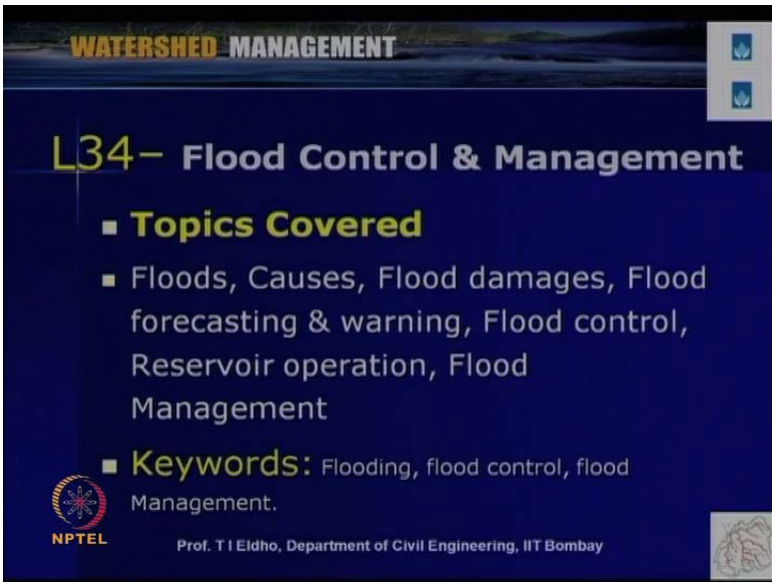

In today's lecture number thirty four, you will discuss about flood control and management. Some of the important topics covered in today's lecture include floods, causes, flood damages, flood forecasting and warning flood control, reservoir operation, flood management. And some of the keywords for today's lecture include flooding, flood control and flood management.

As we were discussing earlier, storm water and its management is a big issue. When we discuss about the watershed management, we have to see that within the watershed, how the rainfall runoff is taking place. And then how the flood routing or flow routing we have to do, and then whether there is any scope for flooding in that area. All these issues we have to look into.

In today's lecture, we are going to discuss why this type of flooding can takes place on a watershed basis or a particular area, and then what are the causes and then, what kind of control measures we can adopt in order to reduce this flooding.

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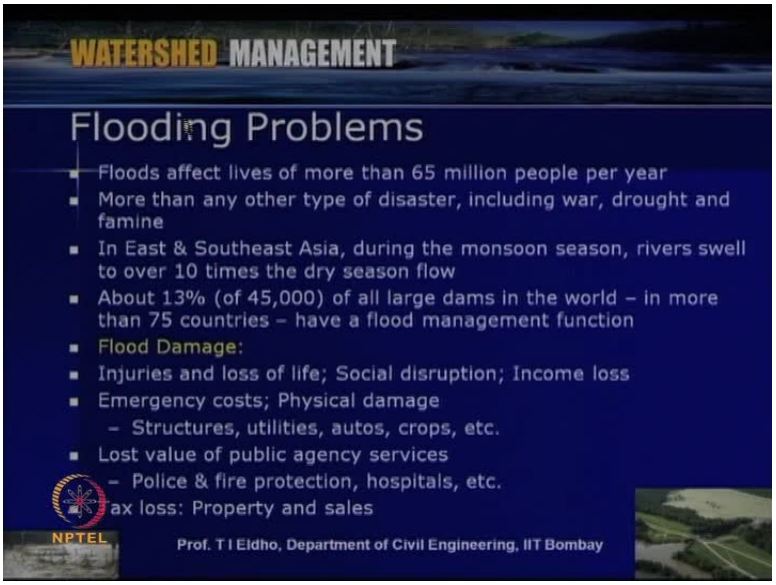

Let us look into the flooding problems. As I mentioned earlier, floods affect large number of people. Some estimate says that, flood affects lives of more than 65 million people per year globally.

You can see that, that indicates how much is the quantum of problems due to the flooding more than any other types of disasters including war, droughts, famine and other problems or including earth quake.

We can see that, these flood related problems or the death or other related issues related to flooding are much more. That way, we have to see that flooding we have to accept, is the major problem and then we have to look into the these problems and then we have to look into the control measures so that we can reduce the problems of flooding. For example, in East and South East Asia during the monsoon season, generally this monsoon season will be from June to September or October. We can see that, most of these rivers in these regions, South Asia and South East Asia, we can see that the river flow will be more than ten times that of dry season flow.

That way, this river, most of the river will be over flowing in many of the regions and then, that creates major flooding problems in many of these areas in South Asia and East Asia.

It is estimated that, that way, many of these countries have taken number of steps to reduce these flooding problems and even large number of dams were constructed in the

past to reduce this flooding problem. An estimate says that, about 13 percent of the 45000 large dams in the world, these dams are built for flood management function. In 75 countries, about 13 percent of the large 45000 dams, these are only built to control the flooding problems in many of the areas.

That way, we can look into what kind of big problem is there due to flooding and then, what kind of losses like deaths and then economic losses, all those things we can see as and this is a major issue in many countries.

Now, let us look what are the damages- flood damages. We can see that, there are number of damages related to the floods. It can be loss of death or loss of life, then injuries and then social disruption, then huge economic losses, then emergency costs physical damage, collapse of buildings, structures, bridges then roads.

All these will be affected. Then, many of the utilities like telecommunication systems, then electric supply, all those will be affected. Then, the cars and autos and other automobiles will be affected.

Then the major impact is especially on crops., when due to the heavy flooding in many areas, we can see that the crops will get spoiled and then, there will be related famine and other related issue.

And then lost values of public agency services like, now whenever this kinds of flooding takes place, we have to put into public agencies like police, fire force then hospital etcetera to cope up with this kind of flooding.

That is another way damage or big loss due to the flooding, and then also like losses like tax losses, property and sales, all those things. That way, we can see that flooding is a big problem. And then, most of the countries, flooding takes place. And then, we have to look into how we can reduce these flooding problems. How we can control this flooding problems. That is what we will be discussing today.

Whenever we discuss about floods generally, most of the time this flood happens due to heavy rainfall; that means, in country like India or South Asia, it will be mainly due to the heavy monsoon which will be taking place from three to four months, starting from June to September or October of the year.

That is one reason, but of course, many other reasons are also there, like in coastal urban cities, as we discussed earlier also, when heavy rainfall takes place simultaneously. If tidal effects also takes place, then the flooding problem increases. Similarly, then the wherever, especially hilly regions or wherever, say snowfall is there when snow melt takes place, then also there is possibility of flooding.

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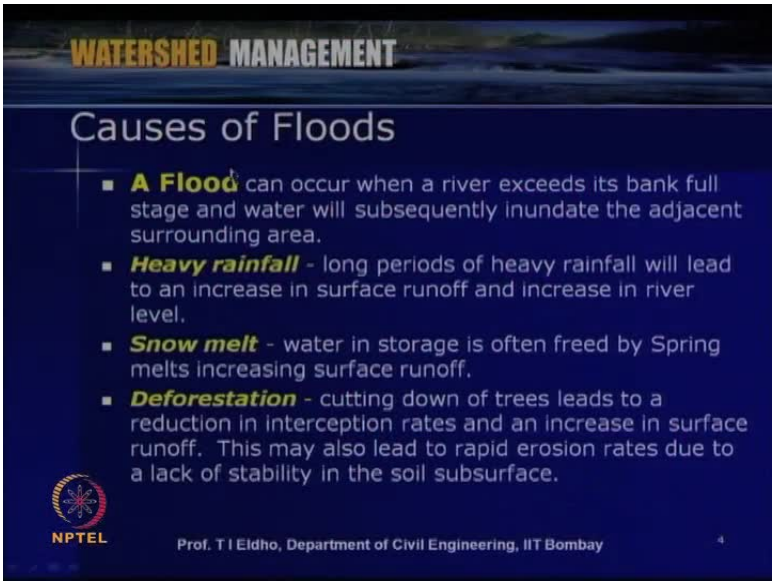

Let us look into the different causes of flooding. As we discussed, flood can occur when a river exceeds its bank full stage, and then water will subsequently inundate the adjacent surrounding area.

Generally, in most of the areas what happens is that, the river will be over flowing and then this water will be going to the surrounding areas, and that inundate the adjacent surrounding areas.

As we were discussing, the floods can be due to heavy rainfall like long periods of heavy rainfall will lead to an increase in surface run off and increase in river level.

That can be one reason and most of the time, this is the main reason as far as flooding is concerned, then snowmelt. Water in storage is often freed by spring melts increasing surface runoff.

With snow melt, the surface run off increases and that can be also a cause of flooding. And then, some of the causes like deforestation. If as we were discussing in some of the early lectures, whenever forest is there, it stores some portion of the runoff and that the runoff will be slowly taking place.

When deforestation takes place in a large scale, then what happens is the cutting down of trees lead to reduction in interception rates, and an increase in surface run off. This may also lead to rapid erosion rates, due to a lack of stability in the soil sub surface. That way, this some of the causes can be like deforestation and also like the coastal regions, tidal effects and then in some locations due to any reasons, any dam break takes place that can be also a cause of flooding.

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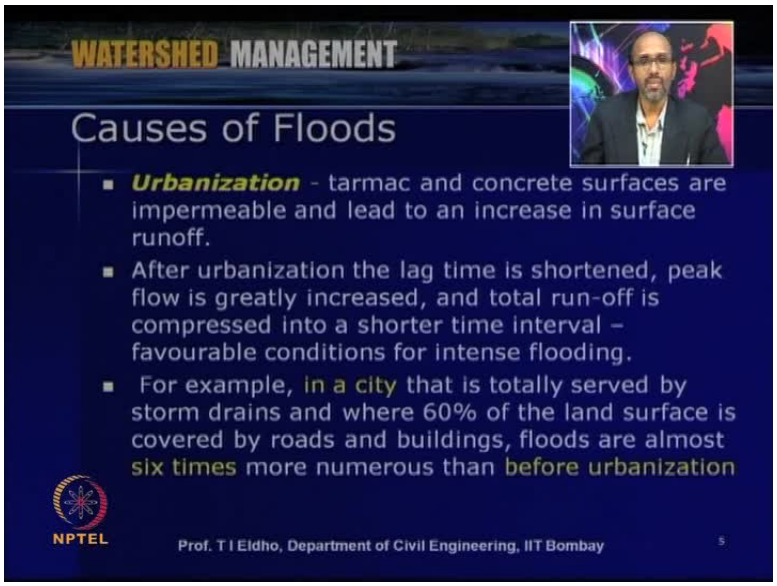

And then of course, in urban areas, whenever urbanization takes place due to sudden increase of urban, the concrete surfaces are impermeable areas in cities. Then that may lead to an increase in surface run off.

As we were discussing in one of the earlier Lectures, whenever the impervious area increases, then the time of concentration will be reduced and then the peak will be increased.

