Soil and Water Conservation Engineering
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Lecture - 01
Introduction

Hello friends. Welcome, to NPTEL online certification course on Soil and Water Conservation Engineering. I am Rajendra Singh, Professor in Agricultural and Food Engineering Department of IIT, Kharagpur and I welcome you to this course and this is week number - 1, lecture - 1.

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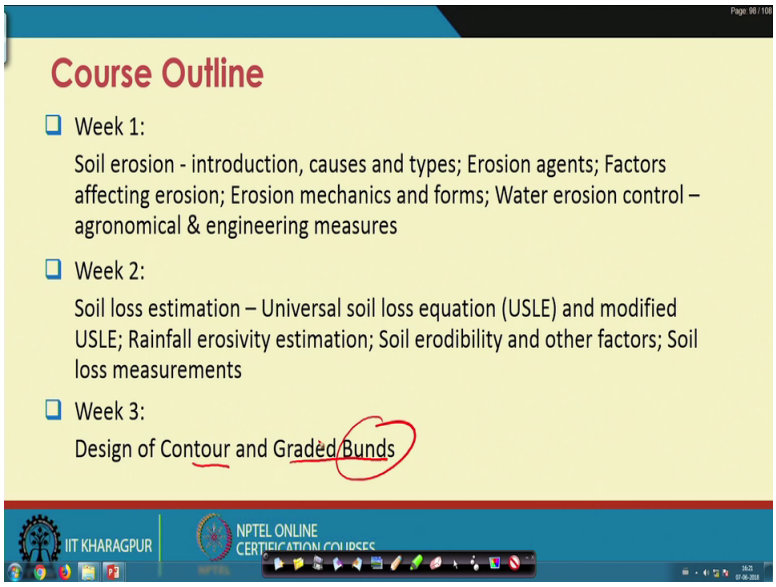

So, we are starting with Introduction. And I will first introduce you to the course outline which we will go through giving this course. So, when week 1, we will start with introducing soil erosion, we will go in to causes and types of soil erosion, we will see what are the erosion agents what are the factors that affect erosion. Then we will go into the various kinds of erosion and what are the mechanics behind them. And finally, we will talk about agronomical and engineering measures that are use for controlling water erosion.

In week 2, we will switch to soil loss estimation and there one of the very popular methods called universal soil loss equation USLE, that is what I will begin with. And over the years there had been several modification made in USLE. So, I will go through

also what are the modified forms of universal soil loss equation. Thereafter, we will move into estimation of rainfall erosivity, soil erodibility and various other factors that are immediate for estimating soil loss using universal soil loss equation and finally, we will close the week with measurements of soil loss.

In week 3 onwards because my introduction I told you that basically here we will be talking about various engineering principle involved in designing engineering measures so, in week 3, we will move into various kinds of engineering measures that are adopted for design of various measures. And we will we again with contour and graded bunds; that is bunds which are one of the common engineering measures adopted for controlling erosion we will you start with them.

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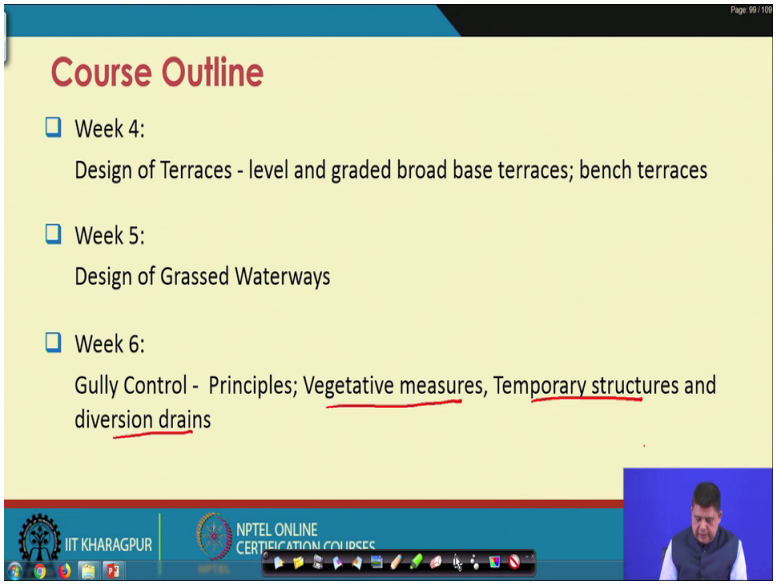

Then, week 4 we will go to design of terraces another level of engineering measures. And we will define level and graded broad based terraces, bench terraces and how they are designed.

In week number 5, we will go to design of grassed waterways that is basically the channels, where grasses are planted or vegetation has grown which can be used for carrying the water safely to any outlet. Week number 6, we will go into gully control, we will see the principles behind gully control, then we will see some of the vegetative measures that can be adopted for controlling gully. And finally, we will go through the temporary structures and diversion drains which are used for controlling gully.

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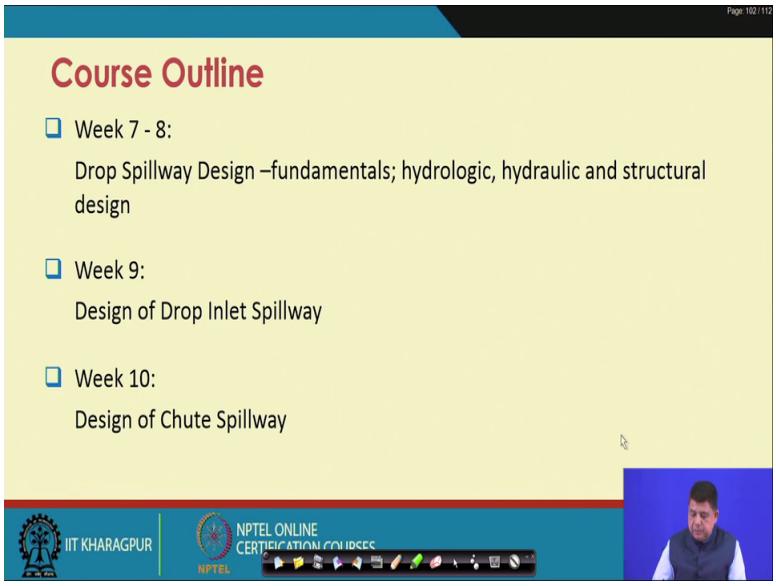

In week number 7 And 8 we will start with basically the permanent gully control structures and we will start with drop spillway design that is will design how see how to design drop spillways. So, first will see the design fundamentals and any permanent gully control structures have three types of design; hydrologic, hydraulic and structural. So, we will see how to go for hydraulic hydrologic and structural design.

