Soil Fertility and Fertilizers
Prof. Somsubhra Chakraborty
Agriculture and Food Engineering Department
Indian Institute of Technology, Kharagpur
Lecture No. 31
Soil Health and Quality, Problem Soil, Land Capability Classification

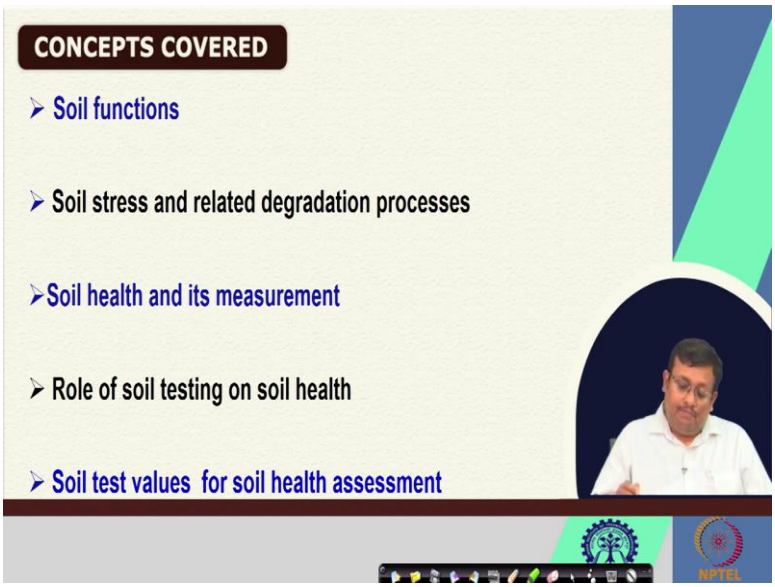
Welcome friends. I hope that you are doing good and today we are going to start a new week, week 7, of this NPTL online certification course of Soil Fertility and Fertilizers.

(Refer Slide Time: 00:32)

And in this week, we are going to discuss Soil Health and Quality, Problem Solve and Land capability classification.

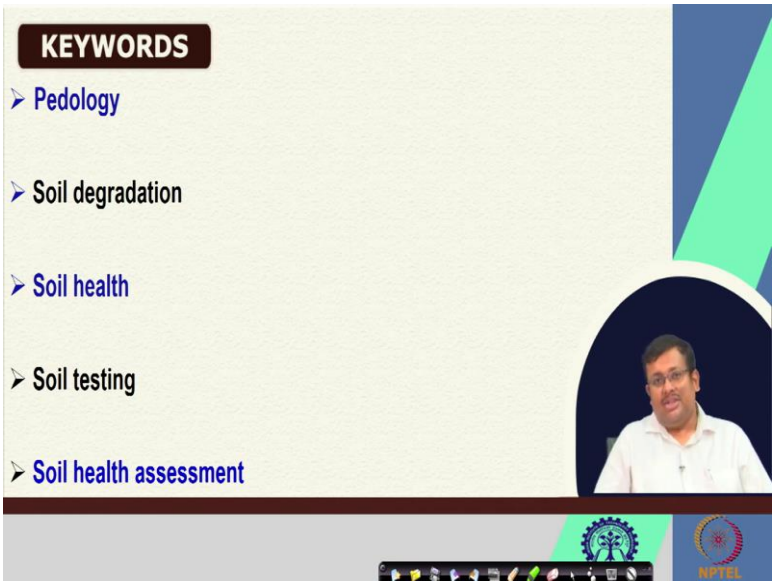
So, in this lecture, lecture number 31, we are going to recall some of the concepts of soil health and soil health indicators, which will be required for better understanding of soil degradation and how this soil degradation is impacting the, soil fertility. We are going to discuss those.