That way also, especially in urban areas, the urbanization can cause flooding and then after urbanization, the lag time is shortened peak. Flow is greatly increased and total run off compressed into a shorter time interval, is a favorable condition for intense flooding, especially in urbanization, can also cause flooding.

For example, some calculations say, in a city that is totally served by storm drains and where sixty percent of the land surface is covered by roads and buildings, then floods are almost six times more numerous than before urbanization.

If before urbanization, if it is a rural area, there is a much impervious area now than compared to that if sixty percent of the area is covered. Then there some estimate says, there is a possibility of six times more flooding in that kind of area.

Urbanization can be a major cause of flooding.

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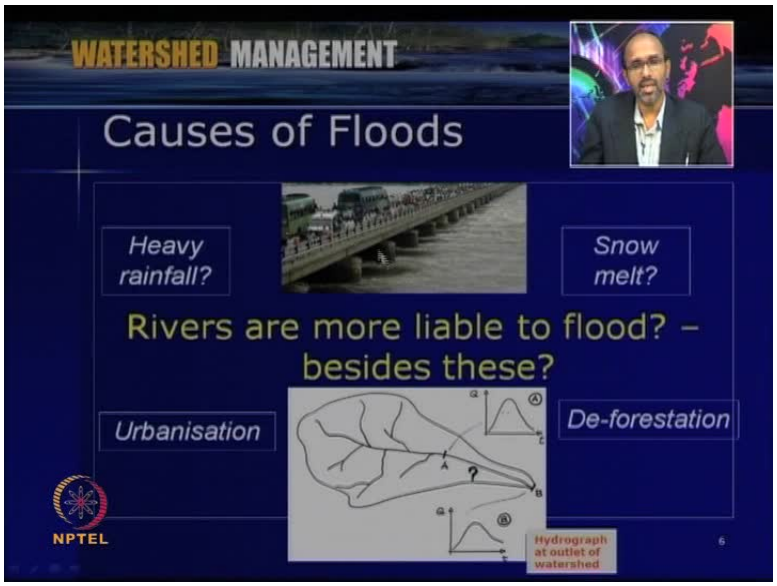

That way, when we look into causes of flooding. As we can see, here rivers are more liable to flooding, like due to various reasons. It can be heavy rainfall, snow melt, all those things and then the banks over flow and then as we discussed, urbanization and deforestation and especially in coastal regions, the reasons can be also tidal effects,

where the tidal also simultaneously rise. And then also, sometimes failure of a dam, all those thing can be some of the causes, as far as flooding is concerned on a watershed basis. As we discussed, if this is a watershed, then all the flow will keep on coming as runoff from various sub catchments.

And then, it will be routed through the channel. That way, then say when this level rises above the banks, then flooding takes place That way, on a watershed basis, we can calculate or estimate how much flooding can take place through some of the mathematical models, which we discussed earlier.

Now, let us look, what will be the results of this flooding. We has seen that the damages, flood damages are much big. It is not only loss of life, but huge economical loss is also taking place.

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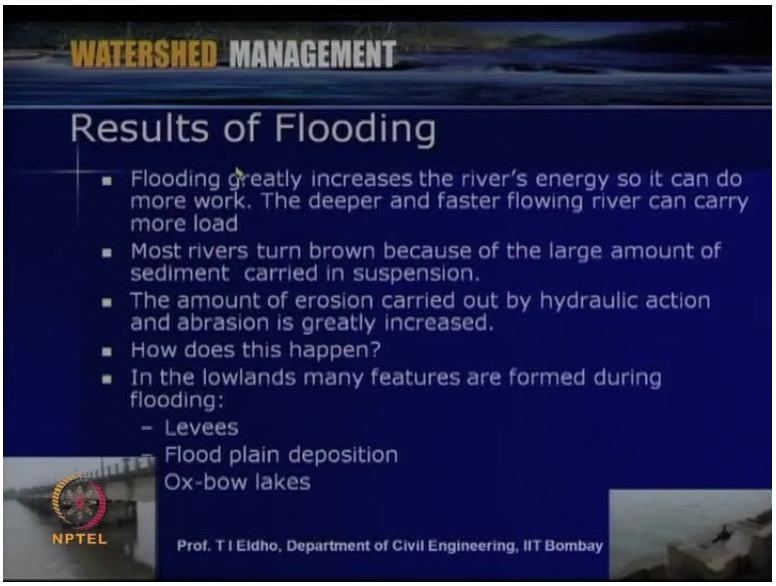

Let us look, some of the important points- what are results of flooding. Due to flooding, as we can see, large amount of water will be flowing through the river.

Flooding greatly increases the river's energy. It can do more work. That way, the velocity of flow will be increasing. The depth of flow will be increasing. A deeper and faster flowing river can carry more load, and more sediments will be carried.

And then also, may be trees and all those things and also garbage etcetera will also be carried through the river due to the increase in carrying capacity. Most rivers turn brown because of the large amount of sediments carried in suspension due to, during the heavy monsoon or heavy rainfall season, the silt will be or sediment will be carried through the river. The amount of erosion carried out by hydraulic action and abrasion is greatly increased.

Due to the increase in velocity, increase in depth. Whatever the river, the flow conditions greatly increase and then, the actions like hydraulic actions, the velocity, depth of flow- all those things and then the abrasion, that the sides of the river may also get eroded. That will be also taking place. These are some of the important effects or the results of flooding. The amount of erosion carried out by hydraulic action is increased, and then how does this happen?

As I mentioned, when the velocity increases, the sides are not stable. The river sides are not stable, or the bed level is not stable, then all the soil will be carried, will be eroded with respect to the movement of the water within the river.

And then in the low lands or the downstream side, many features are formed during flooding like large kinds of depositions can takes place and then, like bow lakes and then, if the levees are there, that will be affected. Large amount of depositions takes place, especially in delta regions or wherever the lowland regions.

These are some of the important results of flooding, which generally we can see during, especially during the monsoon season. Now, when we look into the damages caused by this flooding, we can classify the damages into short term damages, and the long term damages.

Short term means immediately, when flooding takes place immediately within that term period or immediate time period, what are the losses or what the damages? And long term means, what will be the repercussion, economic repercussion or the infrastructure repercussion due to the flooding?

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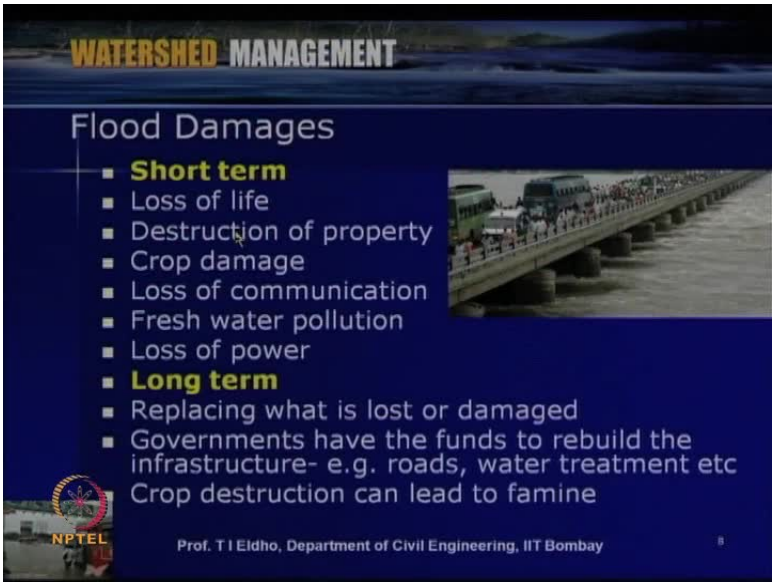

Flood damages- We can classify into short term damages and long term damages. Short term damages, like as we discussed, it can be loss of life, destruction of property, crop damages, loss of communication networks, fresh water pollution and loss of electric power.

All those are some of the short term effects or damages due to the flooding. These are immediately visible damages, and then that these kinds of damages critically affect the area and then, large kind of migration can takes place due to these kinds of short term effects.

And long term effects or long term damages include replacing what is lost or damaged, when due to the heavy flooding, much of infrastructural facility will be affected, then much area will be eroded, and then crop will be affected. And then, electric power network or the communication network will be affected. Now, after the flooding event is over, we have to replace what has happened since so that, people can start their normal life. That is the long term effect. It is mainly economical loss, huge economic loss,huge infrastructural losses.

Governments have to get the funds to rebuild the infrastructure like roads, water treatment, then bridges, then electric power network like that. That is the especially long term damages. We can measure terms of economic terms.

Then also, due to heavy flooding, many of the agricultural land will be affected and then crop destruction takes place.

Once one crop is lost, then you can see that food shortage will take place and that can lead to famine. That way, flood damages can be short term or long term. That way, this when we discuss about the watershed management, we have to see that- how we can control this flooding? What kind of measures can be adopted so that the flooding effect will be reduced? And then, with respect to the weather system, with respect to the weather prediction, and then the model like flood routing or rainfall runoff modeling, whether we can forecast how, for the given rainfall condition or the for non-rainfall condition, how much flooding is possible

Flood forecasting is one of the important things which we can look into. Once we can forecast, then we can also think about flood warning so that the people can be cautioned, as this area will be flooded, that you have to take appropriate measures to take away your valuable things and vacate the people from that flood affected, possible flood affected areas.

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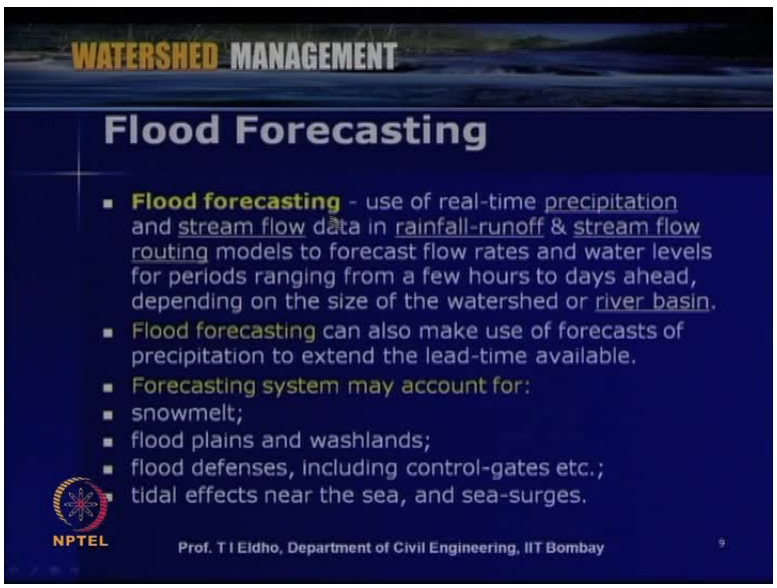

That way, flood forecasting is a very important. Food forecasting generally, it is a use of real time precipitation and stream flow data in rain fall runoff and stream flow routing models.

