Watershed Management

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Lecture No. # 01

Introduction to Watershed Management

Namaste and welcome to the video course on watershed Management. I am T. I. Eldho, a Professor in the Department of Civil Engineering, Indian Institute of Technology, Bombay, – Mumbai – India. My area specialization is water resources and environmental engineering.

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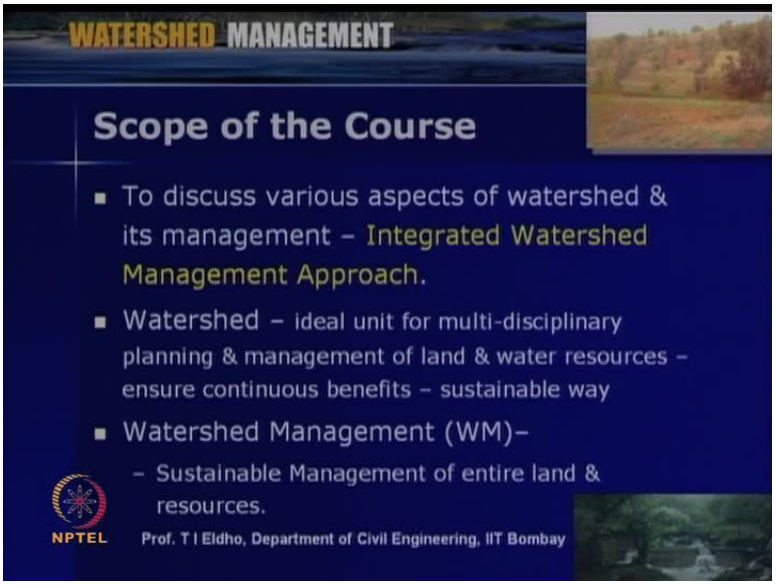

The scope of the video course on watershed management. The main scope is to discuss various aspects of watershed and its management, so, in a holistic way. So, in that way, this course will be discussed in a fashion, which is say so-called integrated watershed management approach. So, we will be discussing the various aspects or the various resources in a watershed in a holistic way.

So, a watershed is an ideal unit for multi disciplinary planning and management of land, water resources, so that the various management practices ensure continuous benefits in

a sustainable way. So, this watershed is a geographical area which we can delineate as per the topography, and that is the basis of the various management practices of the water, land and other resources in that area.

So, when we talk about watershed managements, we will be discussing in the perspective of sustainable management. Sustainable management means all the resources available in the watershed. We will be managing in a way that it will be useful for the present generation and the future generation. Hence, it is the management of all the resources within the watershed.

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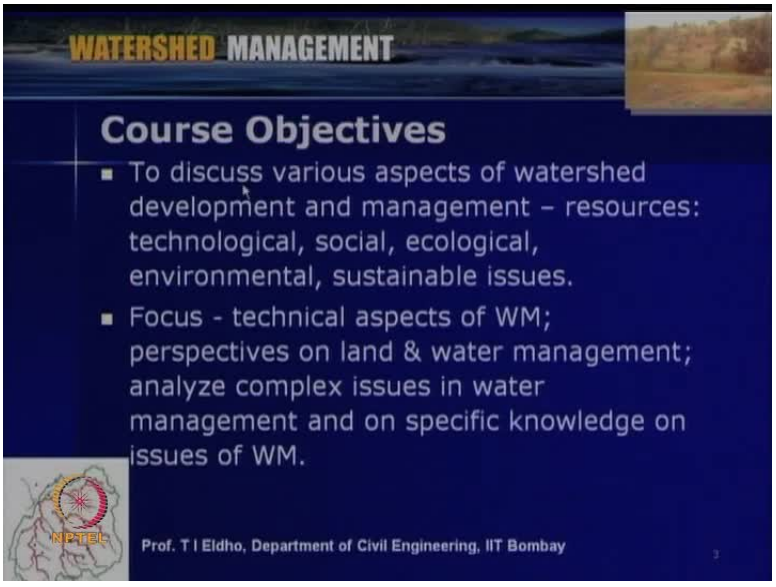

So, now, coming to the course objectives, the various course objectives are listed here - to discuss various aspects of watershed development and management; so, that means the resources within the watershed, it is technological, social, ecological, environmental, sustainable, management issues in a holistic way. So, that is the main objective of this course.

The main focus will be the various technical aspects of watershed management. The main emphasis will be on the perspectives on land and water management. So, we will be discussing the various complex issues within a watershed and analyze the issues, and we will be discussing the specific knowledge related to various issues of the watershed, which we consider and its management in a holistic way.

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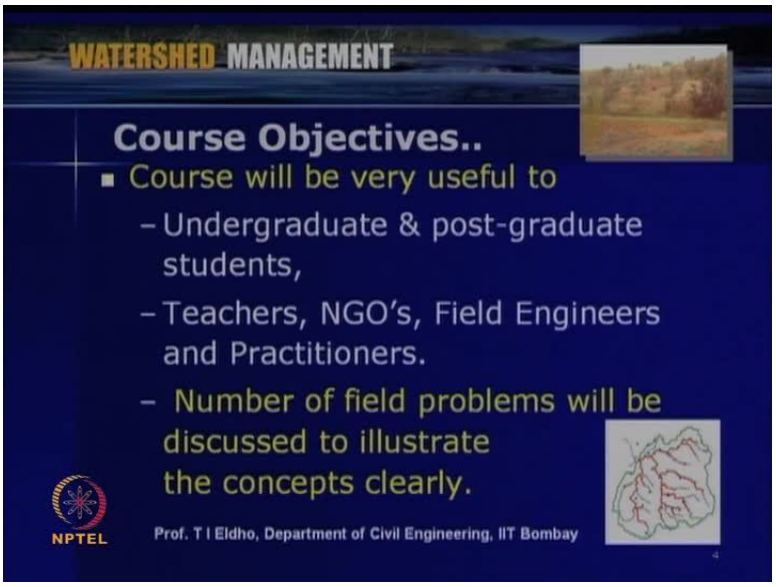

So, this course will be very useful to the under graduates and post graduate students who will be taking watershed management as a course, and water resource engineers, who will be dealing with the watershed and its management. This course will be also useful to various teachers who will be teaching the subject - watershed management, water resource, engineering, agriculture, water management, etcetera, and also it will be useful for non-government organizations, - NGOs - field engineers and practitioners.

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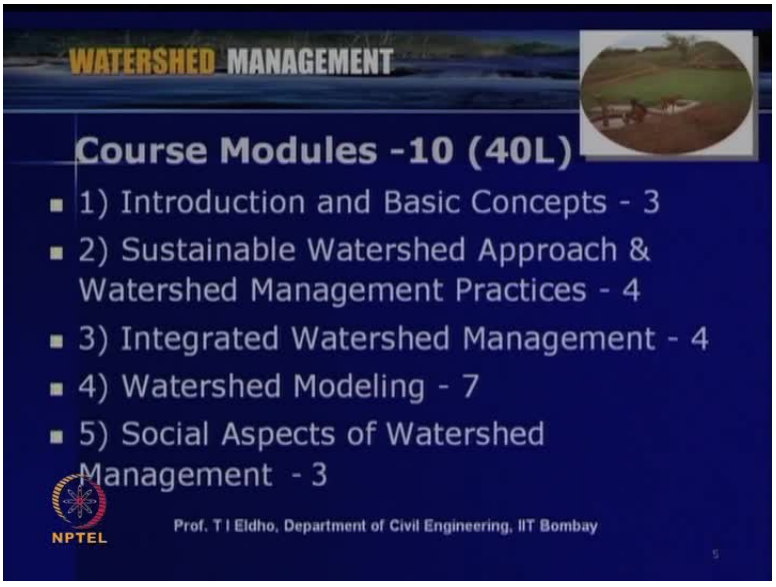

This course includes 10 modules and about 40 lectures and a number of field problems will be discussed in this course to illustrate the concept clearly. So, as I mentioned, there will be totally 10 modules in this course. The modules are listed here and the course will be having 40 lectures. So, the various modules which will be considered in this course include: first one - the introduction and basic concepts; about 3 lectures will be there in this module. Second module on sustainable watershed approach and watershed management practices; 4 lectures will be there in this module.

Third module will be on integrated watershed management; 4 lectures will be there in this module. Fourth module will be on watershed modeling. The various aspects of the modeling of watershed related to watershed water rainfall to runoff and various issues. So, this module will be having about 7 lectures, and fifth module will be on social aspects of watershed management, which you will be having about 3 lectures.

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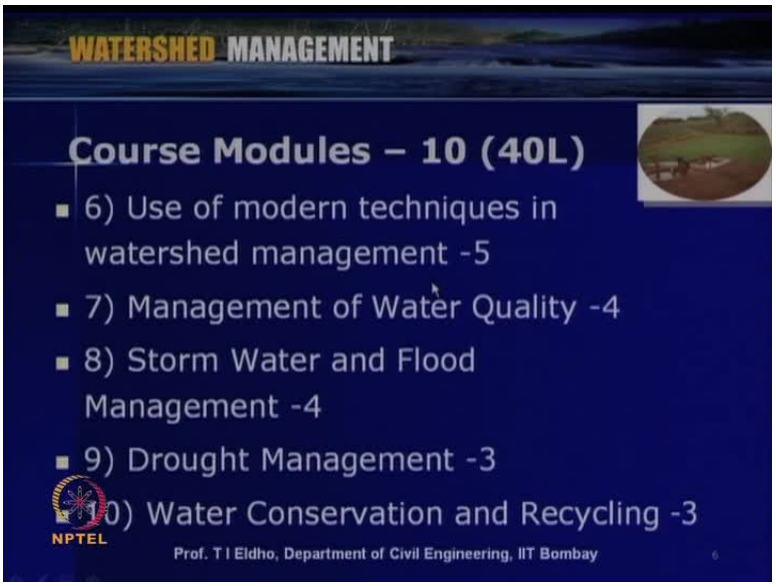

And in the sixth module, we will be discussing about the use of modern techniques in watershed management. We will be discussing about the remote sensing techniques, geography information systems, then computer models, decision support system, etcetera, in this module and this module will be having 5 lectures. Seventh module will be on management of water quality and this module will be having 4 lectures. Eighth module will be on storm water and flood management.

In most of the watershed, the floods and droughts are major issues. So, the flood management will be discussed in the eighth module, and in the ninth module, we will be discussing about the drought management within a watershed and various issues related to the droughts and its management, and the last module we will be discussing about the water conservation and recycling and there will be about 3 lectures in this module.

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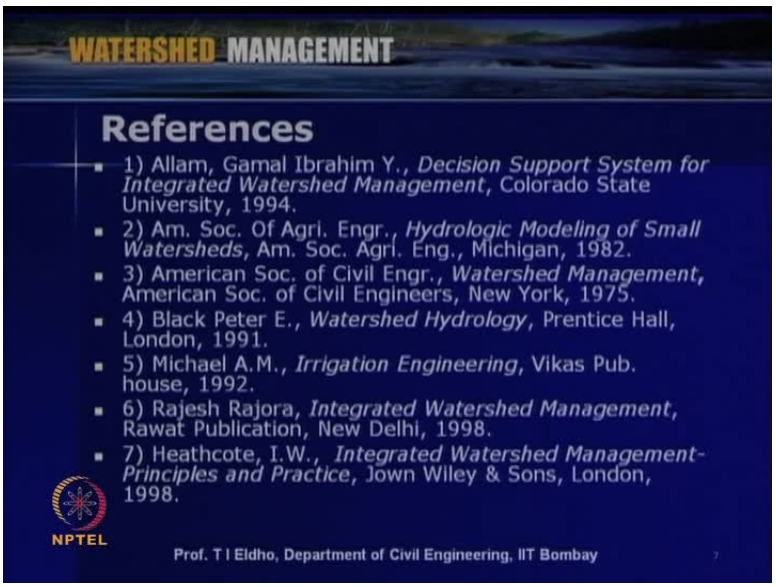

The preparation of this video lecture a number of reference books, journal papers and various internet resources will be used. Some of the important references are listed here which includes decision support system for integrated watershed managements by Allam Gamal Ibrahim; then hydrological modeling of small watershed by American society of agricultural engineers; Watershed management by American society civil engineers and watershed hydrology by black peter; irrigation engineering by Am Michel; integrated watershed management by Rajesh Rajora; then integrated watershed management by heathcote.

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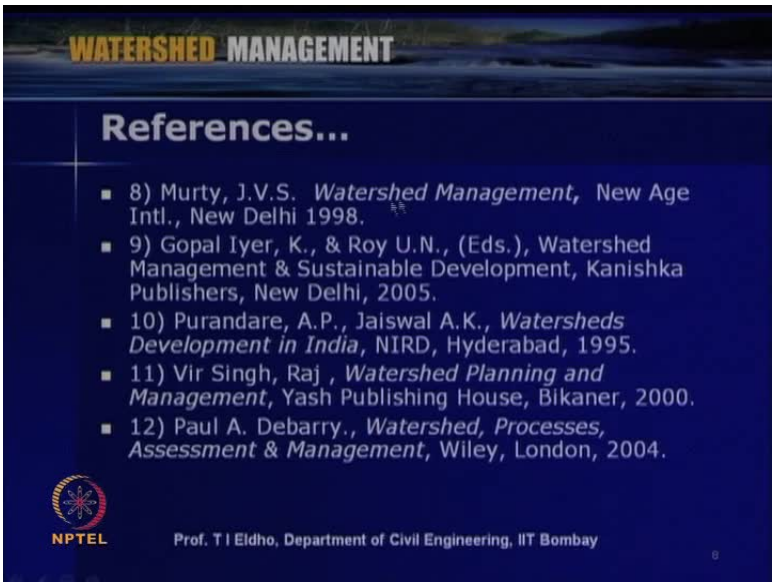

Then watershed management by J V S Murty; watershed Management and sustainable development by Gopal Iyer and Roy; watershed development in India by Purandare and Jaiswal; watershed management planning and management by Vir Singh Raj, and watershed processes assessment and management by Paul A Debarry. So, these are some of the important references which you will be used in the preparation of this lectures, and some other references which will be discussed whenever we will be discussing some issues will be mentioned at appropriate places.