Week number 9, we will move to next structure that is design of drop inlet spillway and there we will use all the principles which you have adopted that is hydrologic, hydraulic and structural design principles we will adopt for drop inlet spillway again. Week number 10, we will move to another permanent gully control structure that is chute spillway. And again we will see how to design chute spillway.

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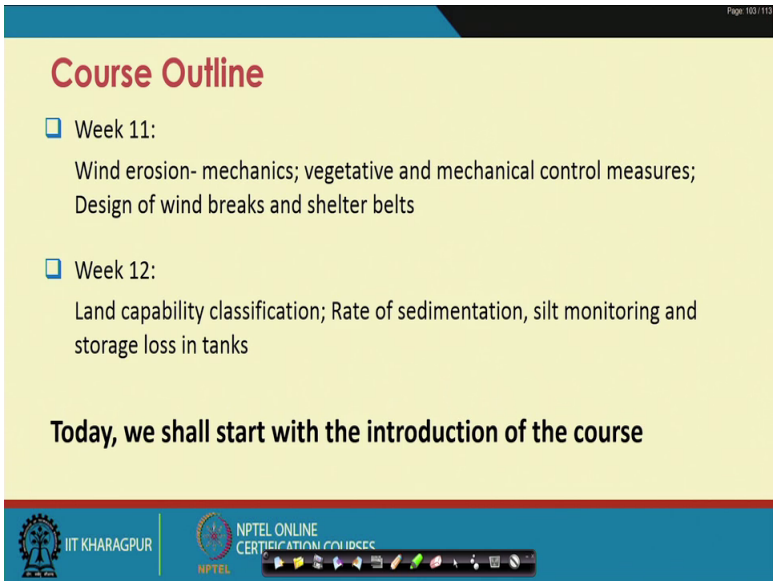

Week number 11, will move to the second important wind erosion agent that is wind erosion. And we will go through the mechanics of wind erosion, then we will see what are the vegetative and mechanical control measures that can be adopted for controlling wind erosion. And finally, we will in we will go for designing two major engineering measures that is wind breaks and shelter belts which are used for controlling wind erosion.

Week number 12, that is of the last week we will go through the land capability classification, the rate of sedimentation, silt monitoring and storage loss in tanks that is basically what are the impacts of soil erosion if you do not controls soil erosion what are their impacts.

So, basically today in this we will start this course with introduction of the course itself.

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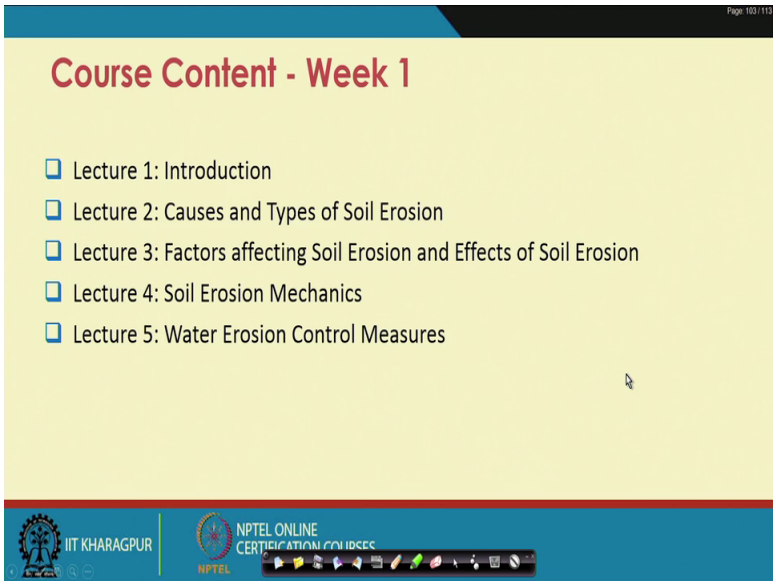

And, the course content for this particular week are week number 1 is today that is we will introduce the subject. Then we will go lecture number 2, we will see causes and types of soil erosion; we will see factors affecting soil erosion effects of soil erosion ; lecture 4, will be on soil erosion mechanics and lecture 5, will be on water erosion control measures.

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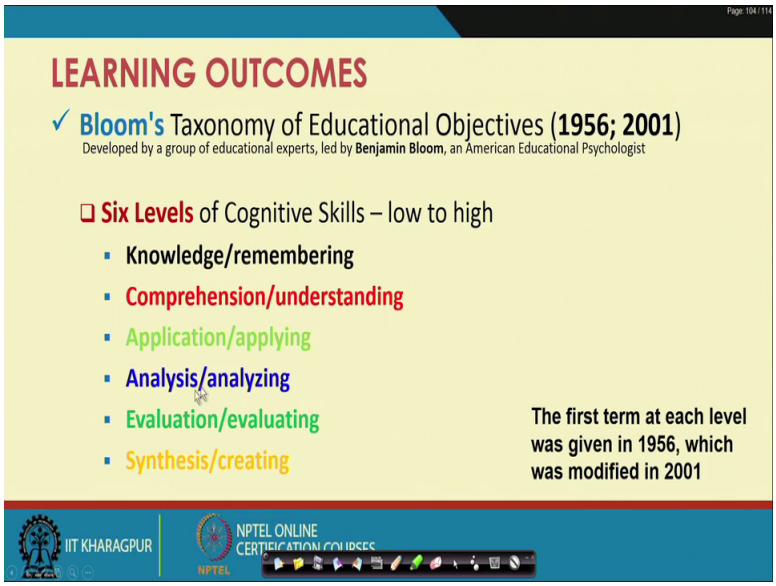

So, let us start with the course, but before we go into the actual content of the course there are certain thing called learning outcomes. Why are we learning this course, what

will be the impact once you learn this course, what will be the knowledge gain you get. So, that is through learning outcomes and in educational sector basically we use Bloom's Taxonomy of Educational Objectives which was first given in 1956 and later revised in 2001.

And, this Bloom's Taxonomy was developed by a group of educational experts, led by Benjamin Bloom, an American educational psychologist and that is why it is named behind him that is Bloom's Taxonomy of educational objectives and expert this Bloom's Taxonomy. There are six levels of cognitive skills starting from low to high and just for your information cognition is the mental action or process of acquiring knowledge and understanding through thought experience and senses. That means, anything our mind does to any action it takes in order to process knowledge or acquired knowledge by other understanding to thought experience or by sensing that is referred to as cognition and this cognitive cognition has six levels of skills that is that is why there are six levels of cognitive skills is starting from low to high.