(Refer Slide Time: 01:27)



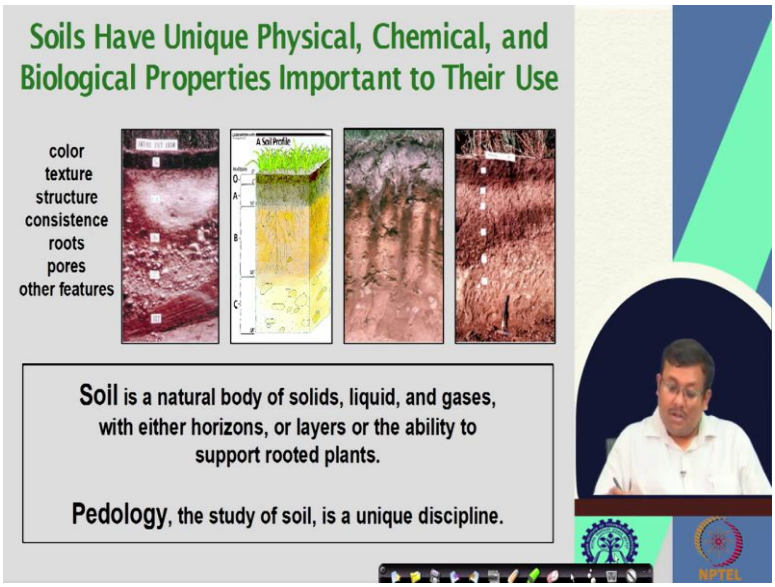
So, these are the concepts which we are going to discuss in this lecture. First of all, we are going to discuss soil functions. Then we are going to talk about soil stress and related degradation processes. And then we are going to discuss about soil health and its measurement. It will be kind of recall which you have already discussed previously. And then we are going to discuss, Role of soil testing on soil health. And finally, we are going to discuss soil test values for soil health assessment.

(Refer Slide Time: 02:06)



Now, if we see some of the keywords for this lecture Pedology, Soil degradation, Soil health, Soil testing, Soil health assessment. So, these are some of the keywords for this lecture.

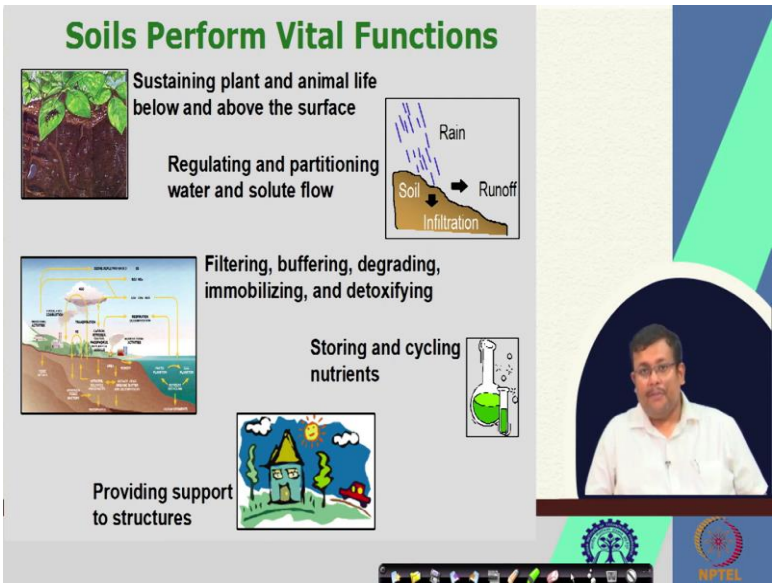
(Refer Slide Time: 02:23)



So, we all know that soils have unique physical, chemical and biological properties, which are important to and also, they are very much important. What are those? They are maybe soil colour, soil, texture, soil structure, soil consist soil, plant roots, soil pores, and other features. We need to remember that soil is a natural body of solids, liquids and gases with either horizon or layers or the ability to support rooted plants.

So, we already know from the definition of the soil, that it is an interface between hydrosphere, lithosphere, atmosphere and biosphere. And when we talk about Pedology, which is a study of soil origin and classification, it is a unique discipline, which describe how a soil is formed and how different characteristics of a soil can be used to distinguish it from other soils and identify its position in the ecosystem. So, the major crux of the slide is soils are unique and they have unique properties. And these unique properties are required for supporting the plants in the earth.

(Refer Slide Time: 04:15)



Now, what are the major functions of soil? First of all, soil can sustain plant and animal life below and above the surface. We know that it can regulate and partition water and solute flow. So, when there is a rainfall, the soil will determine how much will be infiltrated and how much will be lost to runoff. Also, soil can impact, the ecosystem by filtering buffering, degrading, and immobilizing and detoxifying some of the pollutants.