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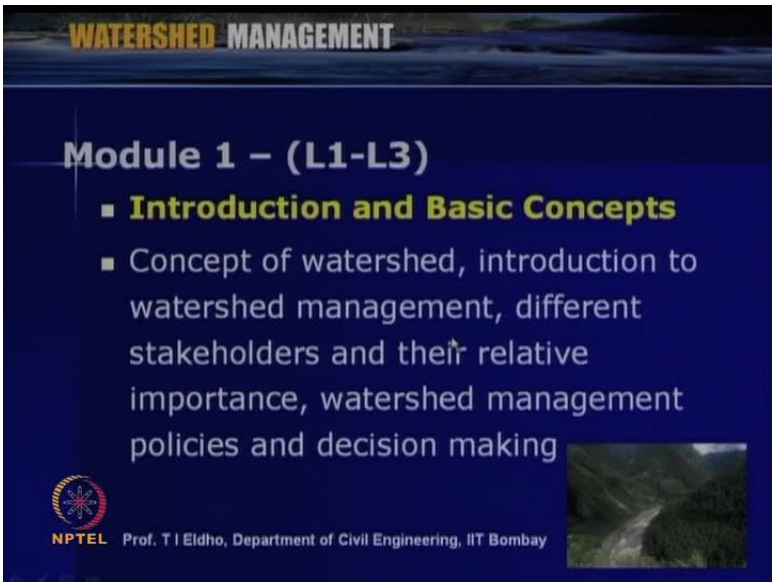

So, today, we will be starting the first module - the module is on introduction and basic concepts. So, in this first module, there will be three lectures, and their contents of this first module will be on the concept of watersheds, introduction to watershed management, different stakeholders and their relative importance, watershed management policies and decision making. So, in this first module, we will be having three lectures, and first lecture, we will be discussing today.

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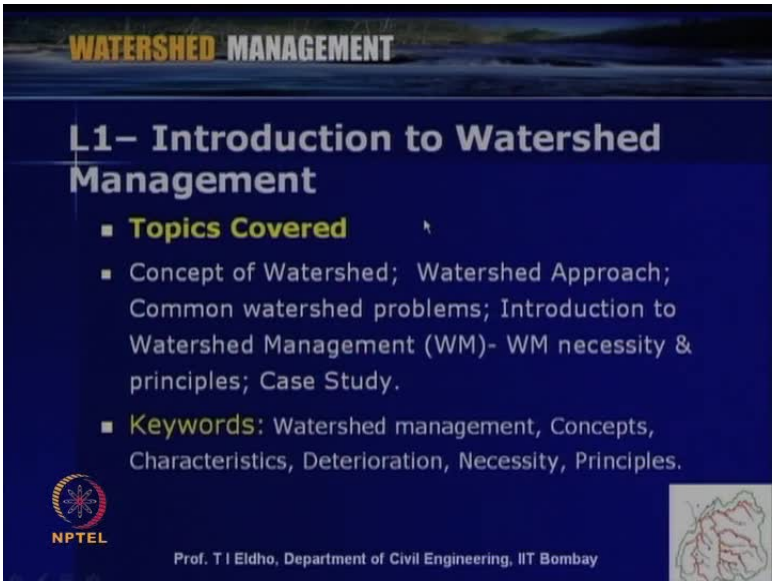

So, the first lecture is on introduction to watershed management. Today, we will be discussing the following topics - the concept of watersheds; Watershed Approach; Common watershed problems; Introduction to Watershed Management - Watershed Management necessity and principles, and we will be discussing a case study with respect to their topics which will be discussing today. Some of the important keywords for today's lectures lecture includes - Watershed management, Concepts, Characteristics, Deterioration, Necessity and Principles.

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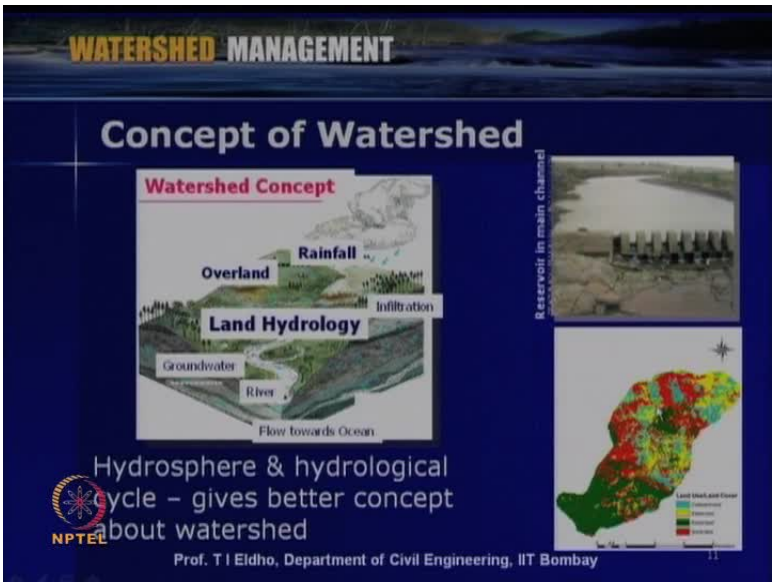

So, first we will be discussing the concept of watershed. So, watershed as I mentioned is a geographical area, which is identified topographically say surrounded by ridges and the water falling on that area will be draining to a single outlet as in a river or a lake. So, when we discuss the watershed in a holistic way, we have to discuss the various issues - what is happening with respect to the land, water and various resources within the watershed.

So, here, this figure shows a watershed. S, this, here there is a ridge and this side another ridge and then you can see a river. So, here, this is the outlet of the watershed. (Refer Slide Time: 09:53) So, you can see that the precipitation falling on this area will be first over the overland, and then, through various streams, - small small streams - it will be join into a main stream and that we can consider as a single outlet as in a river, say for example, this location; so, that is the basic concept of watershed.

So, we can see that here, in this figure, so, this is the outlet of a particular watershed there, a check dam is put so that we can say store sufficient water. The water coming from the river so that we can use this water for various uses within the watershed. So, this figure shows a delineated watershed. So, here, you can see that there will be a major stream and then number of minor streams and different orders of other streams will be there.

So, as you can see that in this watershed, various land use and land cover pattern are shown with various colors. So, you can see the land use just like agriculture land use, then forest land use, then the shrub and various other kinds of land uses are shown in this figure. So, when we discuss the watershed, we have to mainly see the various resources like a land, water, mineral and other resources within the watershed. So, water is an important aspect as for as a watershed is concerned.

So, we have to discuss the watershed management within the perspective of mainly water. So, we will be discussing about the hydrosphere and hydrological cycle within the perspective of this watershed; so, that gives better concept of the watershed.

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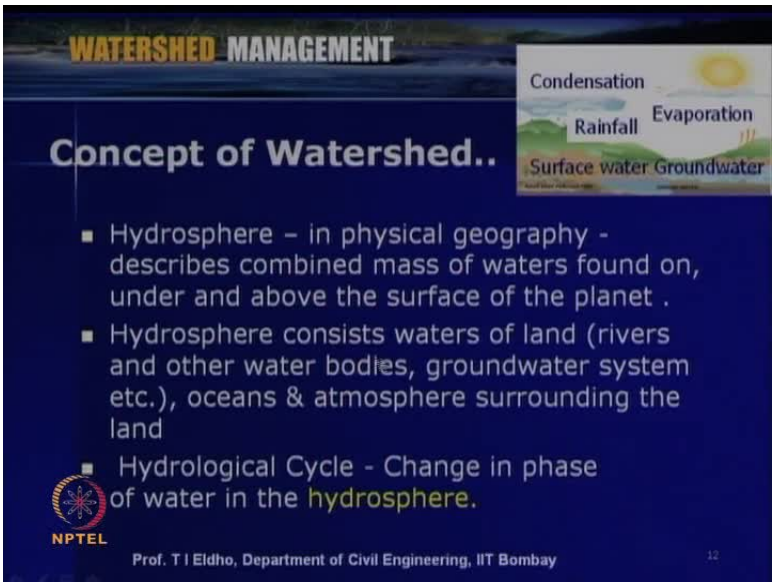

So, as defined here, the hydrosphere in physical geography - describes the combined mass of waters found on, under and above the surface of the planets. So, the hydrosphere consist waters of land, rivers and other water bodies including the ground water system and also the oceans, atmosphere and surrounding the land. So, you can see that when we discuss about the water resources within a watershed, we have to see the surface water, ground water, and then, what is happening to the water resource within the area, within the watershed which we consider.

So, that way, we have to consider the hydrological cycle. So, hydrological cycle means the change in phase of water in the hydrosphere. So, we can see that the precipitation,

water is falling on the ground or the watershed which we consider. So, we initially we are having the run off as overland flow; then that will be joining to the stream so that we are having the stream flow over river run off.

So, then this water will be finally joining to the ocean. So, as a part of hydrological cycle, this water will be evaporated as evaporation or the other forms of changes like transpiration, evaporation and all other forms. So, finally, evaporated water will be condensed, and finally, coming again back to the system, say the watershed which we consider as rainfall and it will be repeated as a hydrological cycle.

So, when we discuss about the management of the water within a watershed, we have to see the various phase changes; what is happening within the watershed like a precipitation to run off; then run off - during that precipitation run off, various processes like interception, then evaporation then infiltration ,finally runoff, say from the outlet of the watershed. So, the various issues related to water we will be considering in a holistic way within the watershed.

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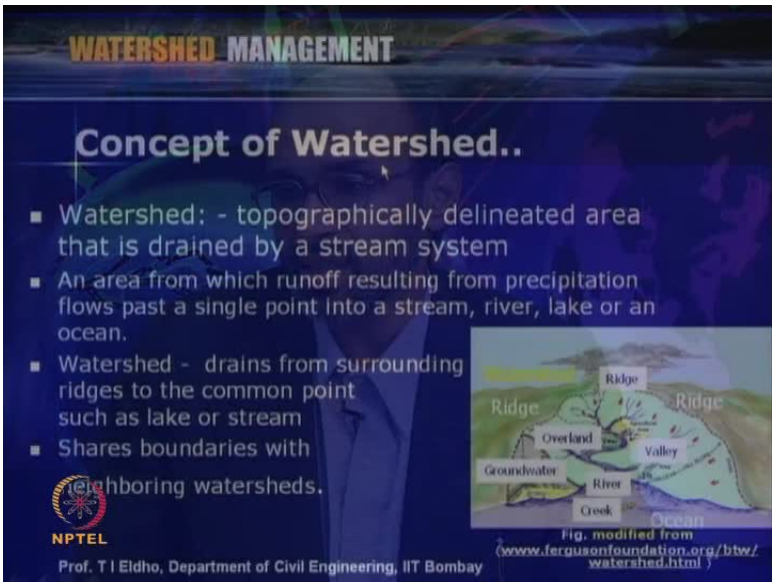

So, coming back to the basic definition of the watershed, so, as I already mentioned, Watershed is a topographically delineated area that is drained by a stream system. So, you can see that a watershed is typically represented here in this figure.

So, this is a ridge and here another ridge and this is a major stream or river. So, whatever the precipitation falling on this watershed area, it is transformed to run off, and finally, that will be joining coming to the river and that we can consider as the outlet of this watershed. So, this watershed is an area from which run off resulting from precipitation flows past a single point into a stream as shown in this figure into a stream, river, lake or it can be to the ocean.

So, the water falling on the watershed as precipitation, it can be rainfall or it can be snow fall so that drains from the surrounding ridges to the common points such as lake, stream. So, you can see that when we consider the geographical area of the watershed, this area we are delineating as a watershed; so, it is of course bounded by other watersheds.

So, you can see that this is the watershed which is we now consider in this case, but surrounding this side, another watershed; this side, another watershed. So, like that, the watershed which we consider shares the boundaries with a neighboring watershed. So, we are separating the watershed as a scientific unit for the various resource management which we consider. So, that is the basic concept of watershed management.