And, we will start with the lowest one the lowest level is knowledge and remembering that is our lowest level and I mean that is very common in our life because when we were toddler our parents were always telling us about this is cat this is dog or they were asking us to repeat 1, 2, 3 or a, b, c and they were all are always asking us to recall those so, that was the process of graining knowledge or remembering. So, that was that is the lowest level of cognitive skill.

Then, next level is off course let me also tell you the first term here that is knowledge and remembering that is the first term knowledge was given when the Bloom's Taxonomy came in 1956 and then later on the second term understanding that was given when Bloom's stocks Taxonomy or modified in year 2001. So, there are two terms for each level. So, second level has comprehension and understanding that is once you know something you have a quiet certain knowledge then you start understanding that that is level number 2.

And, then the third level is application or applying. So, once you have remember something or your acquired knowledge if you have understood that the next thing will be to apply that knowledge to your area of domain and then once you have applied the next level will be analysis or analyzing. That means after remembering after understanding of

applying you want to analyze what happened when we applied you particular knowledge to a particular domain area of your interest and then finally, next level will come evaluation or evaluating, that is once you have applied a particular knowledge, once you have you have analyze then you try to evaluate that what was the outcome. So, that is the fifth level.

And, the last level is synthesis or creating, that is synthesis or creating; that means, you acquire knowledge, you remember something, you comprehend or understand, you apply, you analyze, evaluate. And finally, based on whatever you have learned you create something. And, that is what that is what your last level that is synthesis or creation is all about.

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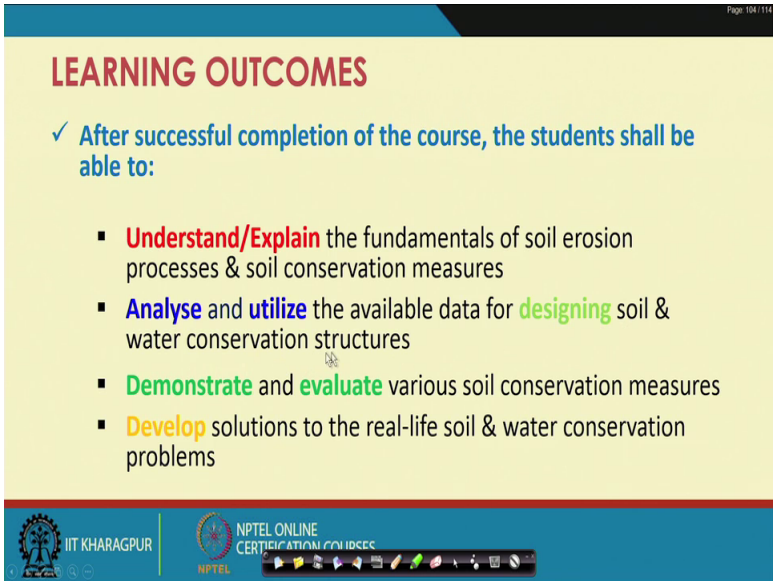

And, after successful completion of the course we will in during the course of during this course we will try to apply all the six levels and after successful completion of the course that we expect that student shall be able to understand explain the fundamentals of soil erosion processes and soil conservation measures. Just I will take you back to previous slide, because I wanted to tell you that we have used a color code here that is your first level is black, second level is red, third level is light green, fourth level is blue, fifth level is deep green and sixth level the final level synthesis or creating is in yellow color.

So, now when we go back to our learning outcome after the successful completion of the course, we start with level number 2 here, level number 2 here, intentionally I have not

kept level number 1, because it is well understood that if you want to study something then obviously you have to remember certain definitions, you have to remember certain formulae, certain variables, what are the common variables you use. So, that is why I am not used first level, but we start with second level that is we have to understand explain the fundamentals of soil erosion processes and soil conservation measures that you should be able to do.

Then, next level is analyze and utilize the available data for designing soil and water conservation structures that is what you are you are expected to do are you should be able to do. So, if you see here designing here is third level of cognitive skills. So, you are using that third level to design soil and water conservation structures and once you have design then utilize level number 4, that is analyze and utilize the available data which is come out of designing this soil conservation structure.

Then you should also be able to demonstrate and evaluate various soil conservation measures; that means what, that you are now using level number 5 of cognitive skill and finally, once you have learn or done all these things then you should be able to develop solutions to the real life soil and water conservation problems. So, that is the final outcome. So, you will be able to understand explain the fundamentals of soil erosion processes and soil conservation measures, you will be able to analyze and utilize the available data for designing soil and water conservation structures. You will be able to demonstrate and evaluate various soil conservation measures and you would be successful in developing solutions to the real life soil and water conservation problems. That is the learning outcome we expect after the successful completion of this particular course.

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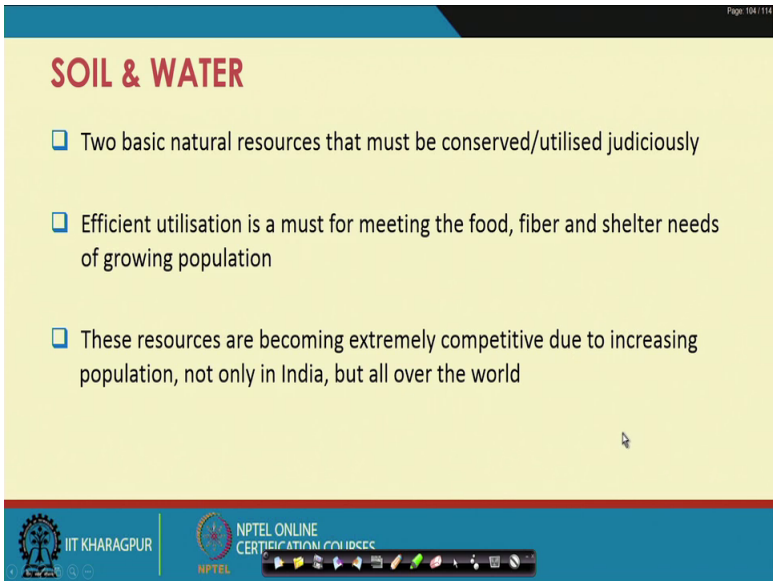

Now, we come to two important factors which are there in our subject name soil and water conservation engineering. So, what is soil and water? We know that soil and water are two basic natural resources that must be conserved and utilized judiciously and that is because for meeting the food, fiber and shelter needs of growing population we to need the efficient utilization of these resources.