It can store and cycle nutrients. We have already know that how these macro and micronutrients like Nitrogen, Phosphorus, Potassium then Calcium, Magnesium, Sulphur and different micronutrients continuously revolves in different forms within the soil and other parts of the ecosystem. And finally soil gives the support to the structures. So, from the biological to structural functions, soil can provide our soil offers a huge amount of ecosystem services.

(Refer Slide Time: 05:59)

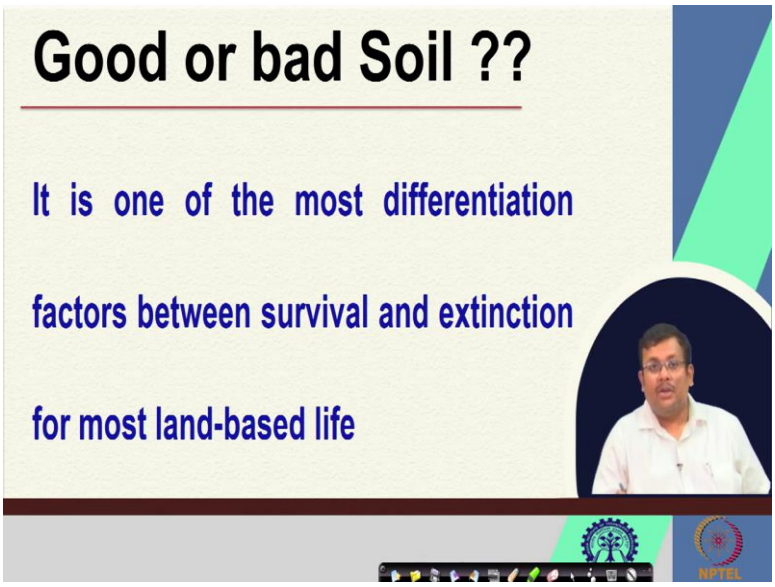
Now that is why soil is very much important. So, the question comes in our mind, why do we concern for soil. Leonardo DaVinci said, the famous painters said that why do we know more about distant celestial objects than we do about the ground beneath our feet? So, see, couple of hundred years ago, people also realized the importance of soil for maintaining the ecosystem.

American president Franklin Roosevelt once said that a nation that destroys its soil destroys itself. So, that clearly highlights the importance of soil in sustaining the nature. So, this is why soil is one of the most important natural resources.

(Refer Slide Time: 06:55)

And one more thing is thousand years are required to develop 25 millimetre of surface soil from parent materials through natural processes. So, the soil formation is a very, very slow process. And however, the soil degradation can remove the soil or can destroy the soil within a very short period of time. So, that is why that makes, that shows more, I mean, that shows the more importance of soil for and also that highlights the need for conserving the soil resources.

(Refer Slide Time: 07:52)

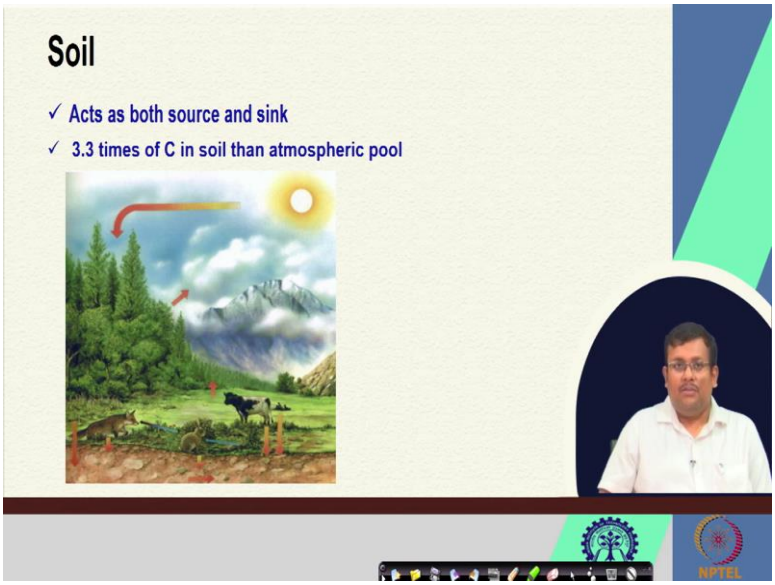


Now, what is good soil? What is bad soil? Now it is one of the most differentiation factor between survival and extension of most land based life. If the soil is continuously degraded, a time will come that that will impact the civilization, which you already know.