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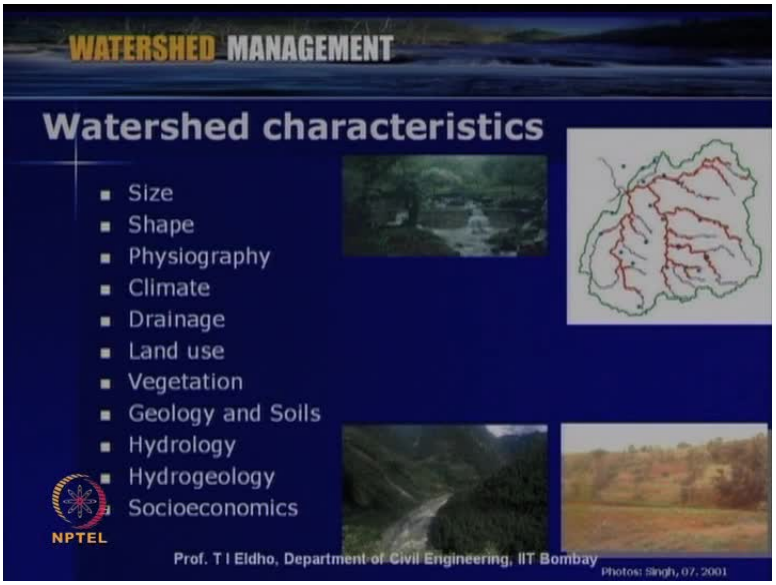

So, now, before going to further details of the watershed and its management, we have to understand what are the basic characteristics of a watershed since the watershed

management practices depends upon the characteristics. So, we should have a fundamental understanding of the characteristics of the watershed.

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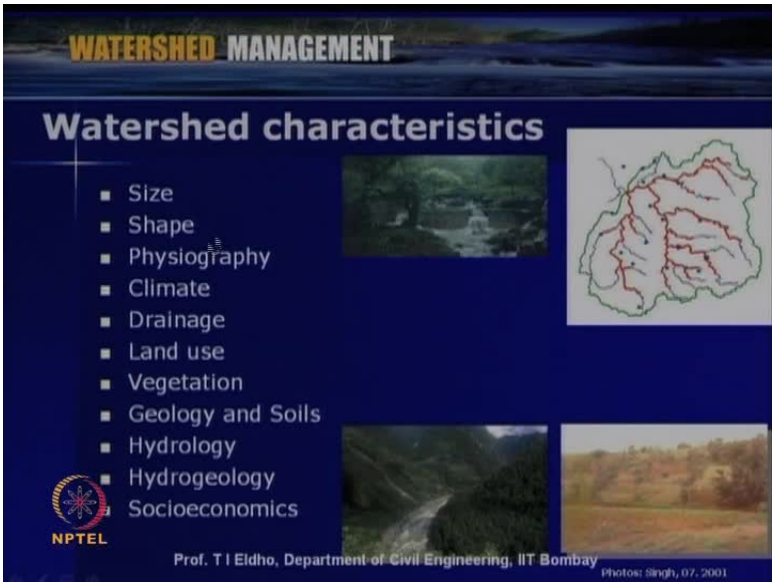

So, some of the important watershed characteristics, I have listed here – so, first one is size of the watershed; second one is shape of the watershed. So, size means it can be larger watershed or a smaller watershed depending upon the area which we consider; shape means generally naturally it will be irregular shape. So, shape can be this a broader shape or a elongated shape or a narrow shape; so, different shapes can be possible.

Then third important watershed characteristic is the physiography or the physical geography. So, you can see that say how the land is changing whether it is the watershed considered having hills or the plain area or sloppy area like that; so, the physiography is very important.

Then some other important characteristics include climate. So, as I mentioned, we will be discussing about the various resources within the watershed. So, one of the important resources is water.

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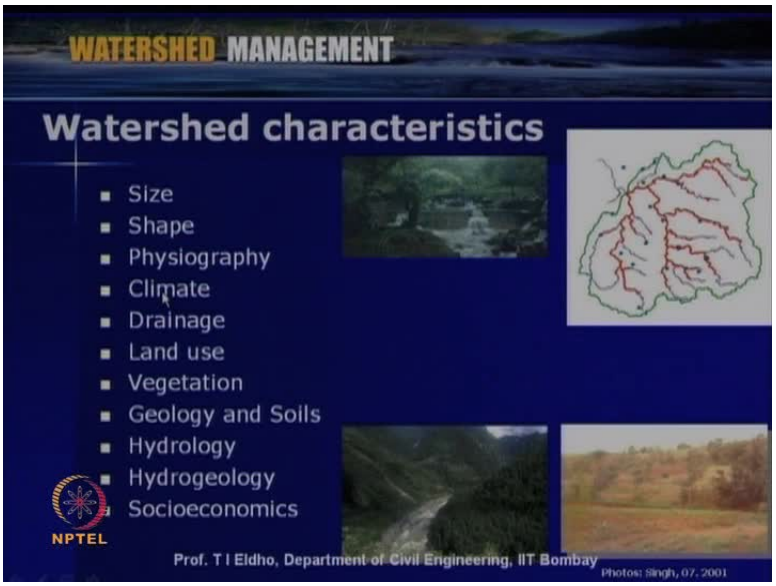

So, climate issues like how is the rainfall pattern within the watershed; how is the temperature pattern, temperature changes and say rainfall to run off, how the changes. So, all those issues will be discussing in this climate issues related to watershed.

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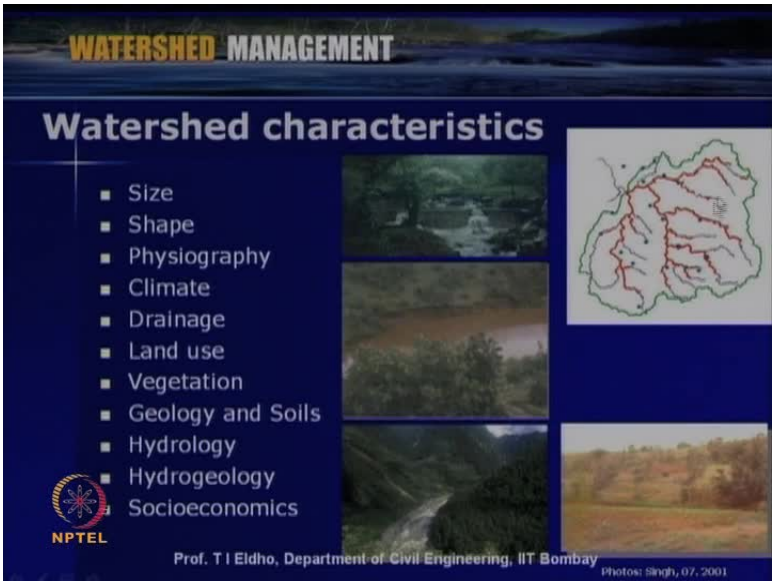

Then the drainage system – so, as you can see in this figure, so, the, for the considered watershed the rainfall to run off process is taking place through first overland and then to the channels. So, the drainage system is a major factor depending upon that the water

moves through the watershed which we consider. So, the drainage system needs pattern its characteristics is very important.

Then of course another important issue is the land use. So, how we are using the available land for the various management of the resources like the agriculture practices and other industrial uses. So, land use is very important, so, how much percentage is for us; how much percentage for agriculture purposes; how much percentage for the industrial purpose.

So, like that, the land use is a major issue. Then how much is a forest in the watershed. So, vegetation is an important issue in most of the watershed management practices. Then another important watershed characteristic is geology and soils. So, you can see that the various resources management taking place within the watershed which we consider depends upon the soils and then the geological aspects. Then of course, some other important characteristics like hydrology; so, that is related to the climate issues.

So, like how much rainfall is there within the watershed average annual rainfall. So, accordingly, we will be going for various management practices. So, hydrology of the watershed is important. Then hydrogeology – so, generally for the available water, we have to consider surface water and ground water. So, the ground water depends upon the various hydrogeological characteristics. So, the hydrogeology is an important issue.

And then, finally, another important issue as for as watershed characteristics is concerned is socio-economics. So, for the holistic development of the watershed area which we consider, we have to see the socio-economics of the people residing within the watershed. So, we have to study in detail how is the socio-economics of the watershed area which we consider. So, these are some of the important watershed characteristics which we have to consider before going for any watershed management practices. So, all these various characteristics we will be discussing detail in various lectures.

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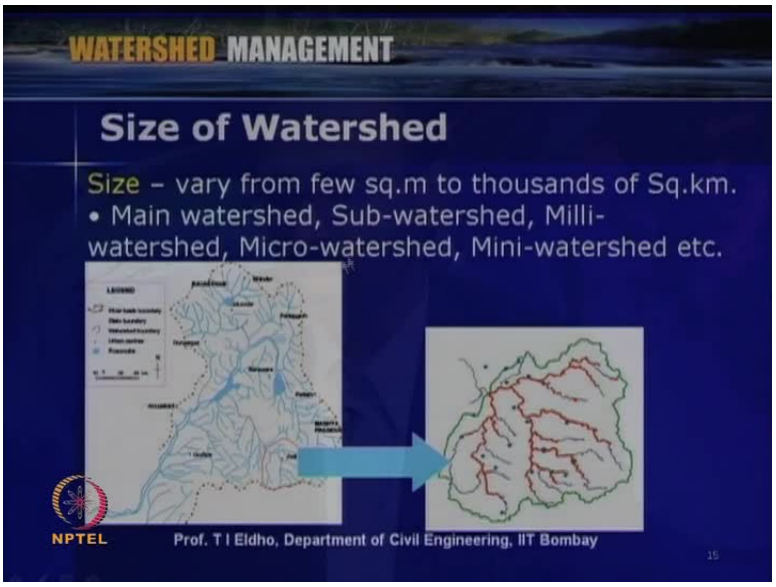

So, before going to other issues, so, let us initially look into the size of watershed. So, other than other characteristics, we will be discussing the other characteristics like a shape physiography and other characteristics will be discussing in other lectures.

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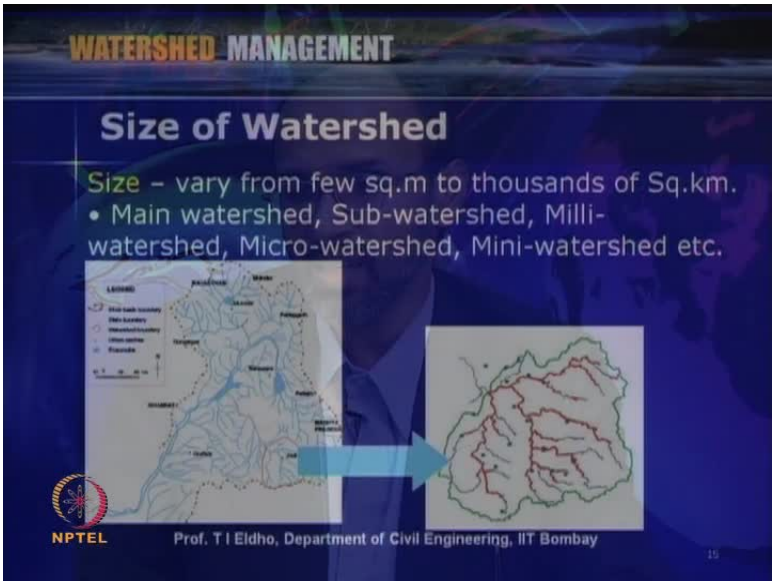

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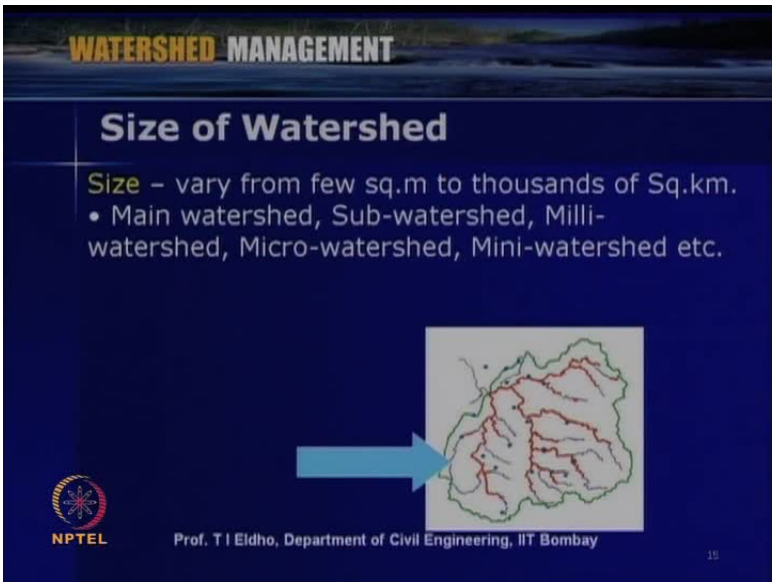

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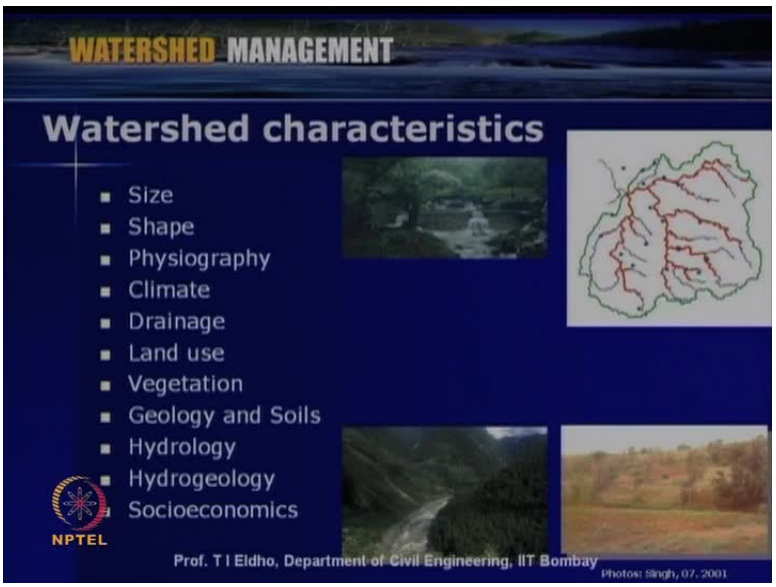