We were discussing in the last, some of the last few lectures about this rainfall runoff modeling as the stream flow routing. These kinds of model, we can directly utilize for flood forecasting.

The forecasting is to identify, how much is the flow rates and then water levels for period ranging from few hours to days ahead, depending upon the size of the watershed or the river basin, Depending upon the location, depending upon the watershed or river basin scale, and then depending upon the precipitation pattern, sometimes the rainfall takes place for few days or few hours. Depending upon that, we may have to go for short term flood forecasting or long term flood forecasting.

And then, also we may have to calculate for the given rainfall condition, how much is the runoff and then corresponding stream flow and then its routing. All these are very important, as far as flood forecasting is concerned.

Flood forecasting can also make use of forecasts of precipitation to extend the lead time available . In flood forecasting, we have to also identify the rainfall pattern which is going to come now, presently. If heavy rainfall takes place and next few days, how the rainfall is going to take place or precipitation is going to take place?

This forecasting is also required, since there will be some lead time available. We can predict from one rain fall event to, how another rainfall event, what will be the effect as far as flooding is concerned.

That way, the forecasting system may account for other than the precipitation, we may have to account for the snow melt. If the area snow, in some of the areas snow is there, then what is the possibility of snow melt?

Then flood plains and wash lands. How the flood plains will be affected? Then flood defenses including control gates. If the reservoirs, if you have got some control gates or if tidal gates where the tides will be entering from the estuaries to the river, that kind of gates how we can control?

Then tidal effects near the sea and sea surges all those things we may have to account for. flood forecasting is not only a simply the rainfall to runoff forecasting or the rainfall forecasting and then corresponding runoff evaluation

But we may have to also deal with various other phenomenon like snow melt and then the control gates operational control gates and then the tidal effects sea surges like that

That way, in all these things we have to account as far as the flood forecasting is concerned.

That way, if you can forecast for the given weather prediction system for few days or few hours, accordingly if we can identify the rainfall pattern or the rainfall intensity and from that, we can identify the runoff or the flow depth variations or the discharge variation.

And then, depending upon the area, depending upon if we can identify the possible areas of flooding, then we can prepare flood warning maps, and then that can be transmitted to the public so that, the administration and public can take appropriate measures.

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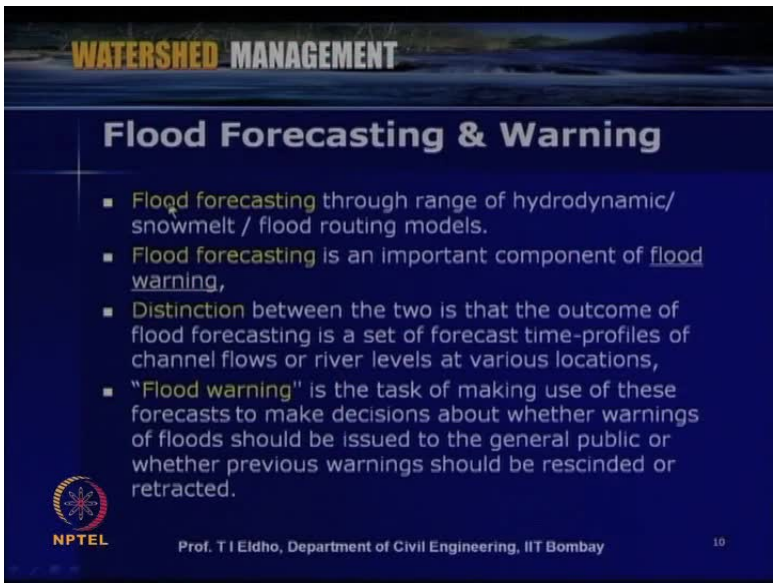

That way, flood forecasting and warning is very important. Flood forecasting, through range of hydrodynamic snow melt or flood routing models, Through these models only

we go for flood forecasting. That way, flood forecasting is an important component of flood warning system. The distinction between the flood forecasting and warning is that, the outcome of the flood forecasting is a set of forecast time profiles of channel flows or river levels at various locations. When we do these kinds of rainfall to runoff modeling or flood routing, We can identify with respect to time, which of the areas will be affected. Then the water levels, how it will be varying in the channels or rivers and then at various locations, how the flood or the water will spread like that.

That way, the flood warning is the task of making use of these forecasts, to make decisions about whether warnings of floods should be issued to the general public or whether previous warnings should be rescinded or retracted. That way, whether we have to go for flood warning, depending upon the rainfall condition, depending upon the river level conditions or channel level conditions, we can decide whether we have to give a warning, and if already some warnings are given, whether that is going to continue.

That, if it is not going to continue, we can retract back or not so that, yes the possibility of flood warning is flood, is not there so that, people can start their normal way of life.

That way, flood forecasting and flood warning are very important aspects, as far as flood management is concerned, either on a watershed basis or on a river basin scale.

Now, within this perspective, we are discussing about the flooding, dam flooding. The damages due to flooding, then causes of flooding, and then flood forecasting and warning. Now, let us look at what kind of control measures we can adopt so that, the effect of floods can be reduced.

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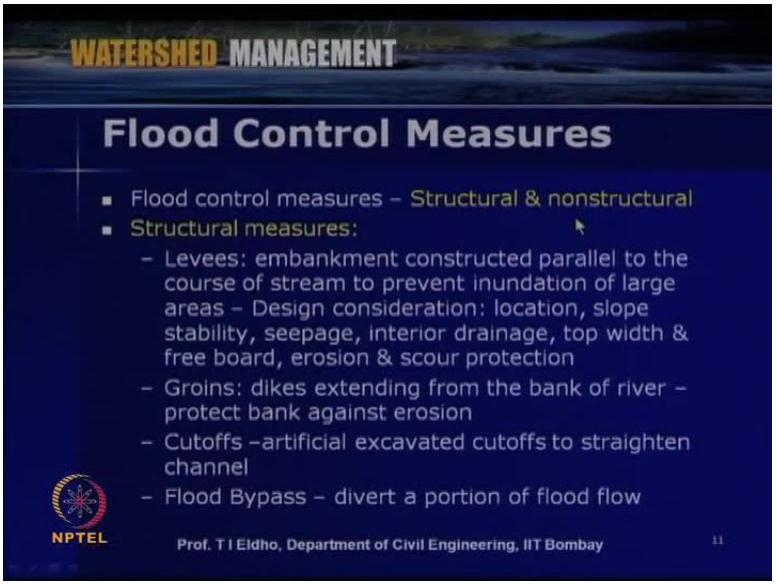

Generally, the flood control measures can be of two varieties- one is structural type of flood control measures, and second one is nonstructural type of flood control measures.

When we look into structural measures, actually what we are doing is- if we identify some areas where flooding problem is there, then we construct certain structures or various measures so that, the flooding will not takes place or flooding effect will be reduced in that area.

That way, there can be number of structural measures which we can adopt, depending upon the location area, then the river flow condition and the geographical conditions.

And as far as nonstructural measures are there, we are not doing any of these kind of construction activities, or these kinds of things, but for example, we can go for floods warning map so that, people will be careful while making a building in particular location, wherever the flood zones are there.

Now, let us look into the details of the structural measures. So many structures can be constructed, as especially on river sides or river banks so that, the area, the flood prone area can be protected.

Some of the things, which we can do are listed here. Like first one is levees. These levees are embankments constructed parallel to the course of stream, to prevent inundation of large areas. That way, on both sides of the river, parallel to the bank. we construct the retaining walls or some embankment kind of structures so that, the river

banks will be raised. So during floods, whenever the water level rises, it cannot spill over to the surrounding land and then we can protect the area.

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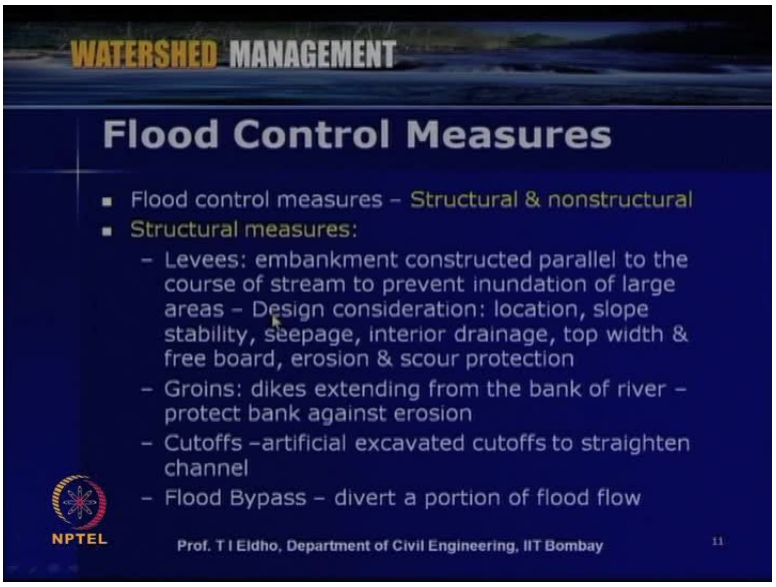

Levees are generally used to say, reduce the flooding problems wherever flood prone rivers.

Some of the important design consideration- while designing levees, including location of the area, then slope stability of the river banks, then the possibility of seepage, then interior drainage coming to the areas, and top width free board. How much free board should be given? Then what are the possibilities of erosion and then scour protection?

All these are, some of the important issues that we will be looking into, when we go for the design of levees. Then another kind of structural structure, which we can make is called groins. These are dikes extending from the bank of river. It will be going either perpendicular to some through some angle, to the bank of the river, and generally these structures are made to protect the river banks so that, the bank will not be eroded and then further, the flooding problem will not take place.

So, these kinds of structures are called groins and then sometimes, we can construct cut offs. Cut offs are artificial excavated cut offs to strengthen the channel. Straighten the channel, not strengthen straighten the channel.

Some, the channels or rivers may be meandering, and then it will be going in a very regular way. And then, when heavy flow or heavy flooding takes place, these irregularly shaped water will try to flow directly on a straight line, and then the area will be affected. That way, before such flooding possibilities, we can straighten the channels through appropriate cut off, by considering meandering nature of the channel.