And, as you know that there is a increase in population not only in India, but all over the world that simply means that the various sectors, there are various sectors not only the human beings, but there are various sectors that are competing for the limited resources, limited soil and water resources we have and that is why they are becoming extremely competitive. So, we have to manage our resources whatever we have in a efficient manner.

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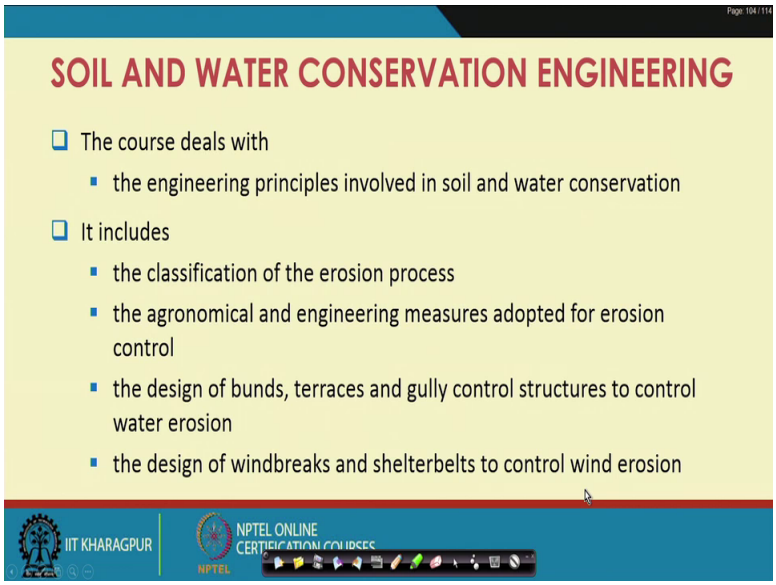

Now, next is soil water conservation engineering. So, basically this course deals with the engineering principles that are involved in soil and water conservation. This we have already seen in the course outline that we will be using engineering principles involved in soil water conservation and we will try to understand, then try to apply them in designing various conservation structures.

And, this includes classification of erosion processes, that is we will spends some lectures there. Then we will take up agronomic and engineering measures adopted for erosion control and we will design bunds, terraces and gully control structures that various engineering measures for controlling water erosion. And similarly, in the case of wind erosion we will see the design of windbreaks and shelterbelts. So, that is what we will do in this particular are this course will deal with these possibilities.

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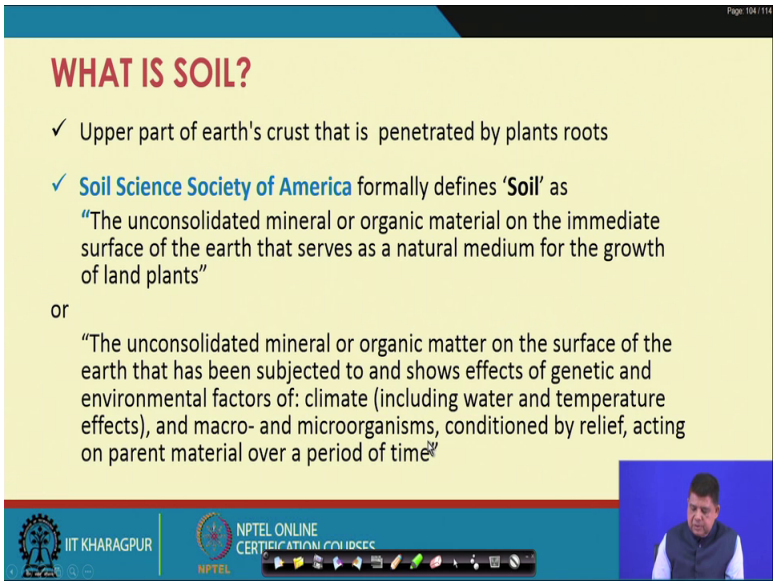

Then question comes what is soil? Then soil can be simply defined as the upper part of earth crust that is penetrated by plant roots. So, anywhere around you if you see plants growing under natural circumstances, then you can automatically say there will be soil there. So, that is the very simplified definition. But, if you look at the Soil Science Society of America has formally defined soil in more systematic manner and as per them the unconsolidated mineral or organic material on the immediate surface of the earth that serves is a natural medium for the growth of land plants that is soil.

I mean, if you look at the simplified definition and this sophisticated definition the last part if see here it is a plant roots penetrated by plant roots, here is says, it serves as a natural medium for growth of land plants. So, that is that part is common. Here we only called is earth crust, here it calls the immediate surface of the earth that is the surface and here we call it curst and of course, it goes little finer in detailing that is it will be an consulted mineral or organic material.

There is a even more sophisticated definition given by Soil Science Society of America of the soil and that is more elaborated. And that reads that it is the unconsolidated mineral or organic matter on the surface of the earth that has been subjected to ensure effects of genetic and environmental factors of climate including water, and temperature effects and macro and micro organisms condition by condition by relief, acting on parent material over a period of time.

So, this is a more sophisticated definition where it just talk about the unconsolidated minerals and organic matter on the surface of the earth, but it also show that genetic and environmental factors that impact on macro and micro organisms that are conditions the relief that act on the parent material for creation of soil over a period of time.

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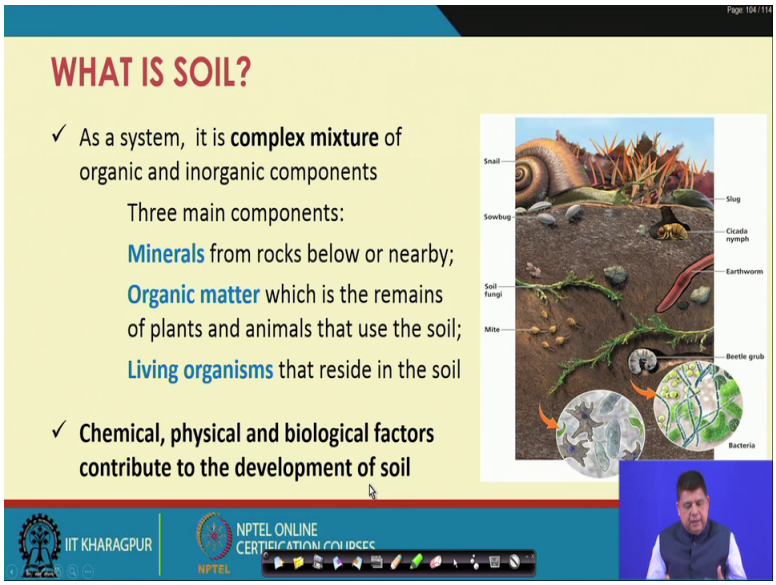

Coming to soil, we can see the soil is a system then basically it is a complex mixture of organic and inorganic components. There are three main components involved in a soil system; minerals from rocks below or nearby and we know that it s the weathering of rocks is cell that is possible for formation of the soil.