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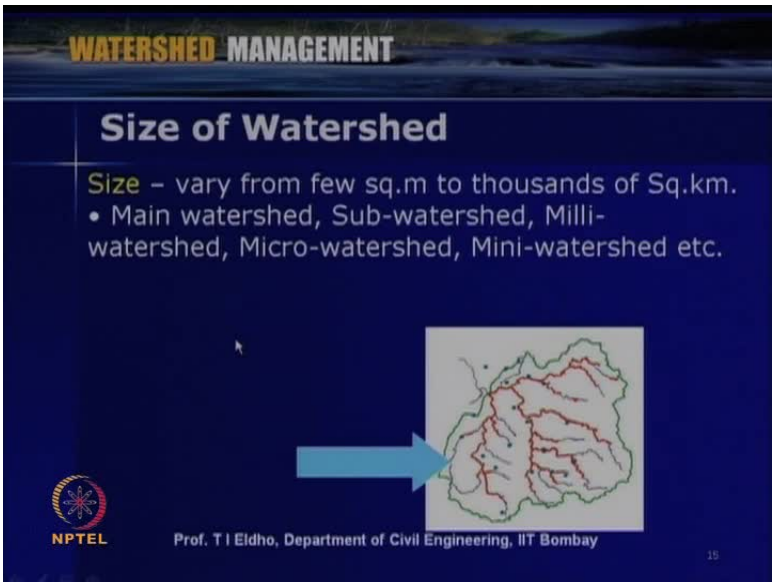

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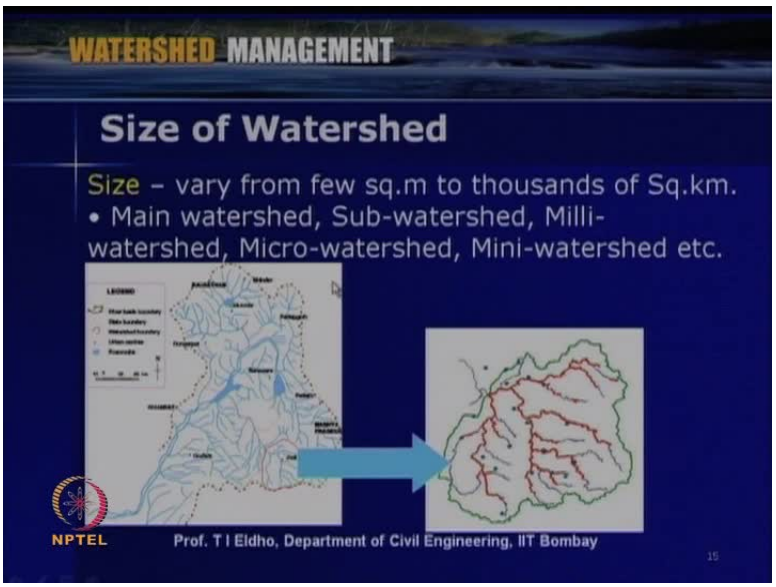

So, today, let us have a brief discussion on the size of the watershed. So, when we go for watershed management practices, the size is important whether there is a very large watershed or a small watershed. So, a watershed size can vary from few square meter to thousands of square kilometer. So, as shown in this slide, there can be major watershed of thousands of square kilometer, and then, depending upon the drainage system, the orders of various streams we can further set consider this main watershed into sub watershed. So, say for example, this is the main watershed; then this is a sub watershed.

So, the sub watershed considered is a part of this watershed. So, we can start the various management practices by considering as a sub watershed also, and then, depending upon the area of the watershed, we can further classify milli watershed, micro watershed or mini watershed considering the area, where small watersheds, very small watershed, like that for the given major watershed.

So, as I mentioned, when we consider the watershed, for the considered watershed, there will be other watershed will be there as boundaries. So, say for example, if you consider this watershed, this is the ridge of this watershed and then this is a major stream and other minor streams of different orders will be joining to the major stream. So, this is the watershed which we consider, so, which is a sub watershed of the main watershed which we consider here.

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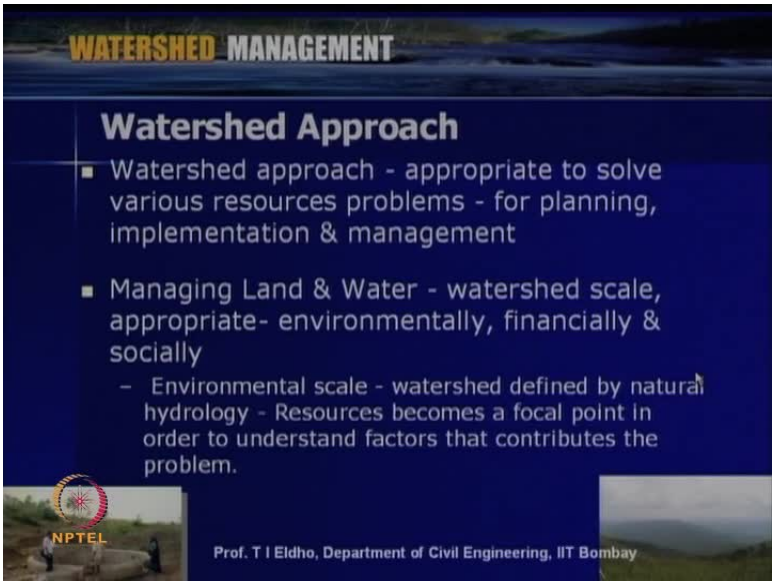

So, now, what we have discussed is the concepts of watershed. So, we have seen that we have to consider the important watershed characteristics. It is very important before considering any management practices as for as the watershed which we consider. So, now, we will discuss about the watershed approach. So, as we have seen, this watershed is a scientific area, which is delineated based upon the topographical features of the area which we consider. So, the watershed area is very appropriate for various planning, management, implementation and the further sustainable development of the area is concerned.

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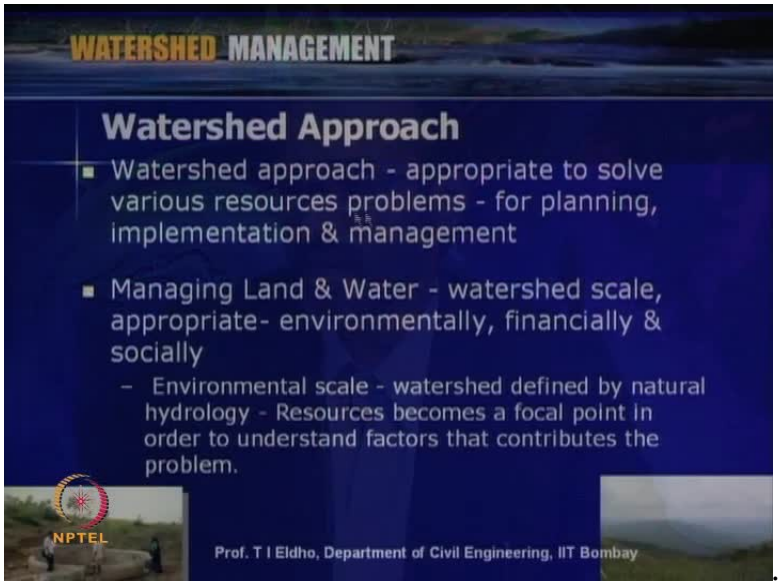

So, watershed approach – here, the watershed approach is appropriate to solve various resources problem, whether the land which we consider, the water we consider or various other resources which we consider for planning, implementation and management. So, as we discussed, when we consider the watershed, so, on a watershed scale, it is much easier to manage the land and water so that we can manage our system in a sustainable way in a better environment friendly way so that we can have better management financially as well as socially.

So, here, when we are discussed about the watershed management, the environmental issues are very important for the considered area. So, when we consider the watershed management on an environmental scale, the watershed defined by natural hydrology as an eco system and whatever the resources within the watershed becomes a focal point in order to understand the factors that contributes to the environmental problem or the ecological problem which we consider for the watershed considered.

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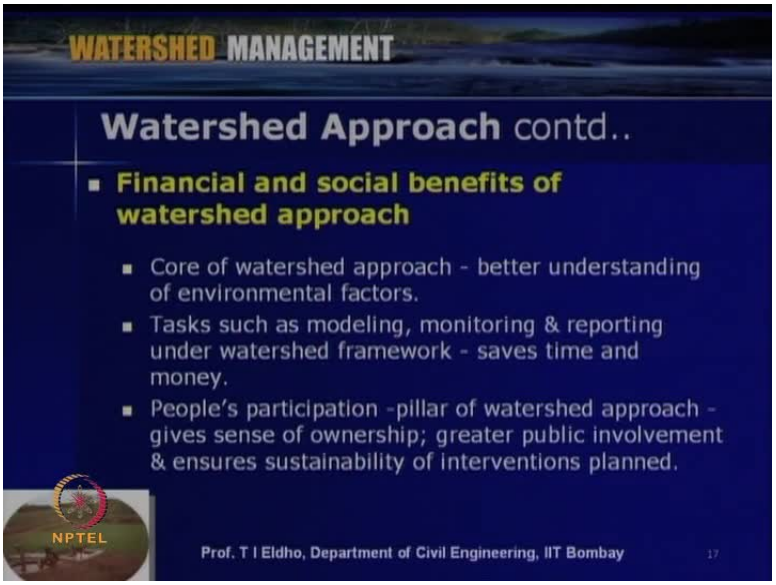

So, when we consider the watershed management, it is the issue of sustainable development and management; so, we have to discuss the various issues like a financial issue, social issues, so that we have the optimal benefits for the area which we consider. So, the core of watershed approach is better understanding of various factors or various resources within the considered watershed.

So, the various when we go for watershed management practices, we have to consider various issues; so, we may have to go for modeling of various system within the watershed. Then monitoring the system when we implement and then reporting under a watershed framework. So, we go in a scientific way as far as the watershed management is concerned so that we can save time and we can utilize the available resources or available money in a better way so that optimal management is achieved.

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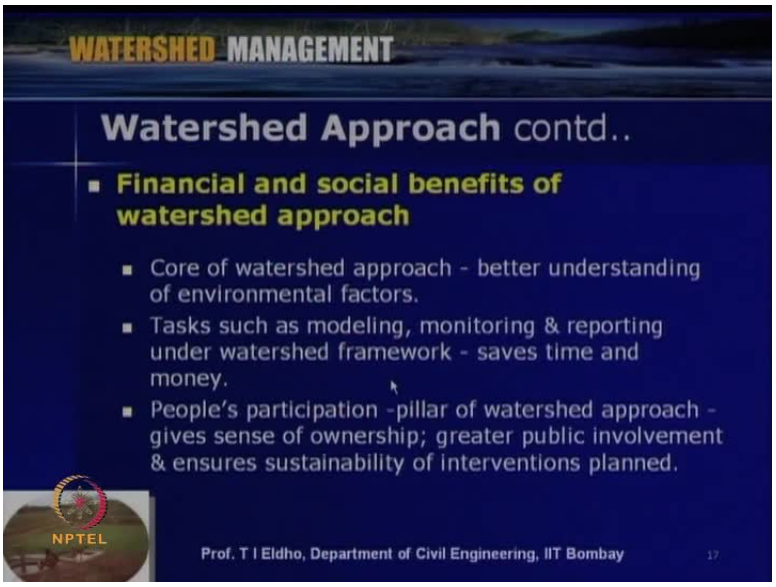

So, when we discuss about the watershed management, one of the important issue is of course the people participations. So, the people residing in that watershed are very important. We have to consider their various issues which are facing for the considered watershed. So, people participation is the pillar of watershed approach so that the various management practices which we consider for the watershed, that is, for the people and for the holistic development of the area.

So, when we consider the people participation, it gives a sense of a ownership; so, greater public involvement will be there and that ensures sustainability of the interventions which we planned within the watershed management perspective. So, when we discuss about the watershed management, we have to see the various issues or various problems faced by a watershed.

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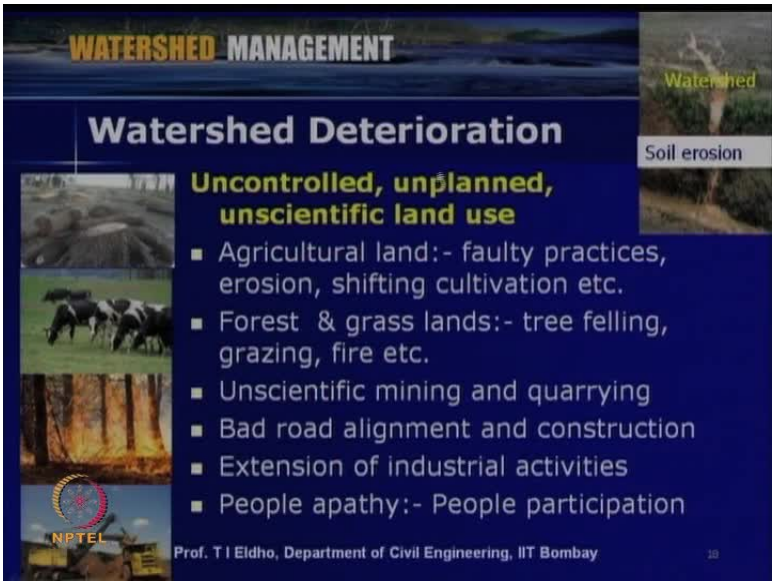

So, here, in the slide, now we will be discussing about the watershed deterioration and watershed related problems. Generally in a watershed, the various problems or so-called deterioration of the watershed happens. When, various project implementations or various activities are happening within the watershed in an uncontrolled unplanned and unscientific way.