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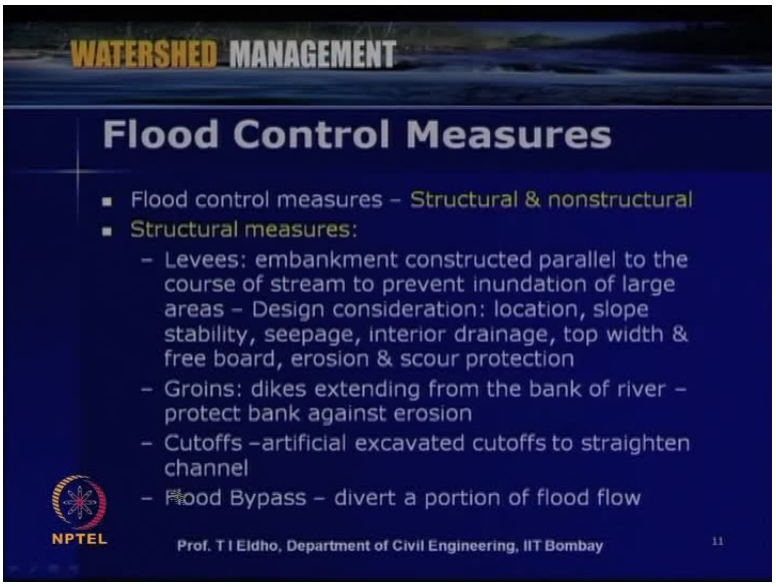

That kind of structure is called cut off, and then we can also have some structures like a flood bypass. This bypass means, wherever possibility of heavy flood in some regions, we can take the flow coming through certain other means like tunnels or the pipes or through some other channels, and then we can divert the flood flow.

Flood by bypass means, we are diverting a portion of the flood flow so that, the area will be safe, especially in city regions, if the chronic flood problems are there then we can construct a flood bypasses.

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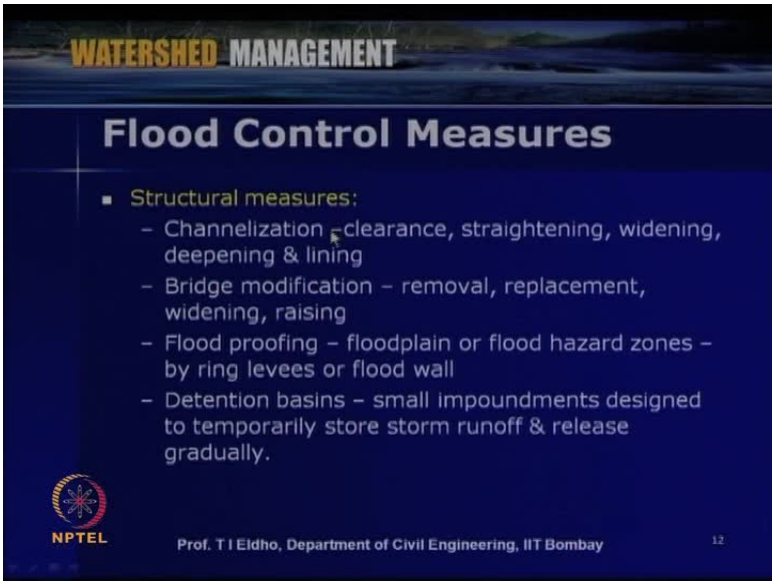

Then, some of the other structural measures include channelization. Channelization means, some of the activities, what we can do ,clear the channel, then we can straighten it, then we can widen it, then we can deepen it and also then the sides can be lined.

So that, this process, we can combined put it as channelization so this will increase the flood carrying capacity of the river or the channel. That way, the flooding problem will be reduced.

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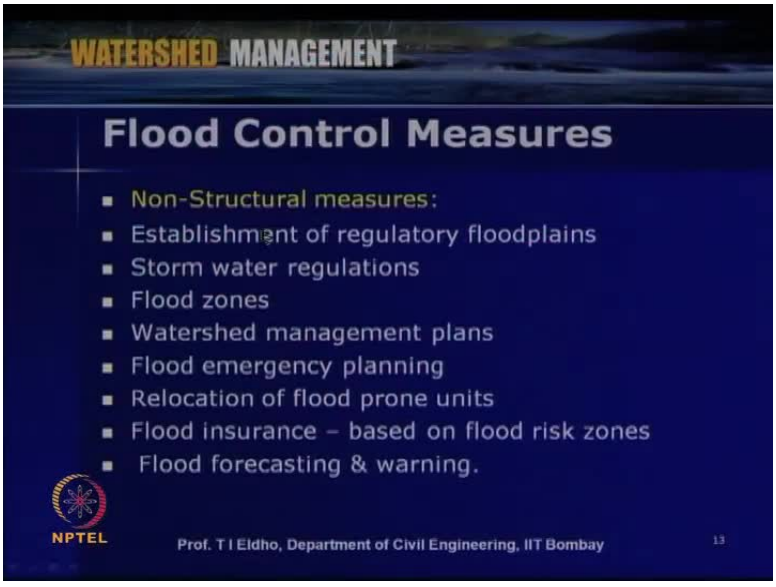

And then if any bridges, especially between the bridge pierce the flow of conditions, sufficient flow cannot pass then, that kind of bridges we can modify by giving appropriate height or appropriate ducts so that, the normal flow will take place. So, bridge modification is another structural measure, like removal, replacement or widening and raising, as far as bridge is concerned, then like a flood proofing.

Flood proofing means flood plain or flood hazard zones by ring levees or flood walls. We can construct flood walls, especially in cities we can do flood proofing by constructing walls or levees, and then the area can be protected.

Then also, depending upon the area we can have. If sufficient area is available, we can have detention ponds or detention basins, where some of the rain water will be stored for some time, and then that will be released gradually, once the rainfall is or the flood problem is receded.

That way, the detention basins are small impoundments designed to temporarily store storm runoff, and this storm runoff will be released gradually. That way, these are some of the important structural measures. That means, we are going for some way or another way of construction, or some modification to the existing system.

So that, the flood prone area will be protected or flood problem will be reduced. These are some of the important structural measures, which we can adopt as far as flood control measures are concerned.

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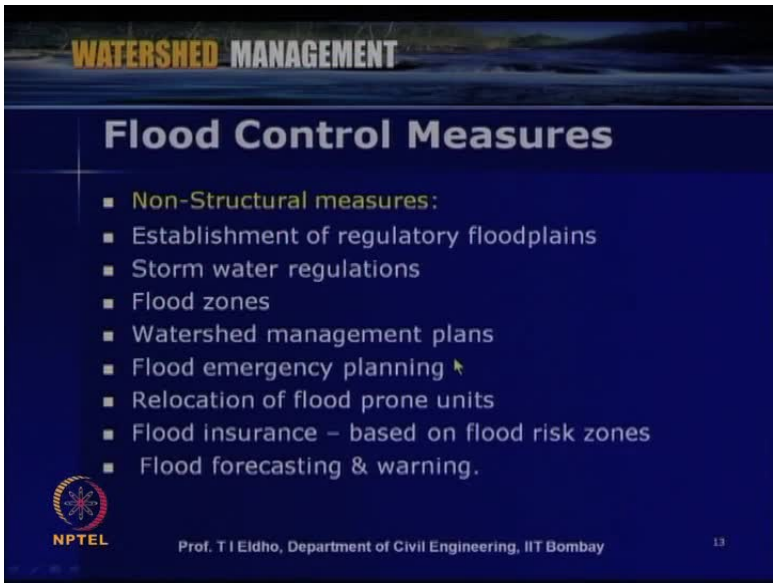

Now, let us look into some of the nonstructural measures. These nonstructural measures, we can do many things, some of the important things are listed here. We can establish regulatory flood plains. Depending upon the river flow, we can study the historical, the flooding problems or the flood levels or the depth of flow taking place in particular location, especially in city regions.

And then, we can have some rules and regulations. So that, no construction will take place in the flood plains so, the property and human life can be saved.

That way, we can establish regulatory flood plains, and then storm water regulations. Storm water, as we discussed, whether we can store some of the water or we can go for water harvesting, or we can that way, through afforestation all those measures which we discussed the earlier. Also, we can reduce intensity of some of the storm water movement, and then that kind of regulations we can have.

Storm water regulations are another nonstructural flood control measures, and then also we can have flooding zones or flood zones. Also, for the given river, according to the given conditions, after studying the rainfall to runoff or the flooding problems for large

number of years, like 10 years, 50 years or 100 years , we can generate flood zone map. So that, we can restrict the development in that flood zone areas. So, flood zone mapping is one of the generally used technique, as far as a nonstructural measures is concerned.

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Then also, as we discussed earlier, we can go for various watershed management plans like rain water harvesting, then water conservation measures within the area. All those things will give us some effect, as far as flood control is concerned.

Then flood emergency planning. If the flood is going to take place, or if there is possibility of flooding, we can create emergency plans. Now a days, when many of the states and at central level in India, we have got a national disaster management authority.

This disaster management authority also deals with the flooding. They will come up with certain guidelines, which each authority or each state and each district has to follow.

That way, we can have flood emergency planning, and then wherever the flood prone areas, if there is any. Some areas we can identify, that is flood prone, then we can relocate the people and whatever that location.

And then of course, another important measure we can take to save the economic losses, we can go for flood insurance. That is another measure, which we can adopt. This is actually flood insurance. Various insurance companies provide this flood insurance.

But this is generally based upon flood risk assessment or flood risk zones of the area, which we consider. And then of course, another important nonstructural measure is appropriate flood forecasting and warning, so that the people can take or the public can take appropriate measures to protect themselves and their properties.

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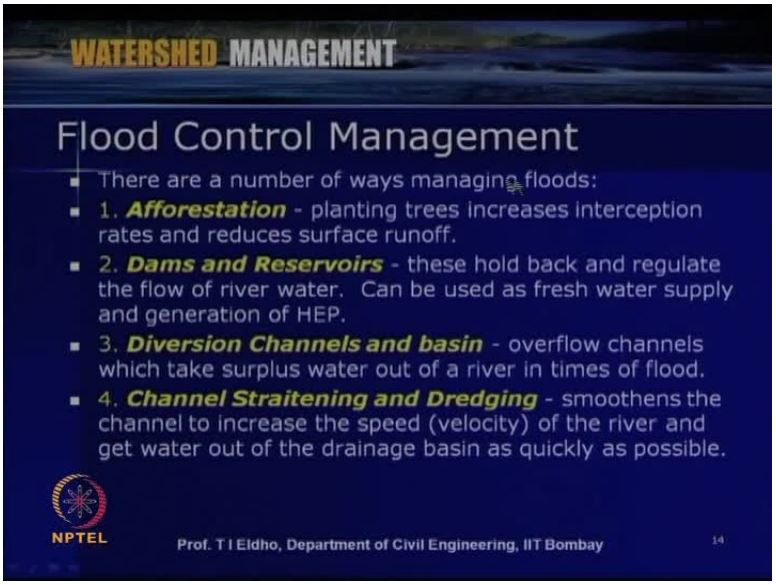

.That way, we can see that the flood control measures are concerned, it can be either structural measures or nonstructural measures. Now, let us look into how we can control this flood or let us look at some of the important aspects, which we can do to manage the flood or flood control management.