So, basically the minerals that are there in the rocks that they form one of the main components and the other main components then the other main component is organic matter which is the remains of plants and animals that use the soil. So, if you really see the soil take the soil sample there will be certain remains of dead plant roots, animals and which has been converted into organic matter and of course, there can be living organisms that reside in the soil.

So, I mean these are the three main components minerals organic matter and living organisms and obviously, if you take a chunk of soil then obviously, you could find bacteria, you could find fungi, you could find mite, you could find snail, you could find earthworms and so on so forth. So, that is what complete soil system and of course chemical physical and biological factors contribute to development of soil. So, I mean

there this a long process slow long process that is responsible for creating soil and that is; what is our interest in this particular subject.

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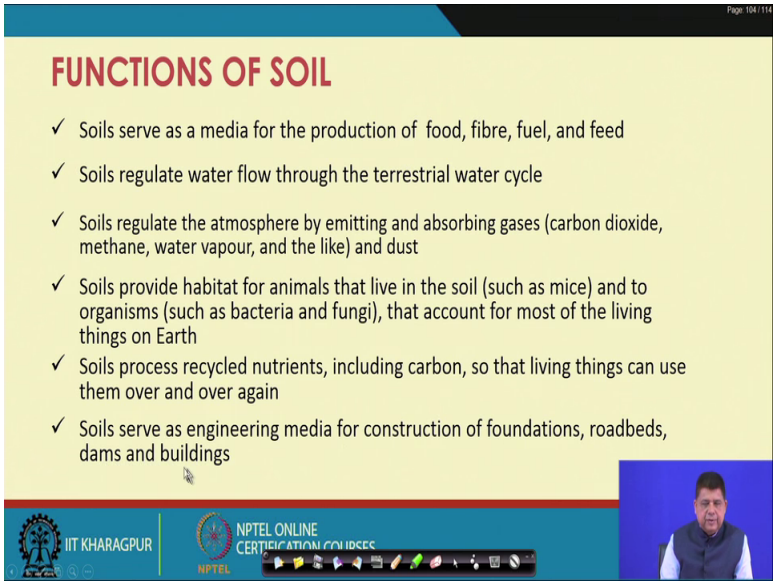

Then coming to functions of soil, there are several functions of soil and of course the most important one is, it serves as a media for the production of food, fibre, fuel and feed. I mean that we have already seen and that is what the plant true that is a basic definition of soil itself contains the plant growth. Then next is it regulates water flow through the terrestrial water cycle. So, when rainfall occurs there obviously, it reaches the soil surface and once it reaches the soil surface, the first process that begins is infiltration that is the vertical entry of water into the soil. I am sure that you have read in Soil Science some it some level of your course.

So, infiltration takes place and that infiltration really fills the soil moisture or the what is shown or the soil moisture let say and once it is completely filled up then excess of water goes percolates and joins the groundwater and also when the infiltration capacity is satisfied on the top, then overland flow star that is whatever rainfall comes that is start flowing in the form of overland flow. So, that is happens. So, and from the soil reserved, soil moisture which is there reserved of course from there plants to plants uptake moisture for their transpiration process and also vapor transpiration take place.

So, that simply means that the soil reserve soil moisture reserve which is there that basically is important part of water cycle or what we call as hydrological cycle and

commonly call it as hydrological cycle and that is how soil functions there. Then of course, soil regulates the atmosphere by a emitting and absorbing gases like carbon dioxide, methane, water vapor and others and of course dust and in today's world when we are talking about climate change so much then basically soil exchanges sync of these greenhouse gases carbon dioxide, methane these are very popular greenhouse gases. So, soil exercises sink for storing these.

Then, it does provide habitat for animals that live in the soil such as mice and to organism such as bacteria and fungi that account for most of the living things on the earth. So, just now we saw the picture where we discussed about this soil is a system. So, here we already saw that I mean we saw that all these possibilities are there. Then, soil processes recycled nutrients including carbon. So, that living things can use them over and over again. So, that is responsible for basically recycling of the nutrients. And finally, soils serves as a engineering media for construction of foundations, roadbeds, dams and buildings and that is of interest to engineers that wherever we see any construction whether be it from be it building, be it road be it dam or bridge whatever there soil will always be there is an engineering media.

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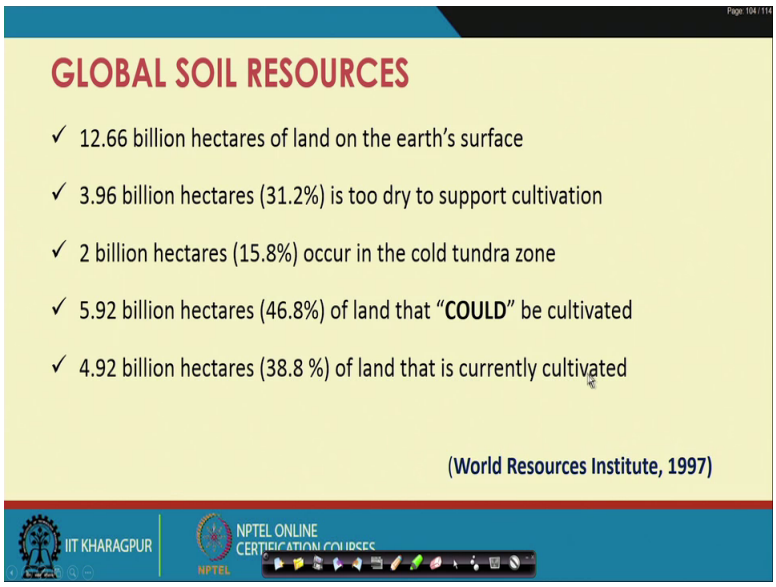

Then, coming to global soil resources, which have been given by World Resources Institute, 1997; on the earth surface there are one hundred 12.66 billion hectares of land. Out of which 3.96 billion hectors or 31.2 percent is too dry to support any kind of

cultivation. So, that means, this is not available for cultivation. Another 2 billion hectors or 15.8 percent of the total earth surface total soil that occurs in cold tundra region and that simply means this is also there is conditions are too cold for any crop grows. So, this is also not available. That leaves us with 5.92 billion hectors or 46.8 percent of the total 12.66 billion hectors of land that could be cultivated and out of these around 4.92 billion hectors or 38.8 percent of the total land is currently being cultivated.