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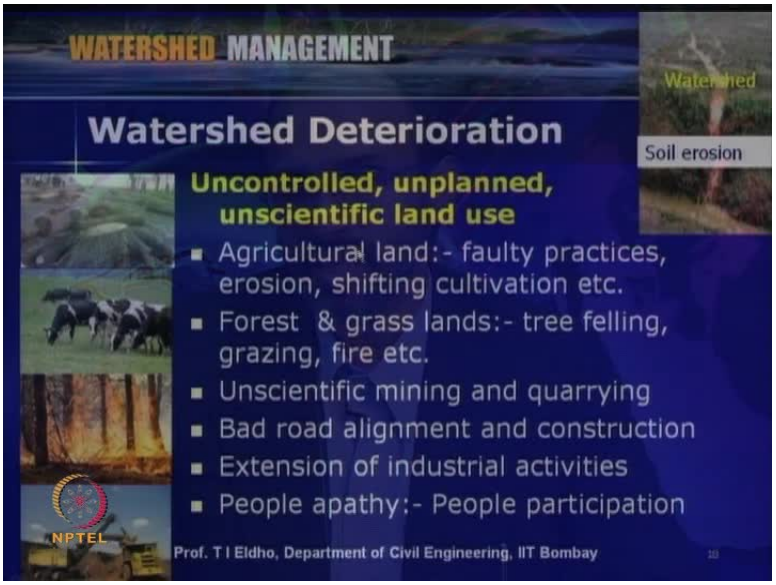

So, generally what happens is uncontrolled unplanned and unscientific land use. That is a major issue generally as for as a watershed is concerned. Say for example, if we consider the agricultural land within the watershed, then the various practices followed by farmers

if they are not scientific if they are not appropriate for the land or the watershed which we consider, then there will be problems or deterioration happens to the watershed.

Then watershed erosion like due to the various faulty land management practices, there can be soil erosion and then the top fertile soil will be eroded away from the watershed. So, that will make the soil unfertile. Then some of the issues like a shifting cultivation by the farmers. So, that also can be an issue as for as agricultural land is concerned.

Then other resources like forest, land and grass lands are concerned, there can be uncontrolled tree felling and there can be issues like a forest fire. So, that can lead to reduction in the forest area for the considered watershed, and then, grass land is concerned, grazing is done without appropriate management practices. Then the grass land will be reduced and then grass will not be available for the cattle; so, that can be an issue.

Then other resources like a minerals and stones like others resources, then the issues can be unscientific mining and quarrying; so, that can lead to watershed deterioration. Then as far as various construction activities which can take place within a watershed like bad road alignments, then various construction activities which are not done in a scientific way.

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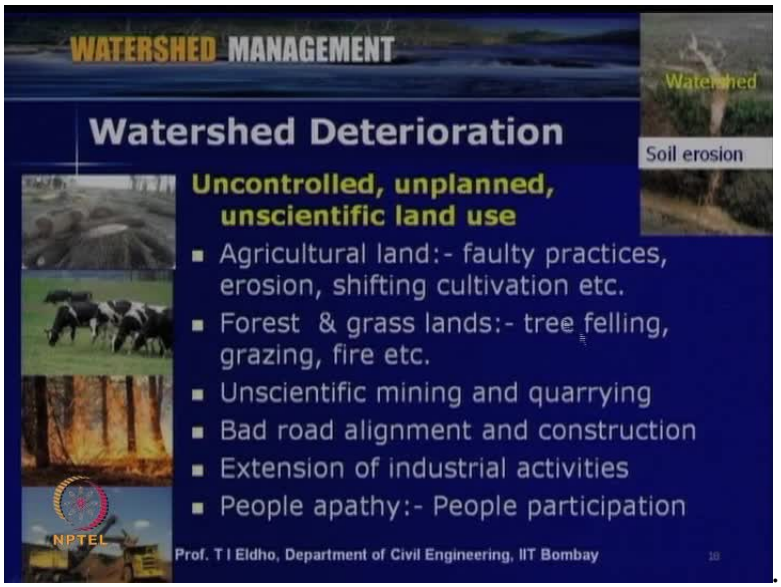

So, these all can lead to watershed related problems and that can lead to watershed deterioration. Then wherever industrial activities are there, so, if the industrial activities are not planned properly, then that can also lead to deterioration of the watershed. Then another major issue as far as a watershed is concerned, it is so people are not concerned what is happening in their locality or in that watershed.

So, as I mentioned for the appropriate management of watershed people participation is very essential. So, people should feel that the various developmental activities taking place within the watershed is for the development of that area and for the betterment of the people in that area. So, people should actively involve in the various watershed management implementations and maintenance of the system.

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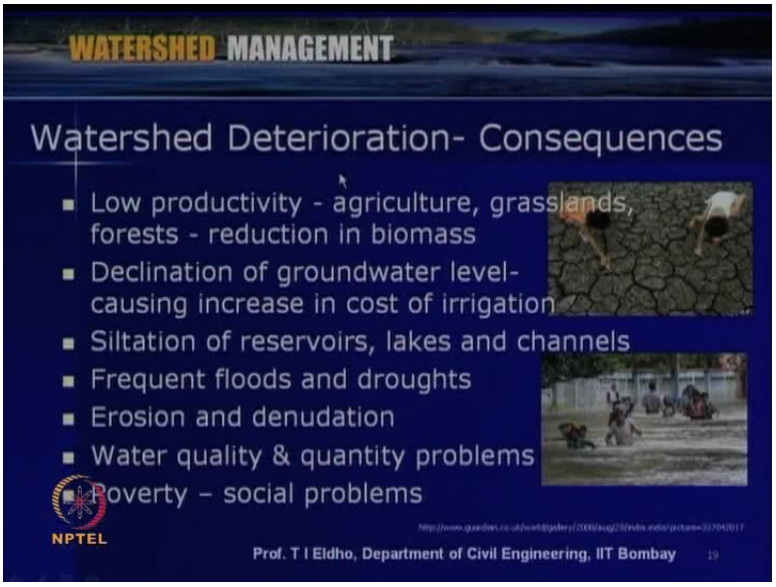

So, now, we have seen the various causes of watershed deterioration and what are the consequences; so, that are listed here. So, one of the important consequence is low productivity. So, the productivity of agriculture grass lands, forest. So, there will be a total reduction in biomass. So, we can see that when we consider this watershed as a scientific unit, so, we will be going for the scientific management of the various resources within the watershed.

So, most of the time the low productivity; that means agriculture whatever agriculture practice are there, the productivity is less and then the products from the forestry, that is also reduced so that low productivity is a major issue.

Then, as far as water issue is concerned, there is lack of sufficient water surface or ground water. So, that way, the farmers cannot go for irrigation. So, that can lead to say various issues related to say not only domestic water supply but water for agriculture and other activities. So, it can be a declination of surface and ground water availability. So, say for example if ground water is concerned, the issue can be say increase in cost of irrigation. Say when the ground water level is going down, we have to use more power and then to drip water to lift the water; so, that can be another consequence.

Then as far as the erosion and siltation problem is concerned, so, siltation of reservoirs lakes and channels - that can be a major issue of the watershed deterioration. Then other consequences like a erosion and denudation. So, due to continuous erosion problems, the overall contour of the watershed itself can change when we consider for a long time. So, that can be another important consequence.

Then as far as water is concerned, as we have discussed it is not only the quantity of water, quality is also a major issue. So, the available water if it is not a good quality for various uses, then it will be another issue. So, all this finally can lead to poverty in the area which we consider, and then, that also can due to further social issues for the considered watershed. So, these are some of the important consequences of watershed deterioration.

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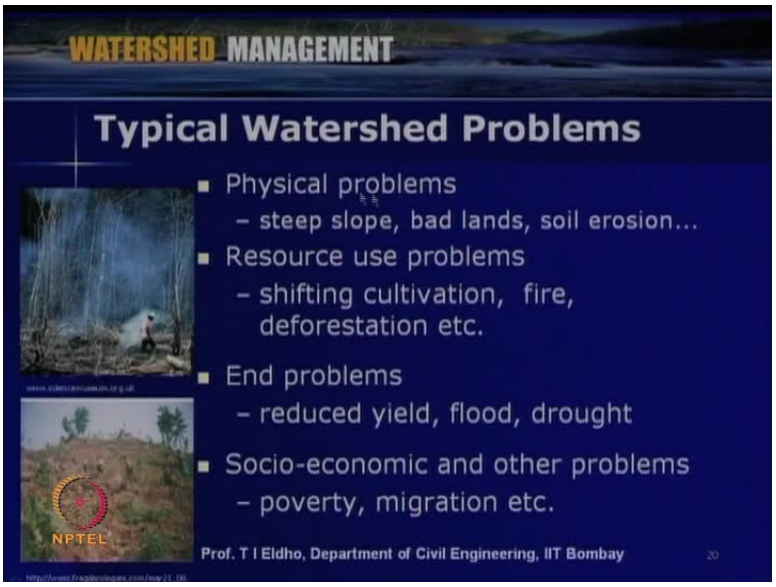

So, based upon this analysis of the watershed deterioration and its consequences let us look into typical watershed related problems. So, the problems can be the physical problems of the area which we consider physical problems such as steep slope, Bad Lands, soil erosion, etcetera, which we have already discussed. Then typical watershed problem can be resource use problems like agriculture practices happening within the watershed, then the forest management.

So, agriculture practices like shifting of cultivation, then, fire, forest fire, then deforestation, etcetera. So, these are some of the resource related issues. The end problems – so, finally all this leads to reduce the yield. Then there can be flooding in rain fall season or monsoon season; then there can be droughts in summer season. So, these are some of the end problems as far as typical watershed problems are concerned.

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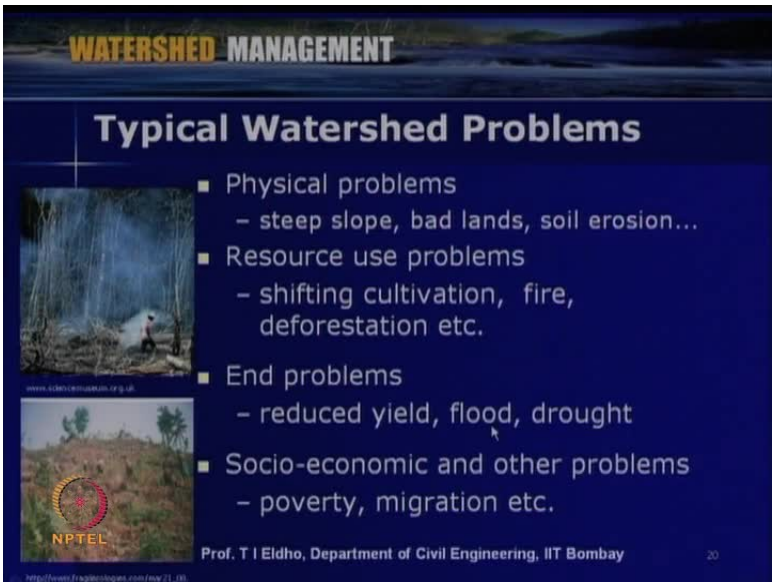

Then all this finally lead to socio-economic problems for the people residing in that watershed. So, if there is no sufficient yield from the agriculture, then there is no sufficient job and then sufficient money for the people. Then that can finally lead to poverty for the people in the watershed and that people may migrate to other areas. So, as far as socio-economic issues is concerned mainly poverty migration and other related issues.

So, when we discuss, so, what we have discussed so far is the concept of watershed, then the watershed deterioration and its consequences, and when we consider typical watershed, what are the typical problems as far as the watershed is concerned? So, when we discuss these typical problems, we have to see that what is the watershed related complications.