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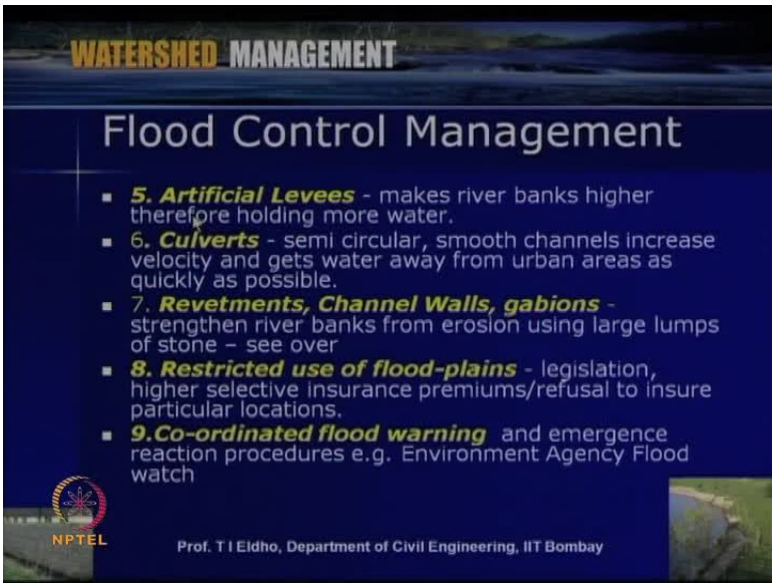
Some of the important ways, through which we can manage the flood s are listed here. This actually reduces the intensity of flooding and then, ultimately it may keep away the possibility of flooding.

Some of the important things that can be done are listed here like afforestation. We can plant trees, that may increase the interception rates and then, that may reduce the surface runoff. This can be one managerial measure.

Then second one is dams and reservoir. Depending upon the area, as I mentioned earlier, about thirteen percent of the world's largest dams are constructed only for the flood protection or flood control management. That way, dams and reservoirs, These hold back and regulate the flow of river water and this can be used as a fresh water supply and also generation of hydroelectric power.

That way, dams and reservoirs and then diversion channels and basins. Wherever flood prone areas are there, we can divert some of the flood water through some other extra channels pipes or tunnels.

Overflow channels, which take surplus water out of river in times of flooding, then



channel straightening and dredging, as we already mentioned. This may smoothen the channels, to increase the speed, I mean velocity of the river, and get water out of the drainage basin as quickly as possible. That way, the intensity of flood will be reduced or the flow depth or flood depth will be reduced.

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Then some of the other measures, like it can be structural measure for flood control management like artificial levees. We can construct levees on river banks so that, more water will be held in the river, and then we can have culverts. Semicircular, smooth channels increase velocity and get water away from the urban areas as quickly as possible.

Then revetment channel walls or gabions. These are some of the measures, which we can adopt. Like, strengthen the river banks from erosion using large lumps of stones, then we can have gabions or walls, then restricted use of flood plains. As we discussed, this is a nonstructural measure. We can have legislation, that higher selective insurance so that, there will not be any construction in the restricted flood plain area.

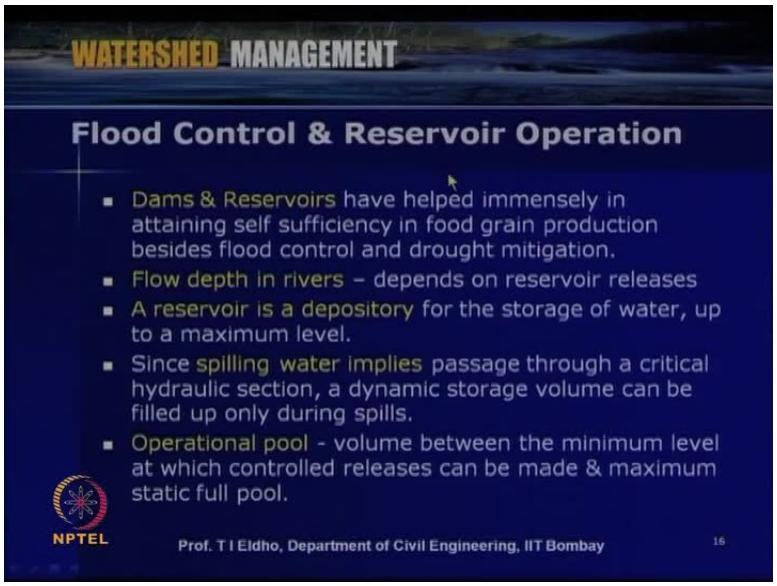
Then, higher selective insurance premiums or refusal to insure particular locations. All these can be used and then finally, coordinated flood warning system. This is one of the important things which can be done as flood control management. This coordinated flood

forecasting and flood warning emergency reaction procedures. We can have Some specified agency for example, environment agency in United Kingdom environment, protection agency in USA or National disaster management has authority in India.

These kinds of agencies can coordinate the flood forecasting and flood warning so that the people can be warned that, there is a possibility of flooding and then appropriate measures can be taken.

That way, flood control management is very important. Earlier, we were discussing that some of the dams constructed, about thirty or fifteen percent of the large dams have been mainly constructed for flood management or flood control.

That way, the reservoirs formed by these the dams, if you operate appropriately many of these reservoirs, we can control flood very effectively. That way, reservoir operation,



with respect to especially in monsoon season or flood rainfall season, that is very important.

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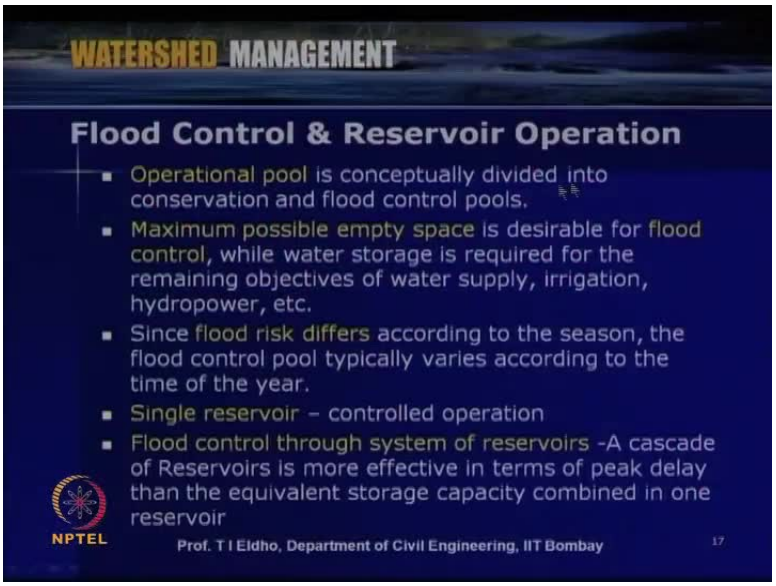
Let us look at some of the important aspects of flood control and reservoir operation. Dams and reservoirs have helped immensely in attaining self-sufficiency in food grain production, besides flood control and drought mitigation Which we have seen earlier.

That way, these reservoirs store a large amount of water, and that will reduce the intensity of flooding or the flow condition, that can take place within a river.

Flood depth in rivers depends on reservoir releases or reservoir storages. A reservoir is a depository for the storage of water up to a maximum limit. They will maximize water level possibility within the reservoir. Depending upon the rainfall condition, depending upon the runoff condition, we can manage this level so that, appropriate flood controlling is possible and then since spilling water implies passage through a critical hydraulic section, a dynamic storage volume can be filled up only during spills. We have to appropriately manage during the rainfall season- how much spill should be allowed and how much should be stored so that, we can have effective flood control through appropriate reservoir operation.

Operational pool it is, which is defined as the volume between the minimum level at



which controlled releases can be made and maximum static full pool. Actually, the difference between this minimum level and maximum static full pool is generally utilized for storage, and that can be effectively operated so that, if possibility of flooding is there, that can be reduced.

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That way, a reservoir operation is very important. Now operational pool is conceptually divided into conservation and flood control pools.We were discussing about this

operational pool in the last slide. This can be conceptually divided into conservation and flood control pools. Conservation means how much water should be conserved for future purposes and then, flood control pool is to reduce the flood. How much effectively we have to store?

Maximum possible empty space is desirable for flood control. Especially in monsoon season, we have to keep maximum possible empty space. Then, while water storage is required for the remaining objectives of the water supply irrigation, hydro power especially if the reservoir is for multi purposes, other than flood control. We have to see that sufficient water is available for future water supply, irrigation, hydro power generation etcetera.

Since flood risk differs according to the season, the flood control pool typically varies according to the time of the year.

As I mentioned during the monsoon season, heavy rainfall season, we have more flooding problem. That way, we should have the operational pool, which is for flood control. That way, we have to control. The reservoirs can be single reservoir, where we can have direct control. Only one reservoir, how much is to be released or how much is to be stored so that flooding will be reduced?- Like that we can easily take decision.

But wherever possible, if there are multiple reservoirs or a system of reservoirs, this always will be advantageous as far as flood control is concerned, since whatever extra flood is coming will be stored.

In cascade of reservoirs. A cascade of reservoirs is more effective in terms of peak delay than the equivalent storage capacity combined in one reservoir, if multiple reservoirs are there. We can effectively operate the reservoir in such a way that, good storage can be also given and good release will be appropriately done from each reservoir so that flood will be controlled, and then also appropriate storage will be given to each reservoir.

Now, when we look into some of the reservoir, which is only constructed for flood management, which are called management flood reservoirs.

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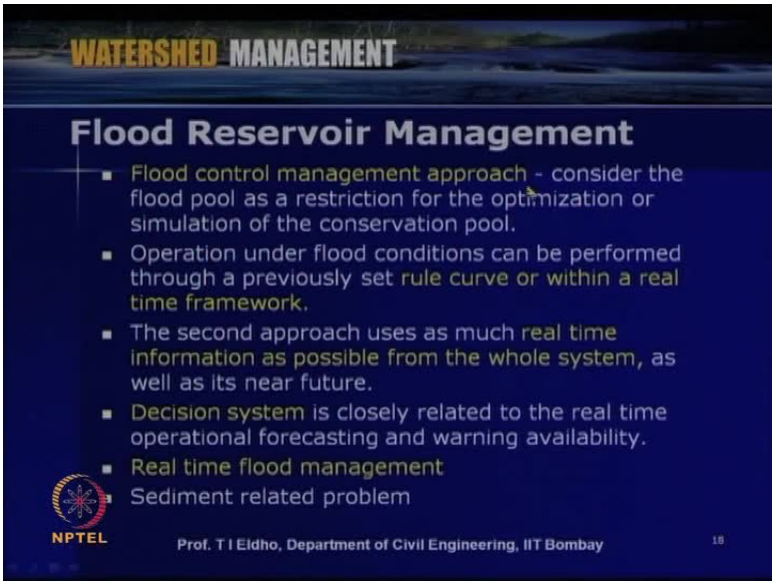

How to manage this? The flood control management approaches, we can specifically develop for that particular reservoir. Considering the flood pool as a restriction for the optimization, or simulation of the conservation pool, we may have to go for simulation in order to identify, how with respect to rainfall to runoff, and how much flow is taking place to the reservoir, and how much storage should be allowed.