(Refer Slide Time: 08:17)

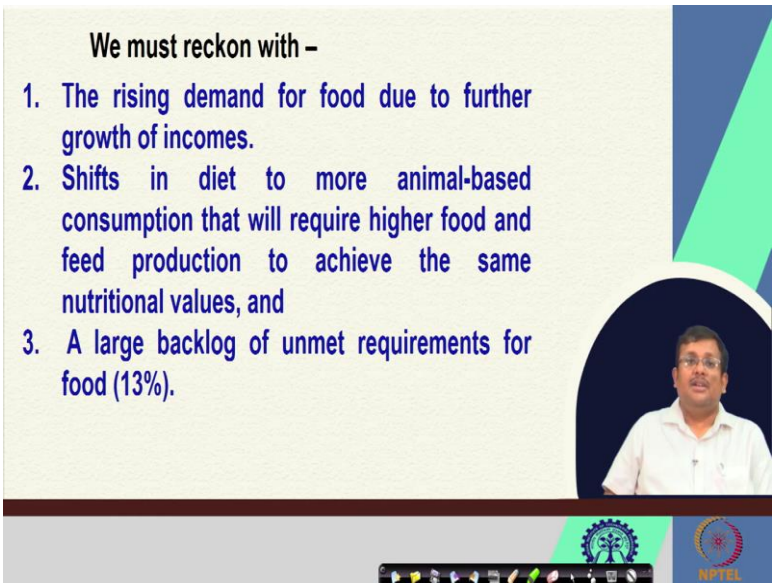
Archaeological evidence suggest that soil degradation was responsible for extinction or collapse of this 3 major civilization Harappan civilization in Western India, Mesopotamia in Asia minor and Mayan culture in central America. So, these are the 3 major civilization which were supposed to be destroyed by, which are supposed to be destroyed by, land degradation.

(Refer Slide Time: 08:54)



So, why soil is very important. Another reason for soil important, another reason for realizing the soil, importance of soil is soil access, both source and sink. As far as the carbon is concerned, it contains 3.3 times of carbon than atmospheric pool. So, soil contains huge amount of carbon, more than atmosphere. That is why in the, in the current scenario of global warming soil takes an important role.

(Refer Slide Time: 09:41)



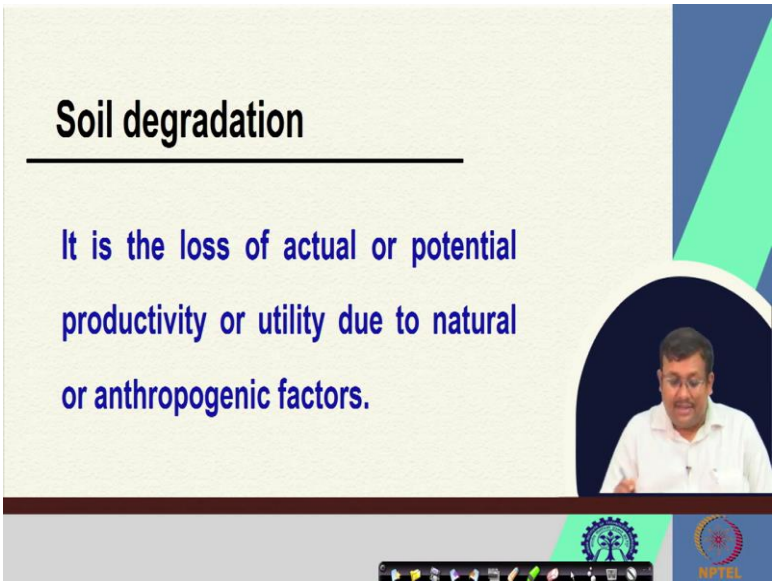
Now, that is why we must reckon with the rising demand for food due to further growth of income and shifts in diet to more animal-based consumption that will require higher food and feed production to achieve the same nutritional values and a large backlog of unmet requirements for food just 13 percent. So, these are some of the important points we should consider while discussing the importance of soil and discussing the ill effects of land degradation.