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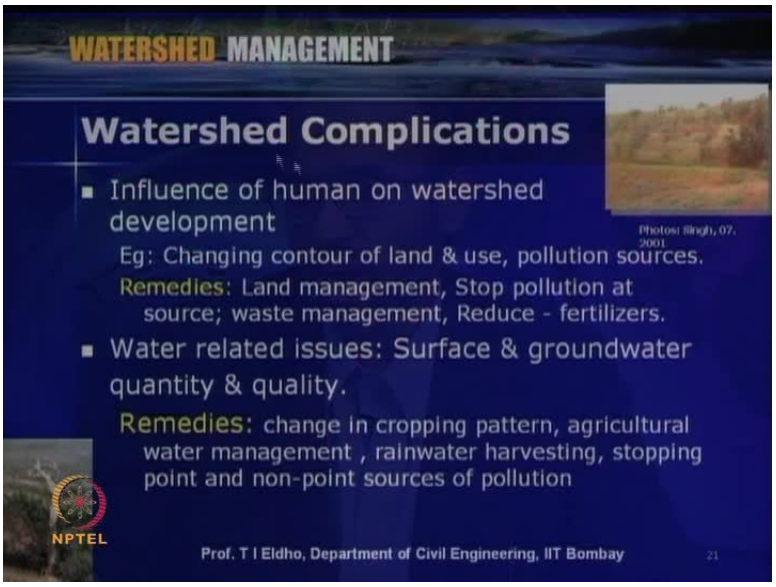

So, some of the complications are listed here. So, mainly the complications can be on the two issues - one is land related issues and then second is water related issues. So, the land related issues are the issues due to the human interventions within the watershed. So like as we discuss the changing of contour of land and land use, and then, various pollution problems within the watershed.

So, some of the remedies can be like appropriate land management, then appropriate waste management so that we can stop pollution at sources, and then, reduce use of fertilizers herbicides and pesticides for various agricultural uses.

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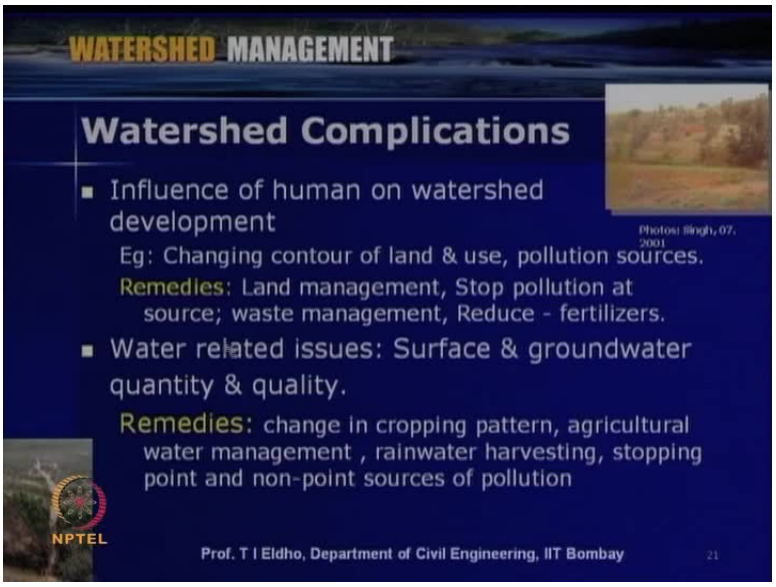

So, like that depending upon the watershed, there can be various remedies. Then second important issue or important complication as far as a watershed is concerned, it is related to water. So, as I mentioned, so, water is one of the important resource which we use for domestic agricultural and industrial uses. So, the water is concerned, we have to see in a holistic way like surface water availability, ground water availability and that should be in terms of the quantity of water available and the quantity of water available.

So, within the watershed management practices, we can look into various issues like appropriate agricultural water management practices; then we can look into rain water harvesting; then we can look into the, changing, change in cropping pattern, and then of course, some other important issues like pollution problems, environmental problems. So, it can be soil pollution, water pollution; so, we can look into the pollution issues as far as the water and land is concerned so that we can achieve better environmental management.

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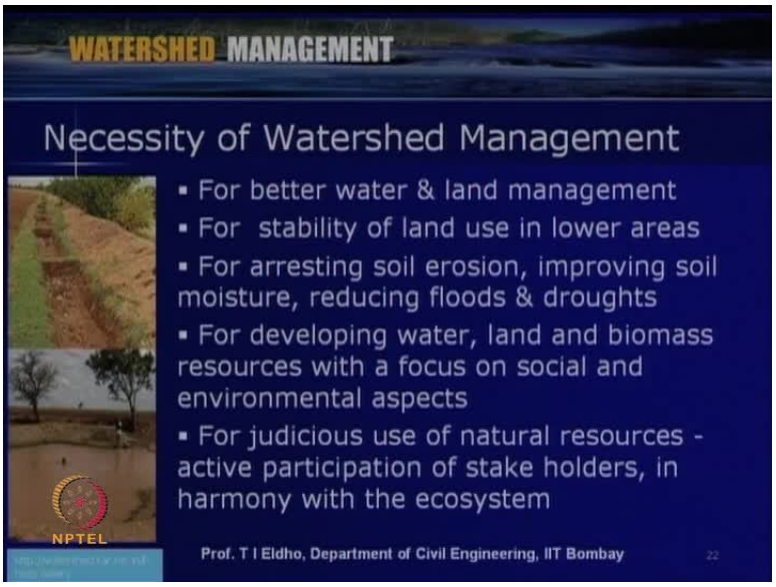

So, within this perspective, we have seen in the previous slide the watershed complications and then its remedies. So, now, coming back to the watershed management, why we have to go for watershed management? What is the necessity of watershed management? Some of the important necessities of watershed management are listed here.

The watershed we are considering a specified a scientific area. So, we are looking for the better management of various resources within that area. So, within that perspective, when we look into the necessity of watershed management, the necessities include say better water and land management. So, we are looking for the best management practices. So, that is based upon the lands which we consider, and then, the water within the land which we consider.

Then, for stability of land use in lower areas, so, you can see that when we consider the topography of the watershed which we consider, there can be upper land, middle land and lower land. So, whatever you are practicing within the upper or middle land that can affect the land use or its management within the lower land.

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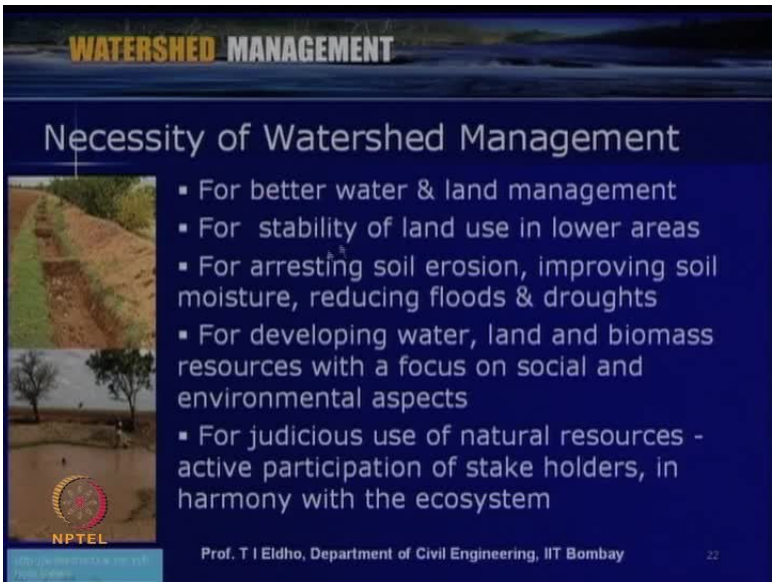

So, we have to see the stability of land use in lower land within the perspective of what is happening within the upper land. Then for arresting soil erosion – so, as we have seen soil erosion can be a major issue, improving soil moisture, reducing floods and droughts. So, as we have seen, one of the important consequences of watershed related issue is floods, and then, another consequence can be droughts. So, we have to do watershed management so that the effects of floods and droughts are reduced.

Then another necessity is for developing water, land and biomass in an integrated way so that we achieve the social needs environmental needs in a sustainable way. So also the watershed management necessity can be for judicious use of natural resources in a holistic way. So, within this perspective of watershed management, we have to see the harmony of various players within the watershed, say like the people within the watershed, then the flora and fauna, and then there is a harmony within the eco system for the watershed which we consider.

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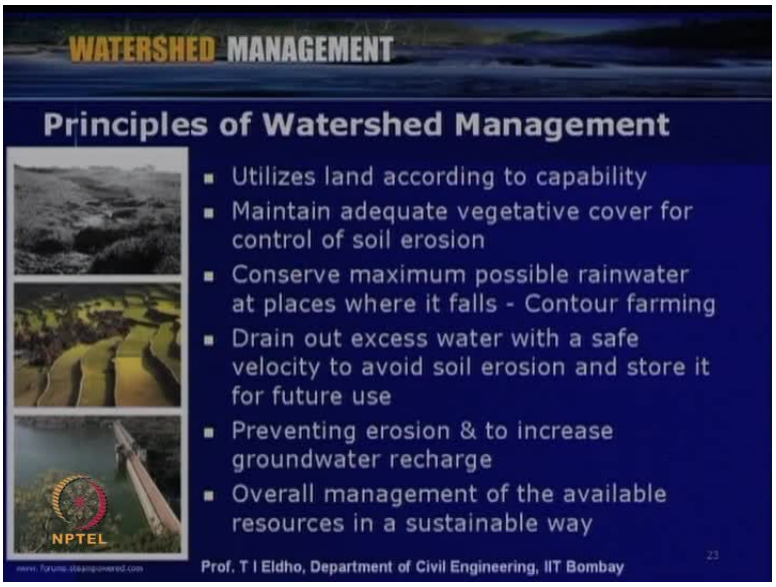

So now, we will looking to what are the important principles of watershed management. So, some of the important principles are listed here: the watershed management - we consider the utilization of the land according to the capability of the land. Then maintain adequate vegetative cover for control of soil erosion. So, we have seen the soil erosion is a major problem.

Then we look into a conservation of rain water at places where it falls. So, this can be like a contour farming as shown in this figure. So then, draining out of excess water with a safe velocity so that we can avoid soil erosion and store it at appropriate locations, so like in a ponds so that we can use the water for future use.

Then preventing erosion so that we are stopping the water at different locations; so, water recharge will be recharge to the ground water system will be improved. So, we will have better management of or better availability of ground water for the watershed which we consider.

And finally, overall management of the available resources in a sustainable way. So, this is the most important aspect of or most important principle of watershed management. So, various resources like land, water, then the forest or the minerals or all the resources available within the watershed in a sustainable way. So, these are some of the important principles of watershed management.

So, now, in this lecture, we have seen the concept of watershed; then the watershed approach the various issues which we consider for a sustainable development and environmental friendly development; then we have seen the watershed related problems like a watershed deterioration; then what are the consequences of watershed deterioration.

Then we have seen the necessity of watershed management practices; then the important principles of watershed management. So, as I mentioned, we are looking the management of various resources within a watershed in a holistic way so that we are achieving sustainable development for the watershed which we consider. So, within this perspective, here, now, we will discuss a small case study - how a sustainable environmental friendly watershed management is possible?

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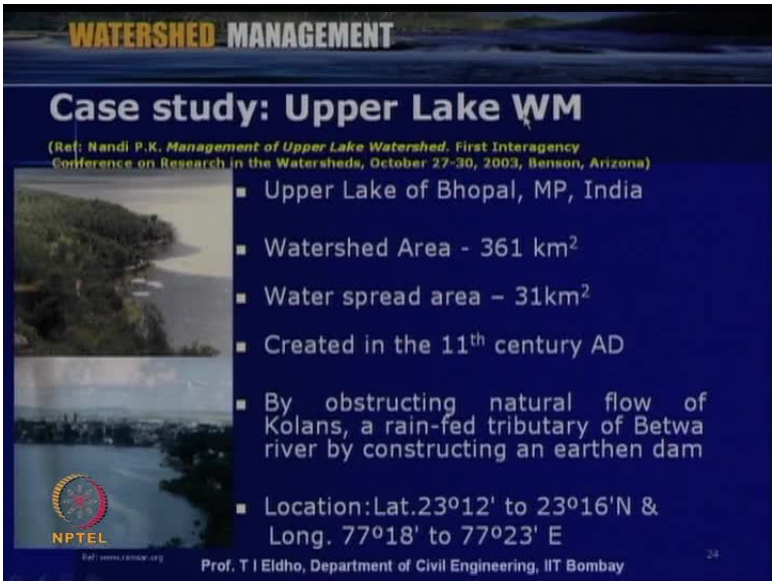

Here we are considering a case study of upper lake watershed management. So, this case study is taken by a paper by Nandi. The paper title is management of upper lake watershed management. So, this watershed is in Bhopal, Madhya Pradesh, India. It is called upper lake, so, the watershed area is about 361 square kilometer and there is a major lake in this area and water spread area is about 31 square kilometer.

So, this lake was created in eleventh century by obstructing the natural flow of Kolans rain fed tributary of Betwa river by constructing an earthen dam. So, this shows the lake which is considered for this watershed. So, this is located this latitude of 23 degree 12 minutes to 23 degree 16 minutes and longitude of 77 degree 18 minutes to 77 degree 23 minutes East. So, as we discussed, when we discuss about the watershed, so, the area of the watershed the size of the watershed is important. So, as I mentioned, this is a sub watershed of the so-called upper lake and area is about 361 square kilometer.

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So, next issue is how is the land use of the watershed. So, here the various land use for this considered watershed is listed here. So, the various land use are - Built up area, then crop land, open forest land with scrub or without Scrub, then barren or rocky or stony land, then other small lakes and ponds. So, like that, area is also listed here. So, the total area of the watershed considers 361 square kilometer.