Then operation under flood conditions can be performed through previously set rule curves or within a real time frame work. We can have real time reservoir management for flood control, or we can also develop a rule curve depending upon the past experiences, past data. We can generate rule curve and using this rule curve we can operate the reservoir for flood management.

But of course, it is always better to go for real time management. That either rainfall variation or with respect to weather condition, we can have real time flood control.The second approach uses a very much real time information, I mean the real time framework information as possible from the whole system, as well as its near future.

It is not only current system, but for coming few days or few weeks also, how to operate the reservoir for flood management. All these issues will be considered. We can have a decision system, which can be closely related to the real time operation forecasting and warning availability.

If, for particular area, if you are having the flood forecasting and flood warning system, by considering these, we can operate the flood reservoir and then we can take appropriate decision how much storage should be given, how much release should be given.

That finally, by considering all those things, we can have a real time flood management. We can develop a real time flood management in these cases. To reduce the silting problem in the reservoirs, we also have to deal with the sediment related problems. That will be also considered, as far as flood reservoir management so that, the capacity of the reservoir will be maintained.

Now, we were discussing about the flood control management. Let us look into what are the important risk associated with flood and flood control. Some of the important risks I have listed here:

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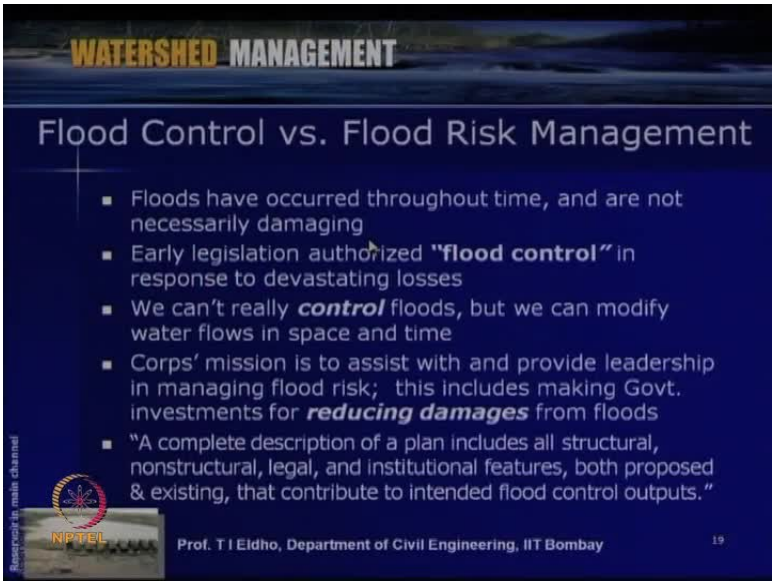

Floods have occurred throughout time and are not necessarily damaging. Sometimes, severe flood can have severe damages, but some minor floods, there may not be much damage.

Early legislation authorized flood control in response to devastating losses. Depending upon the area, depending upon the location, we can have legislation and then we can have appropriate flood control system. Then we cannot rely, we cannot really control floods, but we can modify water flows in space and time.

As we discussed, the flooding situation depends upon many parameters like meteorological parameters, geographical parameters or conditions like an earth quake or the dam break, many parameters will be there.

We cannot control all these parameters. That way, complete control of the flood is not possible. Only thing is that, we can modify the problem or we can reduce the effect with respect to space and time.

Generally in countries like America, US army corps of engineers, they take their mission is to assist with and provide leadership in managing the flood risk. Depending upon the agencies working in that particular country, whether it is army or disaster management cell, whichever the agency.

They can take the lead leadership for the control of flood, or to reduce the flood problem. This include making the government investment for reducing damages from flood like what kind of measures to be adopted in future, and then what kind of disaster management measures to be adopted. That way, complete descriptions of a plan that can include all structural, nonstructural, legal and institutional features, both proposed and existing that contribute to intended flood control output.

That way, we can come up with a flood risk management measures for the given area, for the given location, depending upon the various parameters for the particular agency which is dealing. They can take the leadership, and then come up with appropriate measures, as far as flood risk management is concerned.

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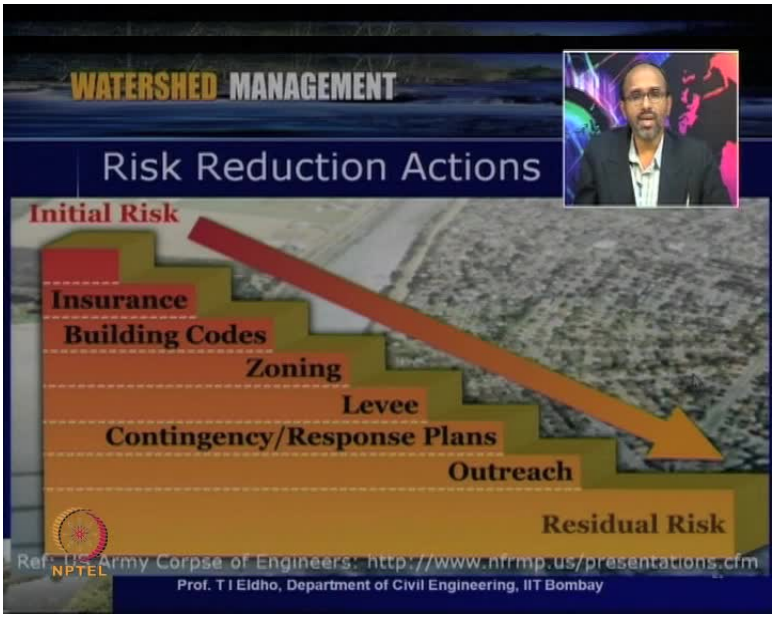

Some of the important strategic goals, when we discuss the flood risk management are listed here. First one is, provide current, accurate floodplain information to the public and decision makers. This is very important. Accordingly, the decision makers can take decision and the public can react. Then, second strategic goal is identify and assess flood hazards posed by aging flood damage reduction in infrastructure.

This, we can assess and then take appropriate measures. Then third one is: improve public awareness and comprehension of flood risk. This public information or public awareness is very important so that, the people can react with, if sufficient time is given and then they can take appropriate measures by themselves and then, government can give appropriate support.

That way, we can improve the public awareness, then integrate flood damage and flood hazard reduction programs across local government, state government or federal agencies.

We can come up with integration of flood damage and flood hazard reduction, then improve capabilities to collaboratively deliver and sustain flood damage reduction and flood hazard mitigation services to the nation.

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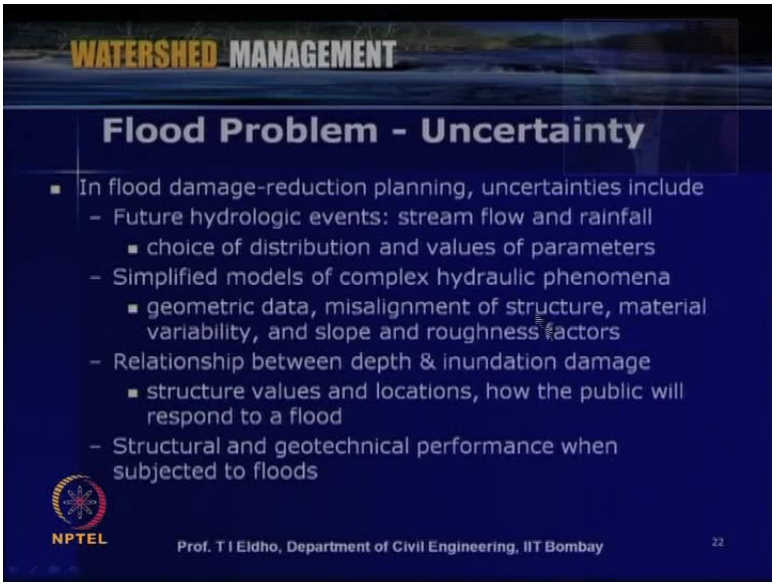

These are some of the important strategic goals, which we can adopt as far as flood risk management is concerned. Then, if you look into this chart, there will be initially higher risk will be there.

Then depending upon the activities given in that particular area, we can see that the risk will be reducing. First one is, like insurance, then building codes, then zoning, flood zoning, then levees, then contingency response plans, outreach, then there will be the risk. Considerably we can reduce through various plans as shown here.

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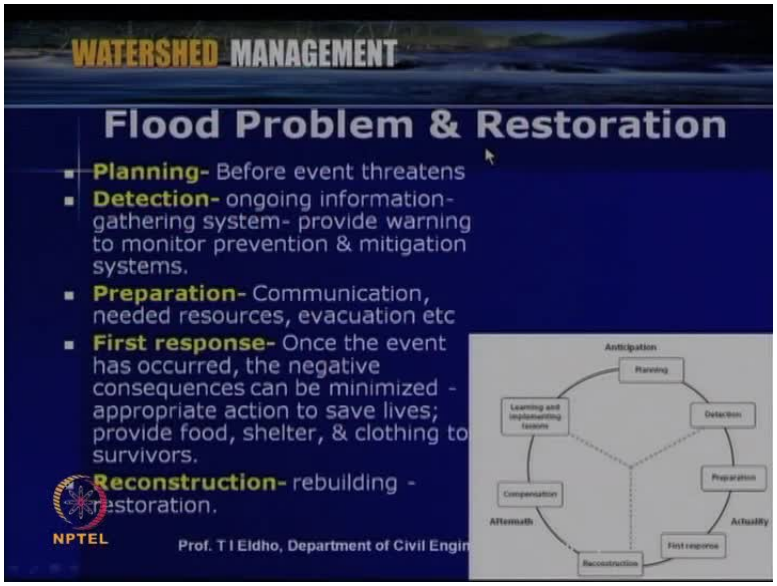
Then, what are the uncertainties associated with the flooding problems or flood risk management is concerned. In flood damage- reduction planning, uncertainties include future hydrologic events, whether the rainfall is going to continue, when the next high hydrologic events can takes place.

Then stream flow and rainfall, then choice of distribution and values of parameters, then simplified models of complex hydraulic phenomena like geometric data, the misalignment of structures, material variability and slope and roughness factors etcetera. Then, relationship between depth and inundation damage. We can identify this depth and inundation damage relationship through structural values and locations and how the public will respond to a flood. Then structural and geotechnical performance, when



subjected to floods. What are the structure related issues for the various structures like bridges buildings etcetera, and then what are the foundation related problems like that?