(Refer Slide Time: 10:32)

So, what are the common anthropogenic stresses on soil? There are 4 major common anthropogenic stresses on soil. First one is agricultural operations, second is deforestation,

third is warfare and fourth one is natural calamity. So, anyone of these 4 anthropogenic stresses can cause soil degradation.

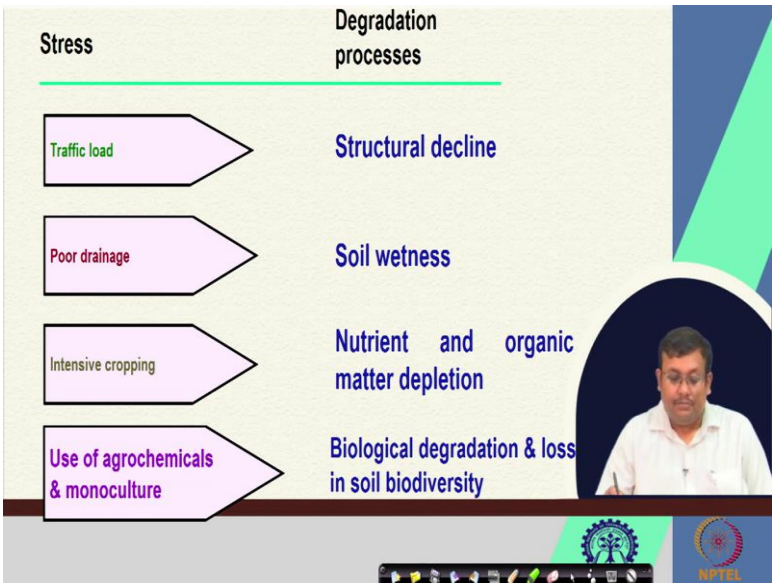
(Refer Slide Time: 11:06)



Now, what is soil degradation? Soil degradation is basically the loss of actual or potential productivity or utility due to natural or anthropogenic factors. When soil losses, it's productivity or utility due to different types of natural and anthropogenic factors, then we call it a soil degradation.

What are the, what is soil productivity? We already know soil productivity is the ability of the soil to produce the crop build in terms of economic yield. So, soil degradation leads towards actual or potential product, leads towards declining productivity of the soil due to mainly anthropogenic factors.

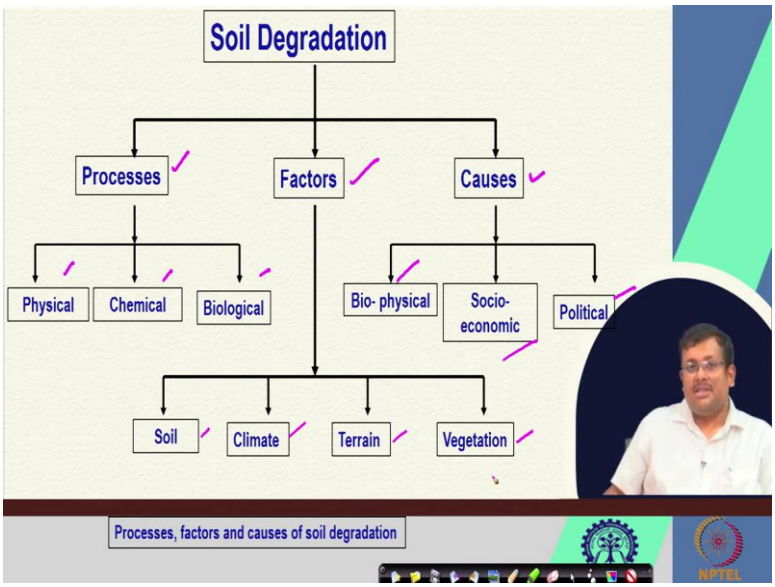
(Refer Slide Time: 12:10)



Now, if we see the stress and different types of degradation processes, if there is a stress of traffic load, it will create the structural decline. If there is a poor drain that will create soil wetness, if there is intensive cropping that will create nutrient and organic matter depletion. And finally, when we go for use of agrochemicals and monoculture setting that can lead to, biological degradation and loss in soil biodiversity.