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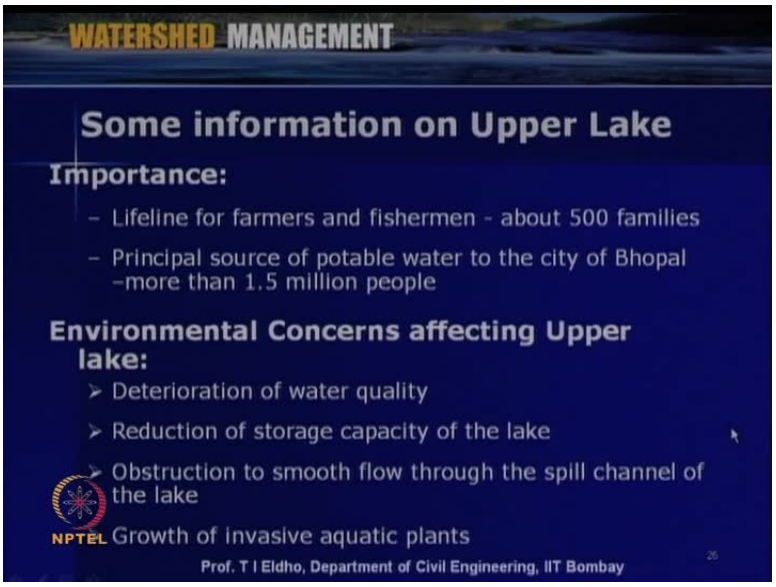

So, when we look into the watershed management for the area which we consider, we have to consider the watershed management in a holistic way. So, first one is the land; then the water in the land, and then of course, various resources within the watershed. So, anyway, in this case study, we are the main issue was the water related issue. So, some of the important information as far as this watershed case study is concerned. So, this lake which we considered in this watershed is the life line for various farmers and fishermen about 500 families are there in this watershed.

The principal source of potable water for the city of Bhopal is from this lake for about 1.5 million people. So, before implementing, some of the important watershed management practices which we will be briefly discussing in this case study. So, the various issues in this watershed where the polluted lake, the major lake and then the total agriculture practice were not scientific; then the land were not properly managed.

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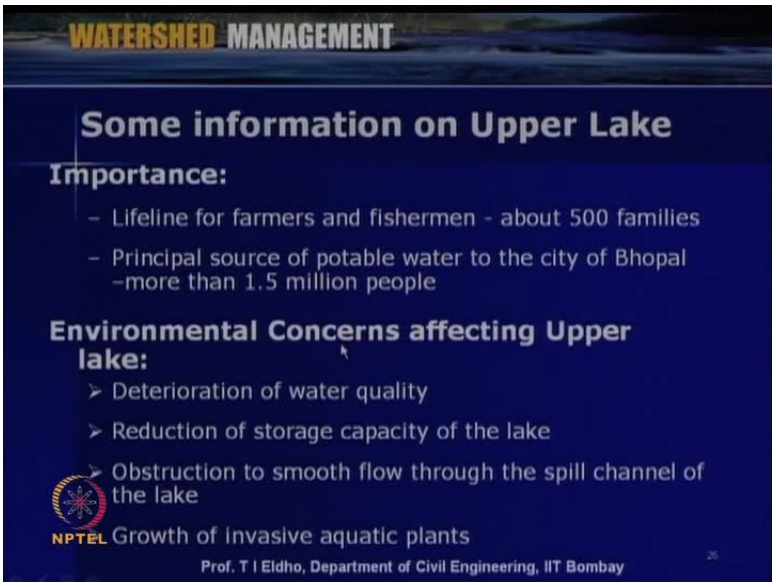

So, some of the important environmental concerns or the important watershed related problems for this area is listed here: so, deterioration of water quality; so, water available in the lake was not good. Then reduction of storage capacity of the lake the issues like a wheat growth and then polluted water were some of the major issues. Then obstruction to smooth flow through the spill channel of the lake. So, the drainage system for the watershed was not proper. Then growths of invasive aquatic plans were there for this watershed so that you can see here.

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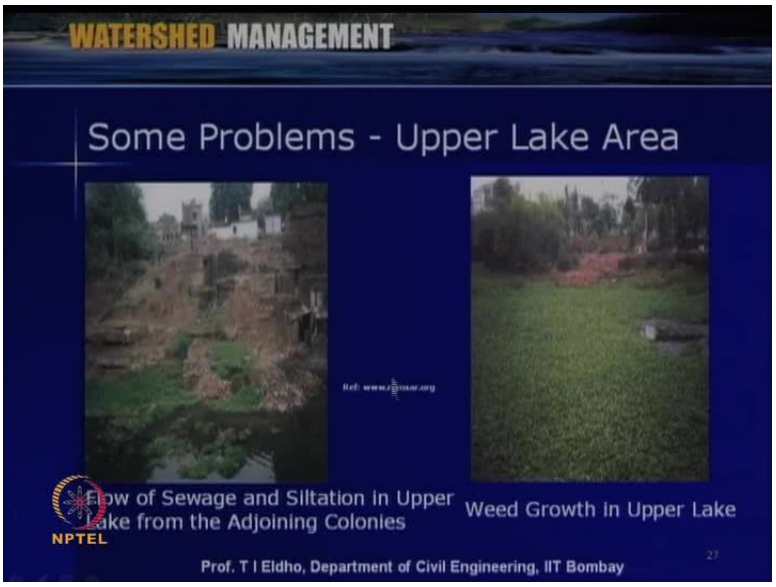

So, these were some of the important issues before implementing this watershed practices for this upper lake area.

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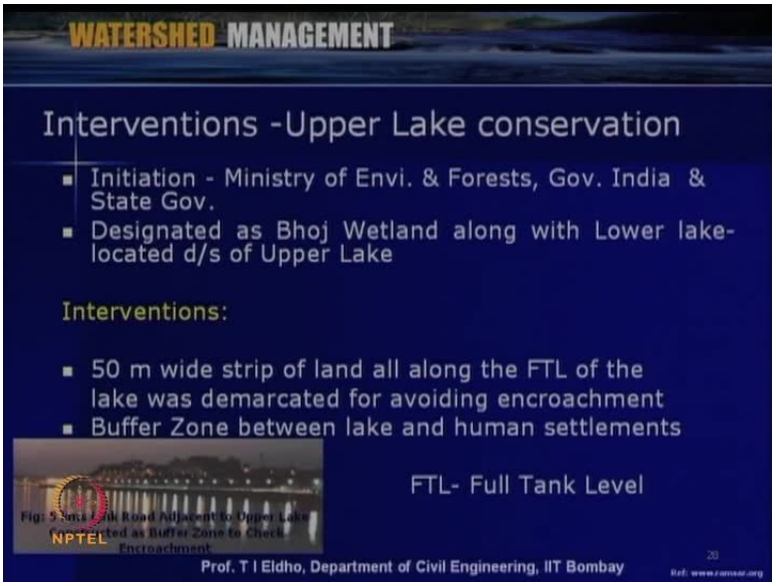

So, due to the various problems for this upper lake area, a scientific study has been carried out in 1990s, and then, the ministry of environment and forest government of India and State government say some plans were put for this watershed area in the late 1990s, and then, they designated an area called bhoj Wetland along with lower lake area of the downstream of upper lake and an initiation and of this project was by ministry of environmental forest and the state government authorities.

So, some of the interventions within the watershed perspective, water related issues are mentioned here. So, we include a 50 meter wide strip of land all along the full tank level of the watershed of the main lake. So, this was demarcated for avoiding encroachment. Then a buffer zone has been created between the lake and the human settlement within that watershed. So, these were some of the important interventions in this watershed.

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Also intensive plantations were implemented in this buffer zone say about 73 check dams across 28 inlets channels were implemented in this watershed. So, all these were done in an end of 1990s and the effects of these interventions were studied in 2003 by Nandi in his paper. So, and also as we discussed some of the other issues where the pollute pollution problems, so, development of appropriate sewage system where done for this area so that pollution management has been done. Also solid waste management practices appropriate were carried out for this area and also organic farming instead of inorganic fertilizers were implemented in this area.

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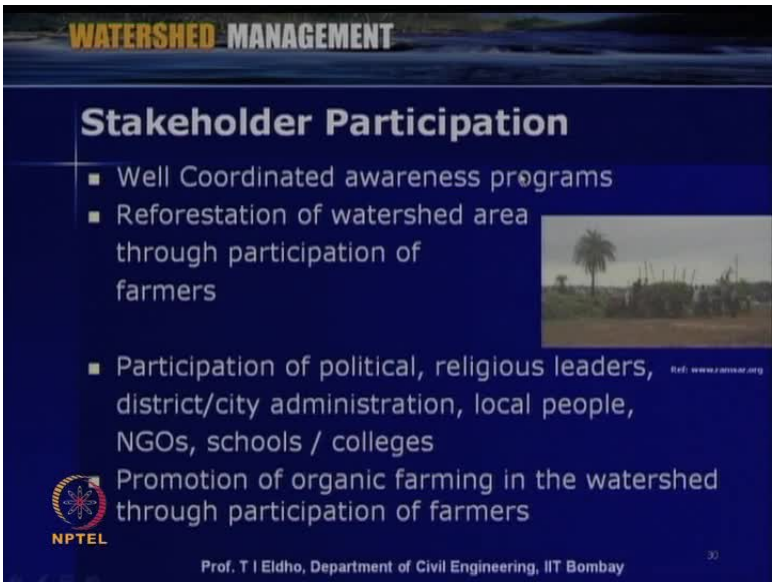

Another important aspect of this study was or this case study is stake holder participation. So, due to the concentrated efforts of various officials and NGOs in this area, well coordinated awareness programs were carried out. Then the reforestation of watershed area through participation of farmers, local people, schools, colleges, city administrations were carried out in this area, and then, promotion of organic farming also were promoted between the farmers.

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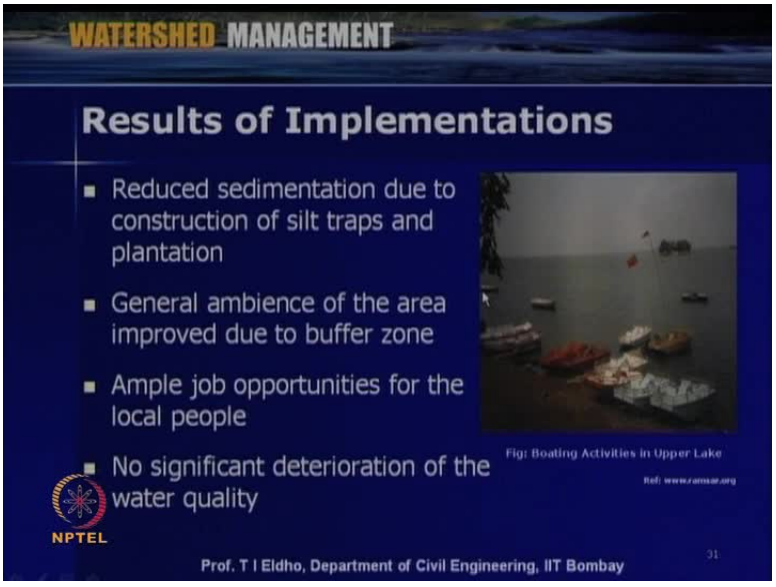

So, when this case study was analyzed in 2003, some of the results of implementations as reported are listed here: after 5 years of implementation, various interventions. So, results of implementations are reduced in sedimentation due to construction of silt traps and plantations. Then, improvement in general ambience of the area due to the buffer zoning. So, you can see this lake is now the water quality is improved; sufficient water is there throughout the year. Then also for the as a total development ample job opportunities were created for the local people within the watershed management scheme by the various agencies.

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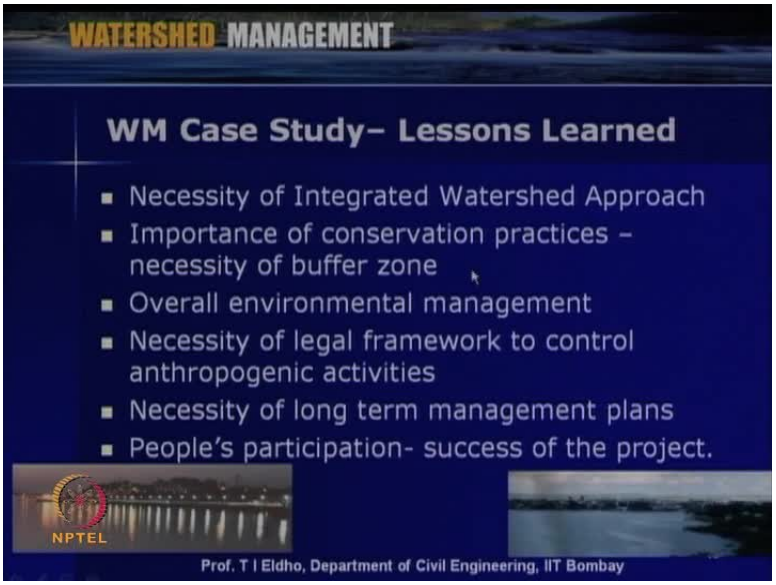

So, as I mentioned, the water quality is improved drastically within this 5 years of the assessment period. Then some of the important lessons for this case study considered are listed here: so, like the necessity of integrated watershed approach – so, as I mentioned for this case study, it is the management of the land; then water; then the various issues for the people, all these are considered in this study;

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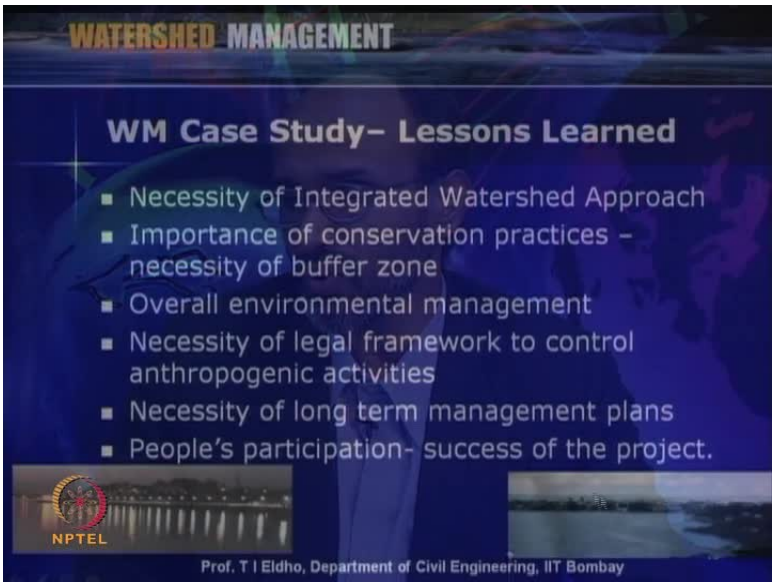

Then importance of conservation practices like a necessity of a buffer zone. So, that has improved very much for the lake which is considered in this area. Then, overall environmental management. Then necessity of legal framework to control anthropogenic activities.