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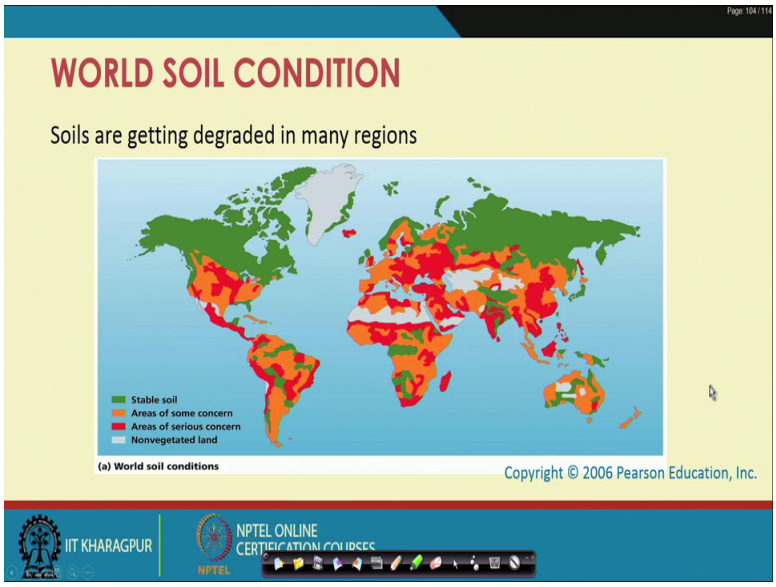

If you look at the world soil condition then soil condition, then soils are getting degraded in many regions if you look at India and the color code then we have areas of serious concern in India and that is why soil management is very important.

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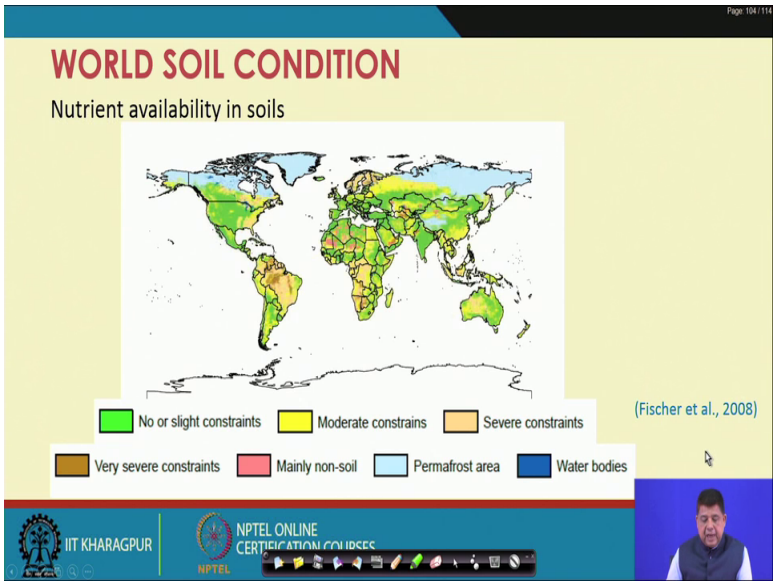

But, everything is not gloomy, if you look at the nutrient availability of soils in India then you find that there is no or slight constraints, which shows that soil in India in general of good quality they are very productive. So, if you can manage them well we will be able to get very high level of production.

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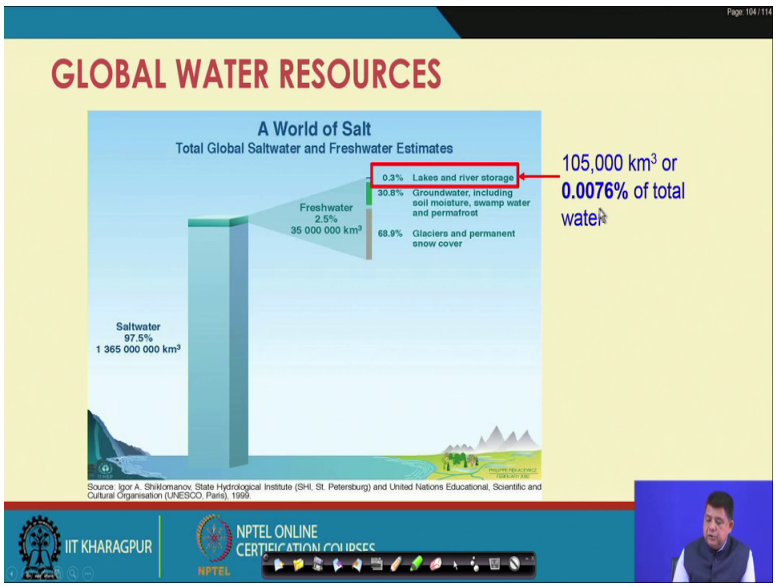

Now, we come to the second factor that is water that is if you look at the global water resources we already know that almost 97.5 percent of the total water resources are in oceans. And that is why we call called the world of salt and out of these only 0.3 percent

to 2.5 percent is freshwater and out of these fresh water only 0.3 percent of water that is available in lakes and rivers storages that is readily available for use for us that is around 105 lakh 105,000 cubic kilometer or 0.0076 percent of total water, that is only available for use for us.