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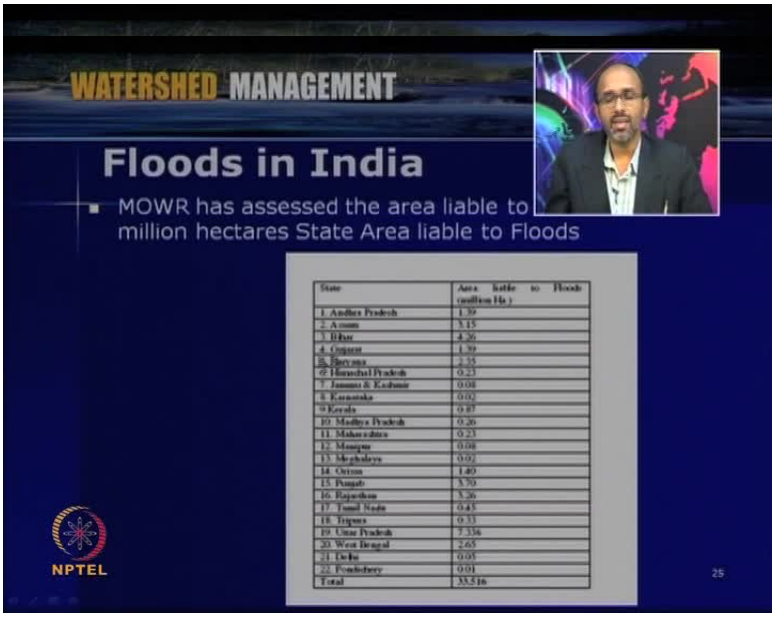
Now, when we discuss about the flood problem and then, we have to look into what is the restoration measures which we can adopt. This, we can have it in about 5 steps. First-one is, we have to prepare appropriate plans. That is in anticipation; flood measures plans we have to develop. That is, before the event returns, then we can go for detection like through warning, flood warning or flood forecasting and warning.

Like detection, ongoing information through that we can gather and provide warning to monitor prevention and mitigation systems and third-one what kind of preparation we can do? so that, once flood warning is put off, we can communicate with the people we can communicate and take appropriate evacuation measures.

Then what will be once the flooding starts or flooding takes place? What will be the first response? Like actually, what is happened in first response? That is, once the event has occurred the negative consequences, how we can minimize it?

And then, what kind of action can be taken to save lives. Then how we can give, provide food, shelters and clothing to the survivors so that, the appropriate response can be there.



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Then once the flood is receded, then what we have to look into is: How we can compensate for the people, or how we can reconstruct what has destroyed, like rebuilding, restoration. This way, we can go through an appropriate cycle, as far as flood problem and restoration is concerned.

Now, before closing for today, let us look at some of the important aspects. What are the flooding problems in India, and then what kind of measures are taken to reduce this flooding?

As I mentioned earlier, in India also flooding occurs in almost all rivers. Then the reasons are, some of the common reason which we discussed earlier, like heavy rainfall, inadequate capacity of rivers, then inadequate drainage network.

And then,sometimes heavy rainfall or climate change effects. These are all causes, the floods in India, then in northern India, especially wherever Himalaya regions, ice jams or landslides block the streams. Then the Eastern regions, like typhoons and cyclones. These all cause the floods in, as far as India is concerned.

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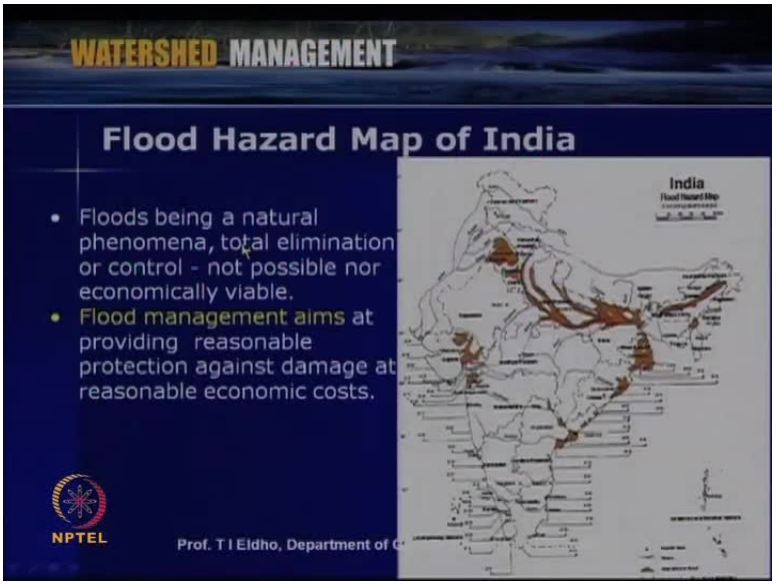

Then excessive rainfall combined with inadequate carrying capacity of streams resulting in over spilling of banks is the main cause of flooding in a majority of the cases in India. Then, if you look into an assessment by ministry of water resources, we can see that about thirty five million hectares of the land is liable to floods, this is about more than about ten percent of the of the land.

Here, as per ministry of water resource website, it is given, state wise how much area is liable to flood. For example, Andhra Pradesh, one point three nine million hectares. Like that, state wise- this distribution is given, which the area, which are liable to floods.

As we were discussing, we cannot control the flood totally, but what kind of measures can be taken, like structural measures or nonstructural measures, to reduce the effect of flood ?

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Floods being a natural phenomenon, total elimination is not possible. That we have to look into, flood management which aims at providing reasonable protection against damage at reasonable economic costs. This is a flood hazard map, as far as India is concerned. Wherever this red color is there, since these are some of the areas highly vulnerable to floods, especially in the Himalayan regions.-Himalayan rivers like Ganges, Brahmaputra river and then Mahanadi river basins, due to various process as we discussed.

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Then in India, the systematic planning for flood management commenced with the launching of National programs early in 1954.In last fifty six years, government of India and many other state governments are doing many measures to reduce the flood hazards.

During the last 58 years, different methods of flood protection, structural as well as nonstructural have been implemented in different states. Structural measures like storage reservoirs, flood embankments, drainage channels, anti-erosion works, then channel improvement works, detention basins etcetera were undertaken on large scale wherever flood prone areas are there.

And then nonstructural measures like- you have flood forecasting, flood plain zoning, flood proofing, disaster preparedness were implemented or a large number of agencies were established in the last two to three decades.

Now, we are having appropriate flood forecasting warning system, based upon the forecast by Indian meteorological department and then the satellite data which is provided by Indian space research organization.

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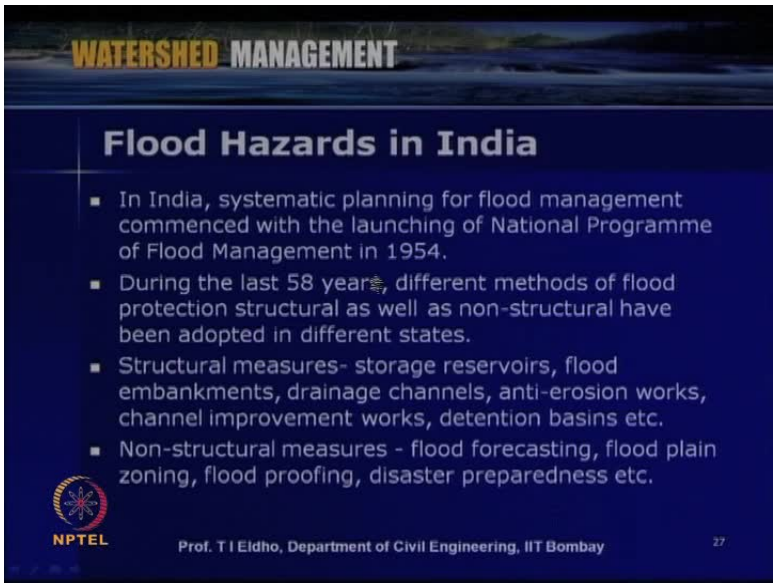
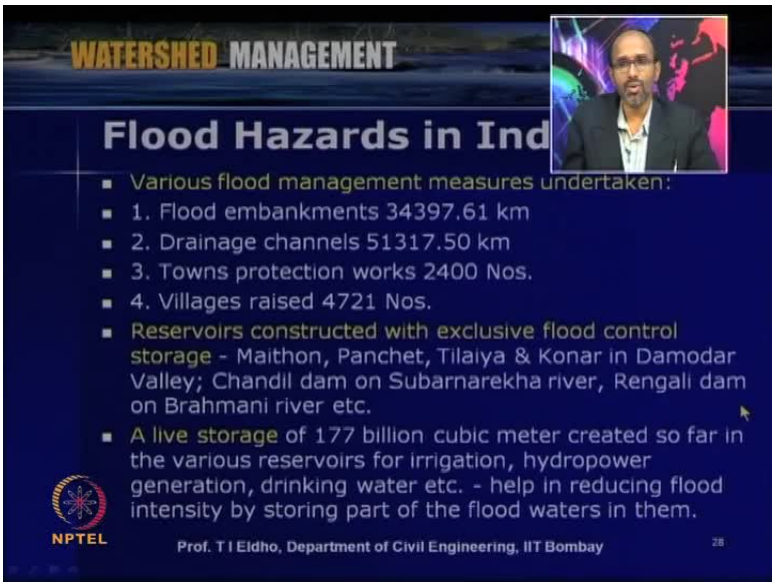


Like that, now number of nonstructural measures are also under taken. As per the ministry of water resource website, some of the various flood management measures undertaken in last few decades include flood embankments, about thirty five thousand kilometers flood embankments were constructed then drainage channels for fifty one thousand three hundred and seventeen kilometer.

Then town protection works about two thousand four hundred numbers, then villages are raised, that it will be protected from the floods. It is about four thousand seven hundred, then reservoirs are constructed with exclusive flood control storage. As we discussed earlier, some of the reservoirs like Maithon Panchet, then Konar in Damodar Valleys, then Chandil dam on Subarnarekha and Rengali dam in Brahmani river.

These are mainly constructed for flood control measures, and then last 6 decades, a large number of dams were constructed so that the live storage of one seventy seven billion cubic meter created. So far, in the various reservoirs for irrigation hydro power generation drinking water etcetera.



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These also help indirectly, in reducing the flood intensity by storing part of the flood water. These are some of the measures taken by government of India and various state governments.

As far as flood hazards is concerned, the flood management measures undertaken so far has provided reasonable degree of protection to an area about sixteen point five million hectares throughout the country.

Area benefited is listed here. Then length of embankment is about thirty four thousand three forty seven kilometer, then length of drainage channel then town village protected. as we discussed earlier.