So, this lake was disturbed due to the various human activities within the watershed. So, a legal framework has been also established by the various government bodies during the implementation of this watershed scheme. Then necessity of long term management plans – so, it is this program was implemented not on a short term base but a long term base, and another important aspect which I want to emphasize here is the people participation. So, the farmers, then the schools colleges, then the various government organizations all the people came together, and then, participated for the overall management of this upper lake area.

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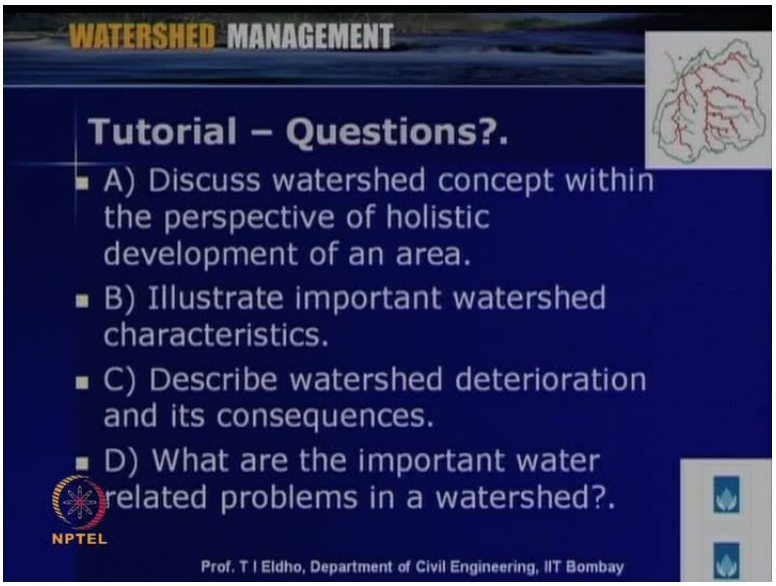

So, that was actually the success of this project as we have seen the effects of this watershed management practices done in upper lake. So, with this the basic concepts of this, the first lecture what we considered in this introduction to watershed management is over. So, before closing the lecture, some of the tutorial assignments problem which will be coming related to this lecture I have listed here: first one is some tutorial questions.

So, most of these questions, the answers are already discussed in the slides. So, the questions I have listed four questions here: first one is discuss watershed concept within the perspective of holistic development of an area. So, this we have already seen. So, we have to see not only the land but then water, then other resources. So, we have to consider in a holistic way. Then second question is - illustrate important watershed characteristics. So, we have seen various characteristic like a size, then the shape, then hydrological aspects, climate aspects or like that various issues we have to consider in watershed management practices.

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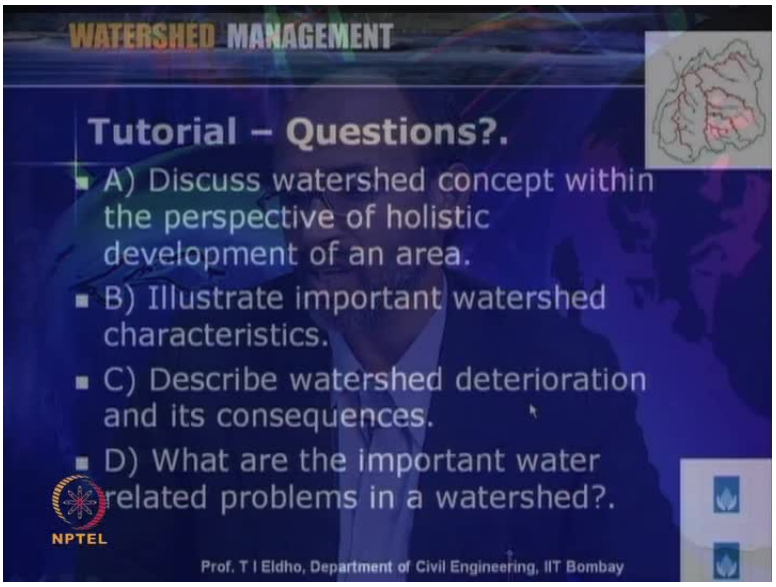

Then describe watershed deterioration and its consequences. We have already discussed the various typical problems or typical issues related to watershed deterioration, and then, what it can lead like it may leads todroughts floods or poverty like that. Then fourth question is - what are the important water related problems in a watershed? So various issues we have already discussed.

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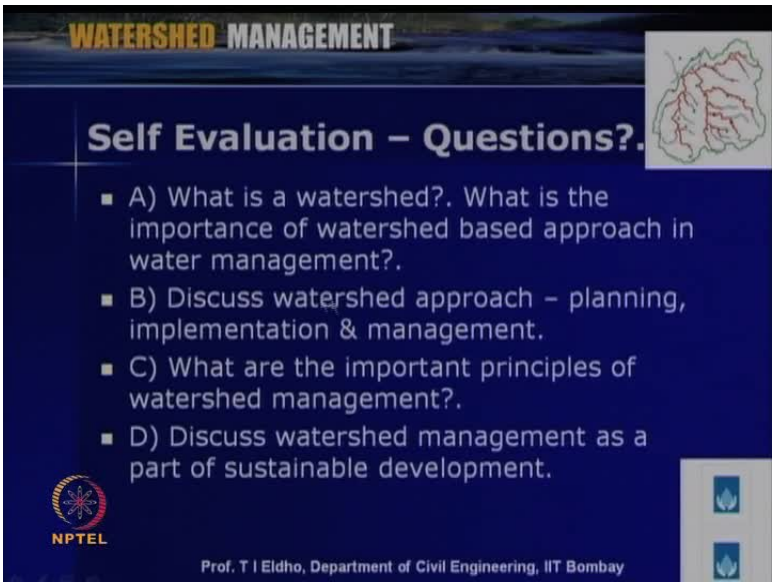

Then those who are going through this lecture with some questions self evaluation I have listed here - like what is a watershed? Then, what is the importance of watershed based

approach in water management? Say then, second question is discuss watershed approach planning implementation and management. Then third question is - what are the important principles of watershed management? And fourth question is - discuss watershed management as a part of sustainable development. So, these, all these self evaluation questions we have already discussed in various slides in the lecture.

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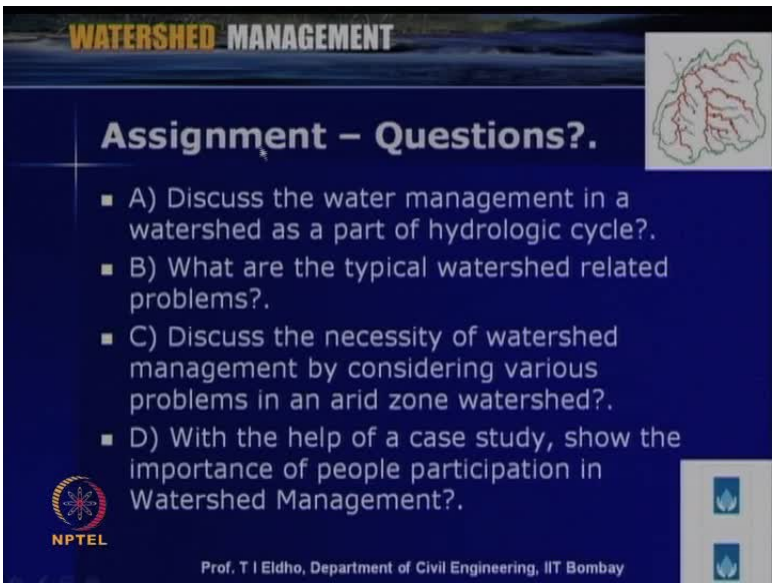

Then, few assignment questions are also listed here: question number one - discuss the water management in a watershed as a part of hydrologic cycle. So, that also we have already seen in the initial part of the lecture. Then, what are the typical watershed related problems? So, like the watershed deterioration, then its consequences and then watershed related problems.

Then discussed the necessity of watershed management by considering various problems in an arid zone watershed so in an arid zone watershed? There will be the rain fall or precipitation will beless. So, we have to see relate especially related to water related issues for the watershed management. Then last question - with the help of a case study, show the importance of people participation in watershed management? So, we have already seen one case; so, similarly, other case can be analyzed.

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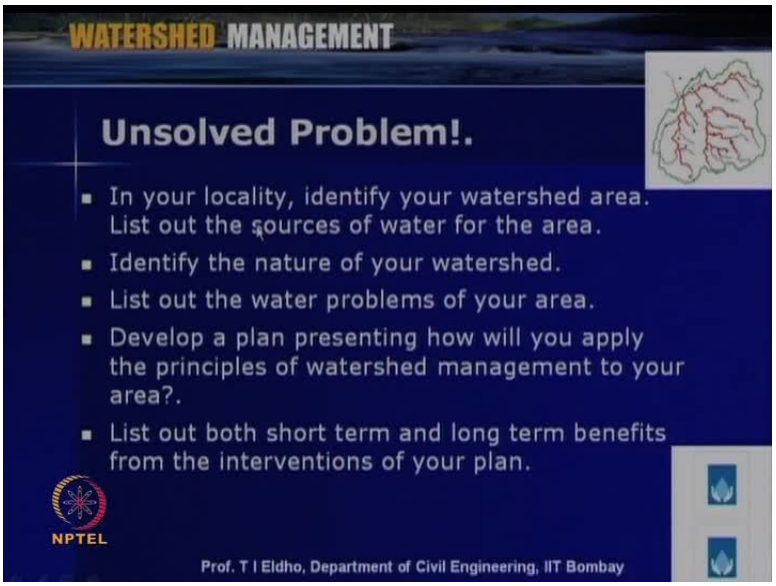

So, as a last slide, here one unsolved problem is put here, so, for the listeners who are going through this lecture. So, one the unsolved problem is - in your locality, identify your watershed area. List out the resources of water for the area.

Then identify the nature of your watershed. List out the water problems for your area. Then develop a plan presenting how will you apply the principles of watershed management to your area? And list out both the short term and long term benefits from the interventions of the watershed management plan. So, this anyway within the perspective of the various issues, we have discussed that you can prepare for the watershed which you consider.

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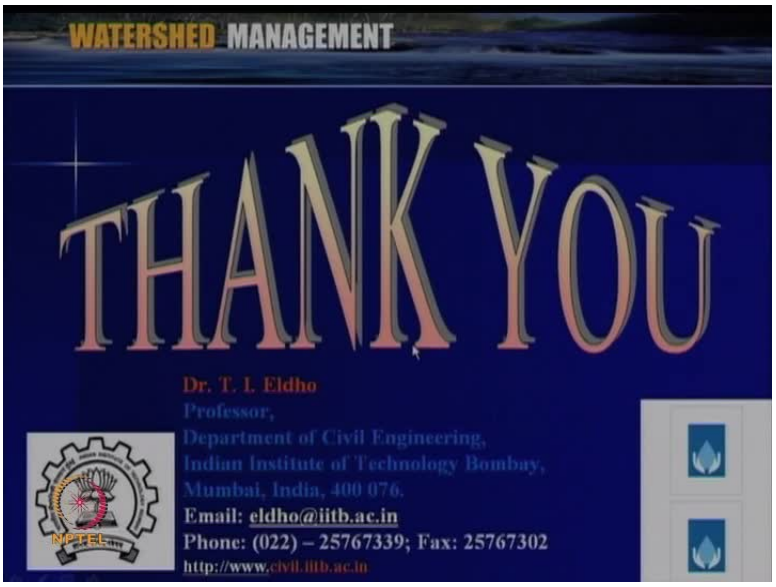

So, some of the important references which are used specifically, for this, for this lecture are listed here: so, in this lecture, this introductory lecture we have seen the basic concepts of watershed, and then, necessity of watershed management; then principles of watershed management and also we have seen a case study related to various issues of watershed management.

Thank you very much.