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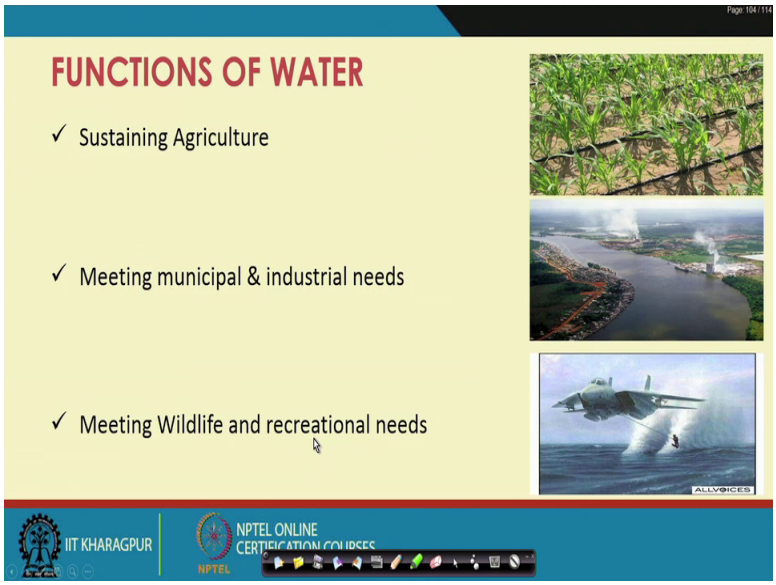

If you will look at the functions of water then obviously, sustaining agriculture is the most important use and if you look at the world data almost 82 to 84 percent of the total water resources are use in agriculture. If you look at India itself we use more than 90 percent of water in sustaining agriculture. So, agriculture is the largest user of the water.

Then of course meeting in important function in meeting municipal industrial needs and of course municipal needs that is drinking water supplies of course, of the most vital. So, that is the one of the major functions of water and lastly of course the water has to also meet the wildlife in recreational needs. So, these are the major functions of water.

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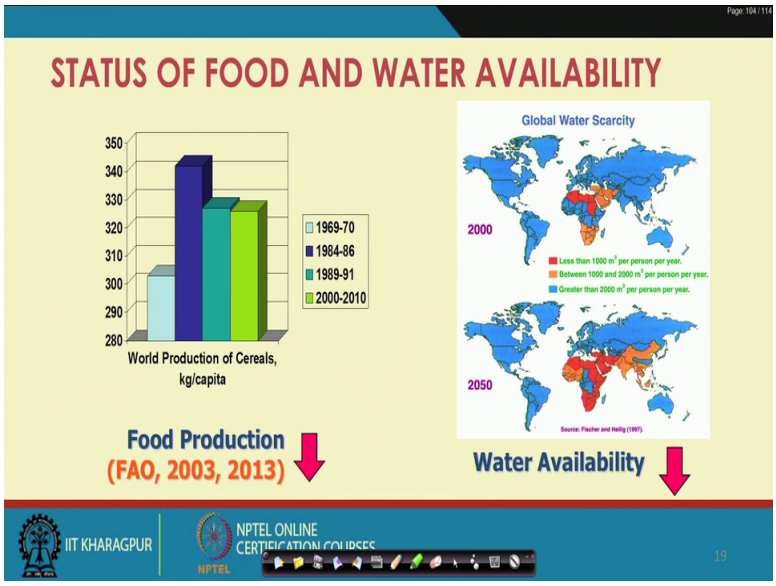

If you look at the status of food and water availability, and if you look at the food production statistics given by food and agriculture organization 2003 and 2013, we find that word production of cereals that is kg per capita was highest in mediates and now it is it has declined and almost it has stagnated.

Similarly, if you look at the global water scarcity if you look at 2000 data India was blue; that means, the water availability was greater than 2000 cubic meter per person per year, but come 2050 this color will change and availability will be between thousand and 2000 cubic meter per person per year. That means, we will we meet from water rich to water stress condition.

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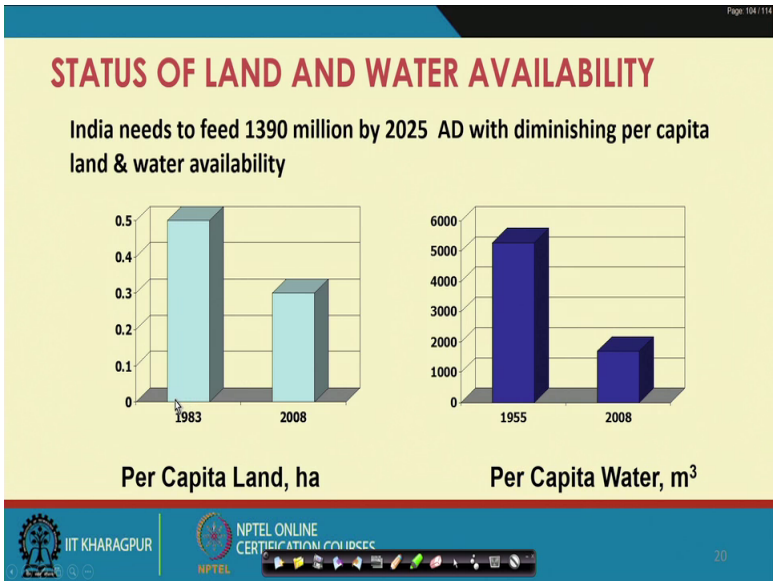

We in India need food and water to sustain around 1390 million of population by 2025, but problem is that per capita land and water availability is diminishing or decreasing. So, per capita land in hectare which was 0.5 hectors in 1983 has gone 2.3 by 2008. Similarly, per capita water cubic meter which was around 5000 in 1955, now it has come down to almost 1700. So, already we are water is stressed.

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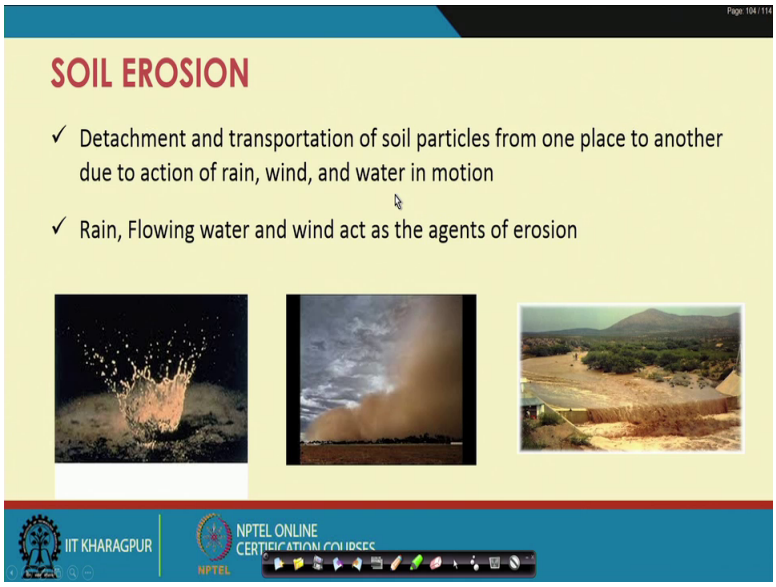

Now, coming to soil erosion what is soil erosion? Obviously, soil erosion is may be defined as detachment and transportation of soil particles from one place to another due

to action of rain, wind and water in motion and this rain flowing water and wind basically they act as the agents of erosion. So, detachment and transportation soil particles from one place to another due to action of rain, wind and water in motion that is soil erosion and rain, flowing water and wind are agents of erosion.