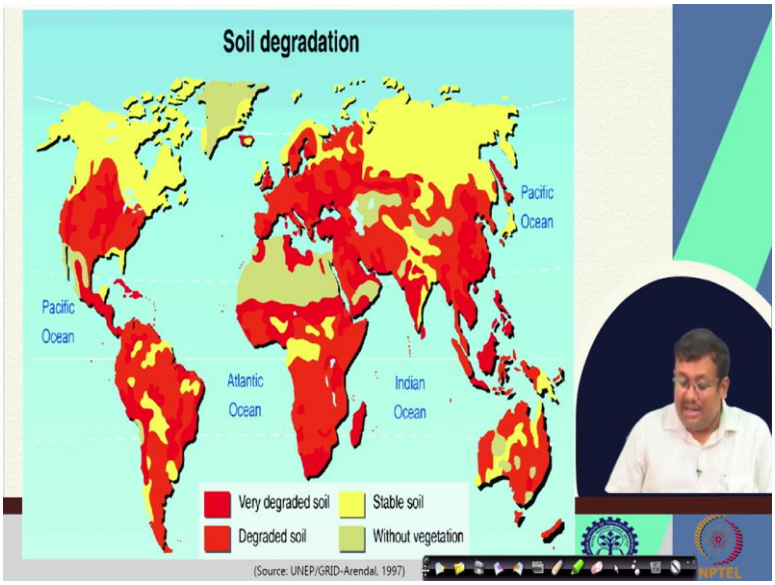
So, to maintain the soil diversity biodiversity use of synthetic agrochemicals should be minimized. And also we should, follow the crop rotation to maintain the soil biodiversity. Of course, when there is an intensive cropping that also can create nutrient and organic matter depletion, because there are some high, this nutrient will be up taken by the plants and due to the crop removal, these nutrient will be lost from the soil. And also the organic matter will be oxidized and there will be depletion of organic matter. So, these are different types of stresses due to different types of anthropogenic processes.

(Refer Slide Time: 13:42)



Now, if we see the soil degradation, the soil degradation can be divided into different processes, factors, and causes. So, the processes could be either physical, chemical, or biological and factors of soil degradation can be classified into soil factors, climate factors, terrain factors, and vegetation factors. Among the causes of soil degradation of course, there are some biophysical reason there are socio economic reason. And of course, there are some political reasons also. So, this schematic diagram, or I would say it is this flow chart basically shows the snapshot of soil degradation process.

(Refer Slide Time: 14:53)

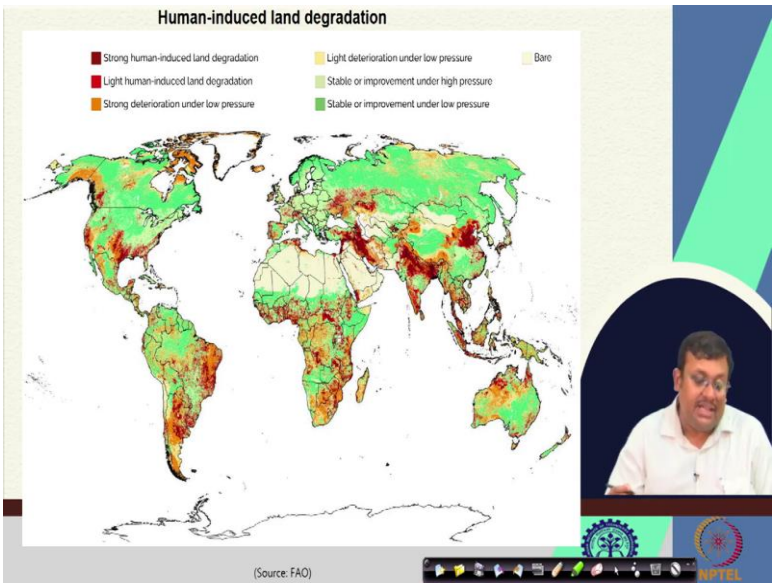


So, if we go ahead and see the global soil degradation, So, this is quite clear that in different countries, we can see a huge amount of soil degradation are going on, including the US,

Southern America in Africa, in Asia, in Europe, as well as in Australia also. So, this red colour, shows the very degraded soil. So, you can see in India also the considerable part, if Western and, in central India, we can see very degraded soil and also some amount of soil are without vegetation or stable.