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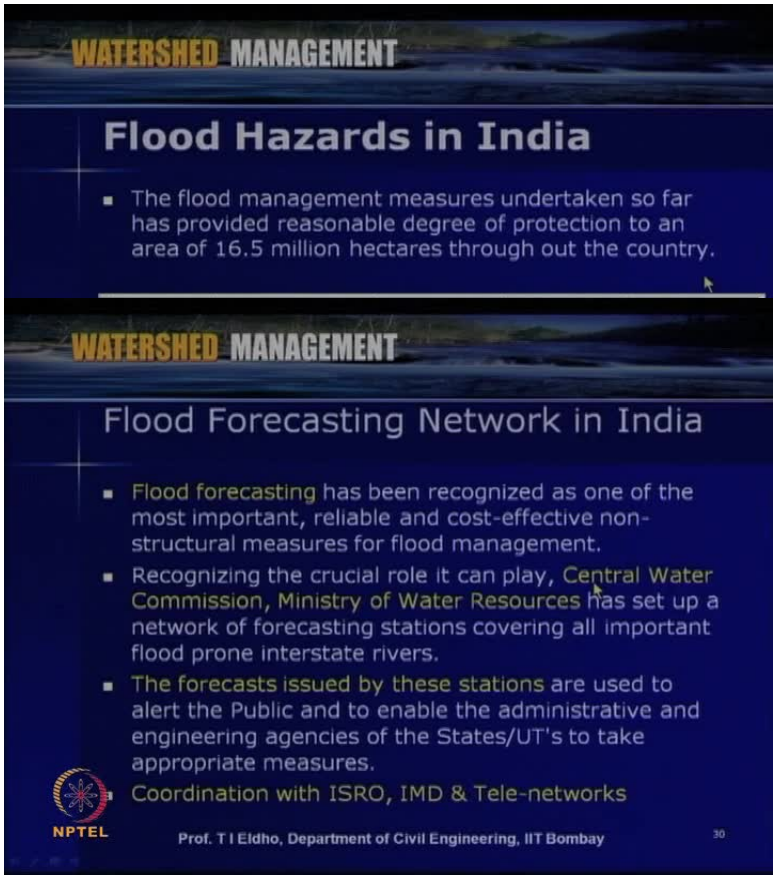
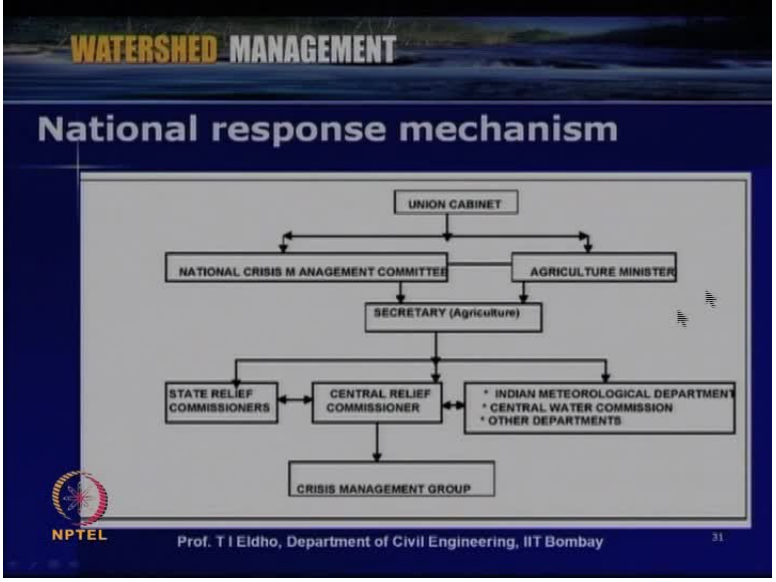


These are some of the effects of this flood and protection measures adopted by government of India and other state governments.



Then also, we are having an effective flood work forecasting system. This has been recognized as one of the most important aspect, reliable and cost effective. Then, recognizing the crucial role it can play, central water commission ministry of water resources has set up a network of forecasting stations throughout the country, covering all important flood prone areas.

Then the forecasts issued by these stations are used to alert the public and enable the administration and other agencies so that appropriate measures can be taken.

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These are all done in collaboration, or in coordination with Indian space research organization, Indian meteorological department and various telecommunication networks so that appropriate warnings will be given.

As far as national response mechanism, for as far as flood is concerned, first the apex body is union cabinet and under union cabinet national crisis management committees like national disaster management committees are there, related to floods. And then agriculture ministry, then ministry of water resource, ministry of environment and secretaries. They are all coming together as far as, this apex body is concerned and then, various states relief commissioners are there, then central relief commissioner will be reporting. They will be, state relief commissioner will be reporting to central relief commissioners.

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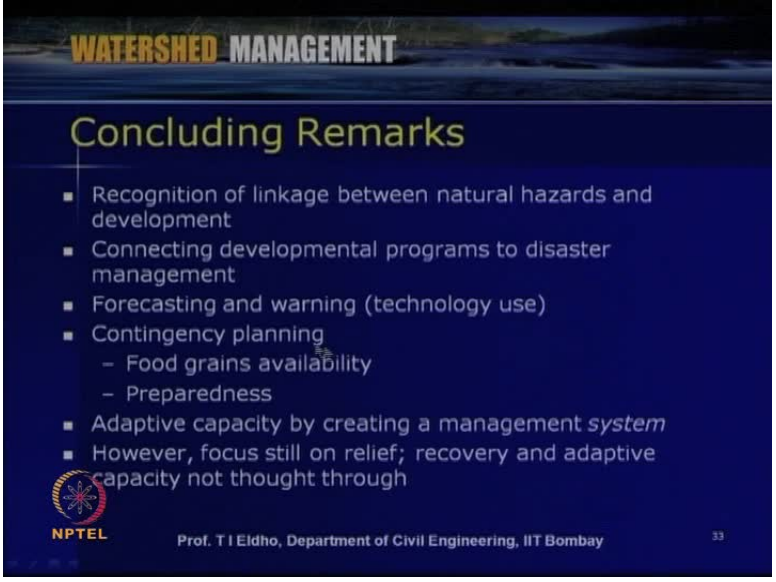

Then agencies like Indian meteorological departments, central water commission and other departments all come together. That way, there is, we are having a crisis management group under national disaster management authority. This authority looks after what kind of mechanism to be done or what kind of response should be done for the given flooding problem. Say for example, in Andhra Pradesh, cyclone hazard mitigation project. Last few years, this has been undertaken and then hazard mitigation studies were done, then Indian meteorological department early warning capacity through Doppler radar were implemented. The infrastructure creation and restoration, then flood drains and embankments studies were done. Appropriate measures were taken. Then road restoration, storm shelters, like what kind of things can be done.

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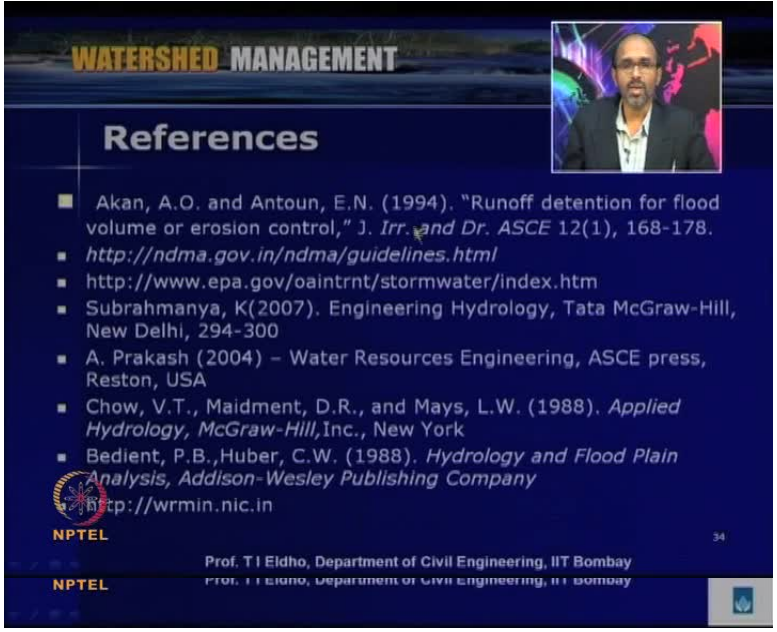
Appropriate studies, through appropriate studies this can be done. Finally, to conclude, flooding is a major problem. We have to recognize the linkage between the natural hazard, like flood and then development or urbanization effects, then connecting the development programs to disaster management, that is very essential.

Then forecasting and warning system. Appropriate forecasting, warning systems are very essential. Then, we have to go for contingency planning, like food grain availability preparedness, adaptive capacity by creating management systems like that. Appropriate authority and appropriate system should be made so that flood management is possible in an appropriate way.



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These are some of the important references used in for today's lecture. Before closing, few questions. One is tutorial questions; critically study the flooding problems in India.

What are the measures taken by government of India and other state governments to reduce flood impacts how we can have better flood control measures on watershed or river basin scale?

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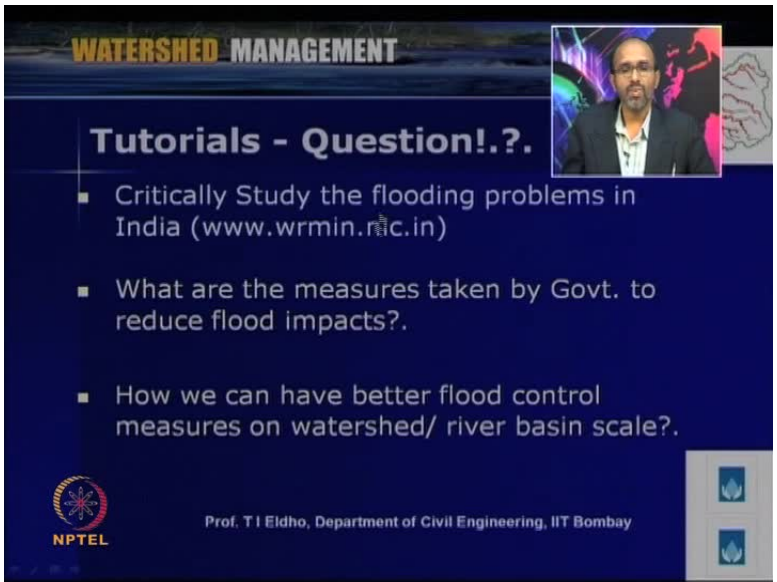
Few self-evaluation questions, describe flood and related problems. Ilustrate short term and long term flood damages. Discuss various flood control measures. Differentiate



between structural and nonstructural measures.

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Illustrate flood control and reservoir operations. Few assignment questions, what are the important causes of floods. Discuss flood forecasting and warning. What are the important ways of flood control management?

Discuss the flood risk management and related issues. These are some of the important questions, which are related to today's lecture. By going through this lecture, you can easily answer these questions.

What we were discussing is flood control and its management. Under the storm water management, this module number eight, we were discussing the flood control and management. With this, module is over. Further, we will be looking to drought management, issues related to watershed management in the next module.

Thank you!