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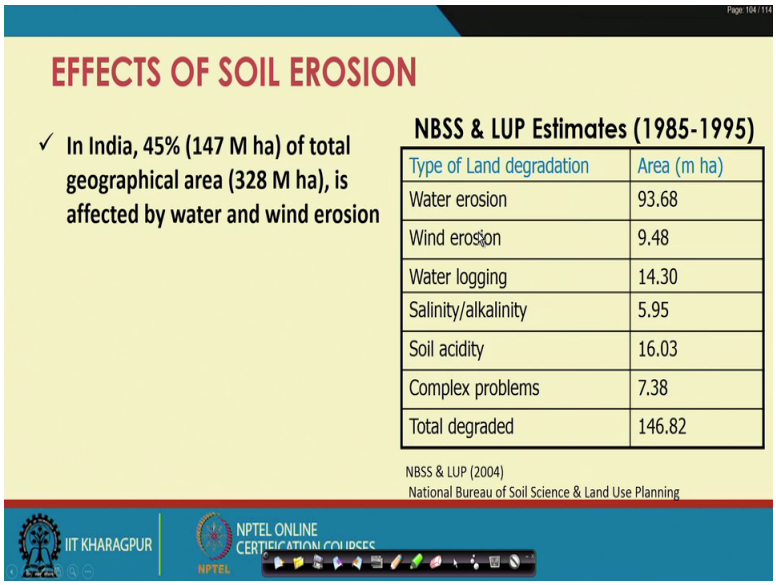

If you look at the effects of erosion in India around 45 percent of the total geographical area that is 147 million hectares out of 328 million hectors is affected by water and wind erosion and if you look at the statistics provided by National Bureau of Soil Science and Land Use Planning, NBSS and LUP. Then we find that almost 94 million hectares of land is affected by water erosion and around 9.5 million hectares of land is affected by wind erosion. So, this probably should tell you why we should study this course because water and window erosion is very important to manage our soil resources and water resources together. And if you can do that then we will be able to we will solve the water and food security problem.

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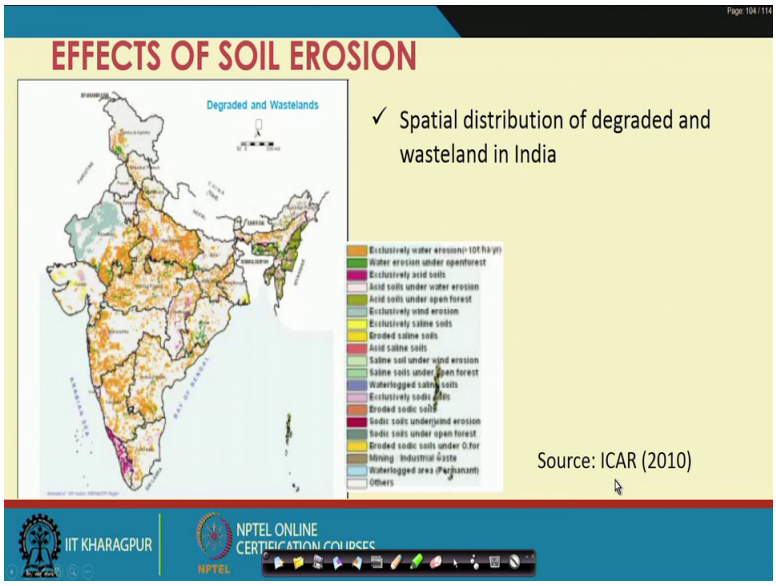

And, if you look at the effects of soil erosion if you look at the special distribution degraded in wastelands in India this is a data provided by Indian council of agricultural research in 2010 and if you see the colors see here most of the colors line the first column probably you cannot see, but this is basically reads exclusively water erosion problem. So, that means, these are the areas where water erosion issued, wherein if you look at the Rajasthan it is basically exclusively wind erosion.

So, if you can see the entire countries has is facing some kind of degradation due to soil erosion and that is why you must study this course and manage our soil resources properly.

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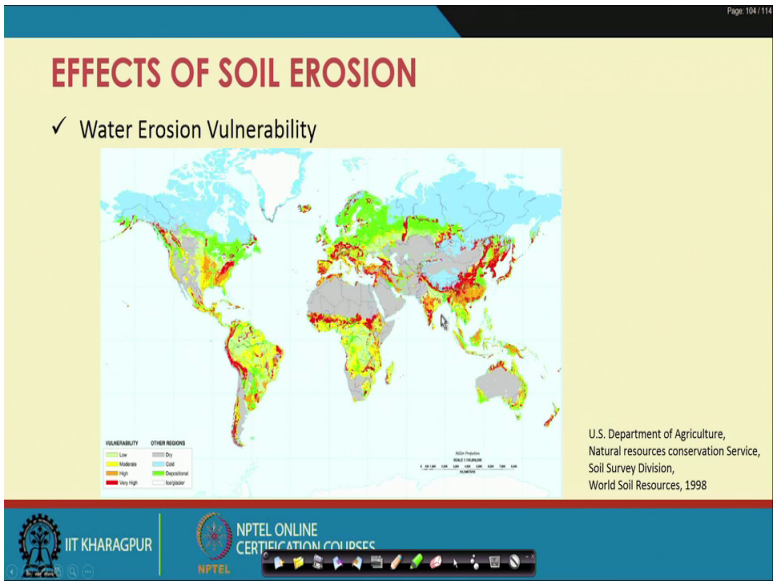

And, if you look at the water erosion vulnerability this is a data provided by U. S. Department of Agriculture, Natural resources conservation Service and if you look here and if you look an India the colors if you see that you see lot of shades of orange and red. So, that simply means that high and very high. So, most of the area in India is very high to very high in the high and too very high category of water erosion vulnerability.

So, I think with this background you will be probably able to understand the importance of soil and water conservations soil, and water soil erosion, and soil and water conservations. And, that is what precisely we will cover during the course of this study.

Thank you very much.