So, this is the global scenario of, soil degradation. Of course, this data is, quite old. It is 1997 data. However, the soil degradation has been increasing since then. And right now, the soil degradation process has increased, the soil degradation has increased, in the global scale.

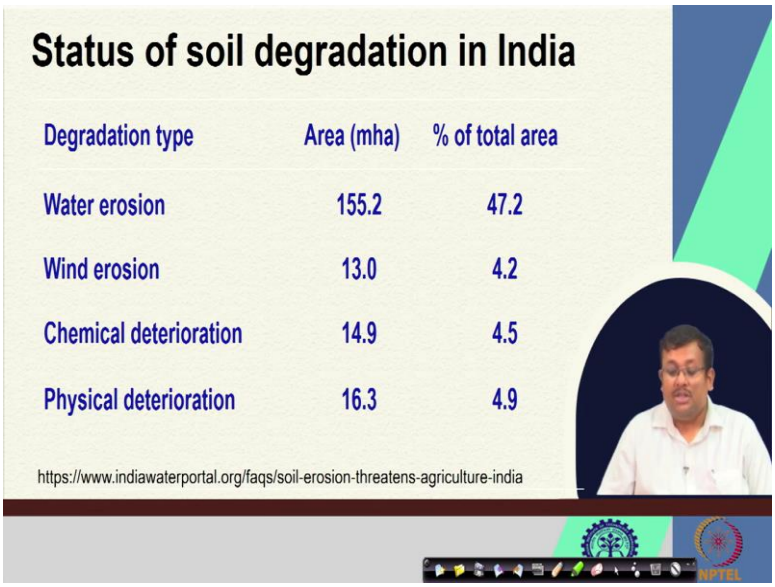
(Refer Slide Time: 16:18)



So, also this, map shows the human induced land degradation, these red patch, this, brown patch shows strong human induced land degradation. These rate patches are showing light human induced land degradation. And these yellow patches are showing strong deterioration under low pressure and yellow patches shows light deterioration under low pressure. And these green patches are shown, showing the stable or improvement under low pressure.

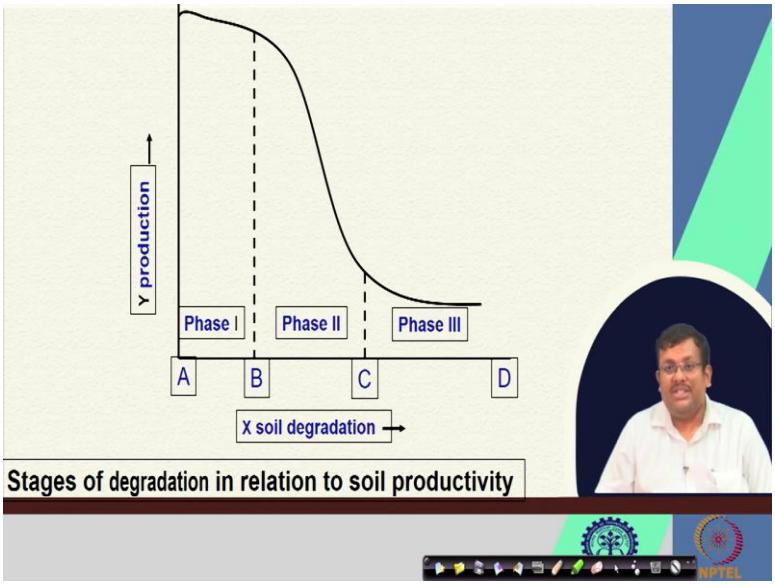
So, we can see in India, Indian subcontinent, as well as in some parts of China, in some parts of, Asia, Africa, south America and north America, we can see strong human induced land degradation. So, that shows the anthropogenic impact on land degradation.

(Refer Slide Time: 17:19)



If you see the status of soil degradation in India, this is, there were different types of degradation, like wind water erosion, wind erosion, chemical deterioration and physical deterioration. So, water erosion accounts for 155.2 million hectare, which is 47.2 percent of the total area, wind erosion accounts for 13 million hectare, which is 4.2 percent of the total area, chemical deterioration accounts for 14.9 percent of the total of, million hector, which is 4.5 percent of the total area and physical deterioration accounts for 16.3 million hector, which is 4.9 percent of the total area.

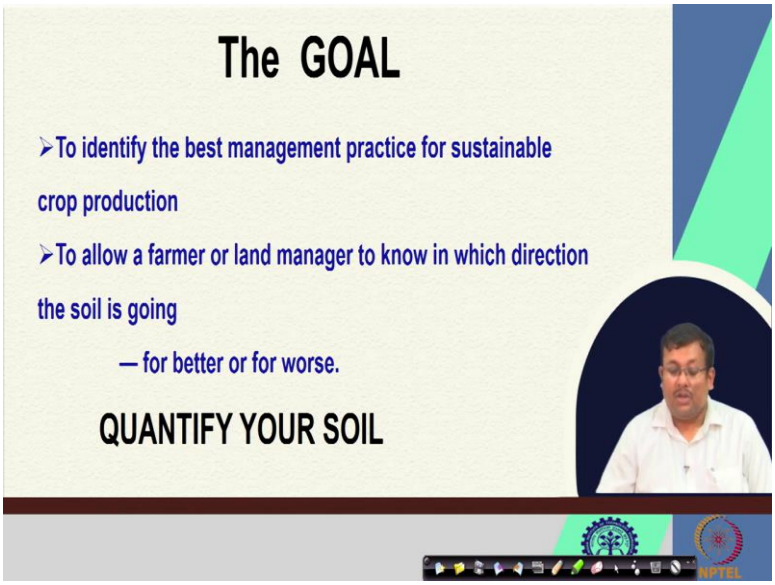
(Refer Slide Time: 18:04)



Also, if you see the relationship between soil degradation and production, crop production, we can see that our soil productivity, we can see there are 3 different phases, phase 1, phase 2

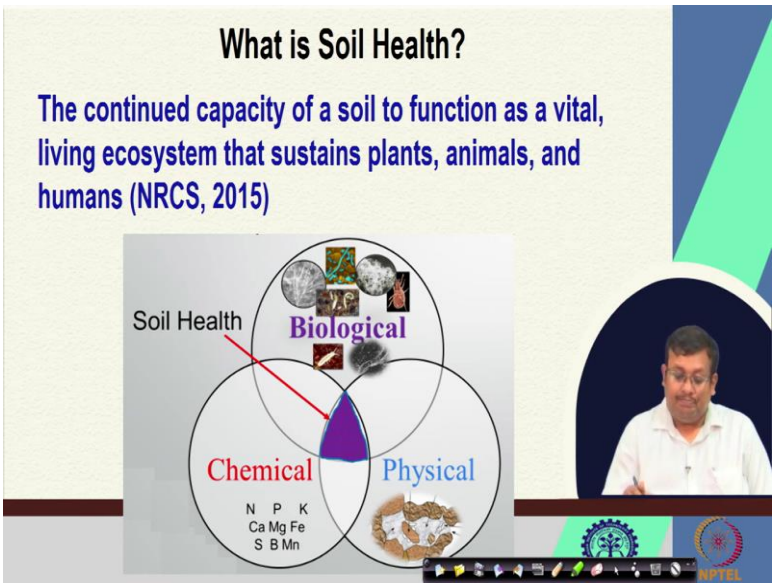
and phase 3, when soil degradation goes from phase 1 to phase 2 to phase 3, of course there is decrease in production or soil productivity.

(Refer Slide Time: 18:30)



So, what is the goal as a scientist or as a soil scientist or environmental scientist would be, our goal will be to identify the best management practice for sustainable crop production and to allow a farmer or land manager to know in which direction the soil is going the for better or for worse. So, we have to quantify your soil or our soil. So, that we can identify the present status of the soil and the future direction in which the soil is going.

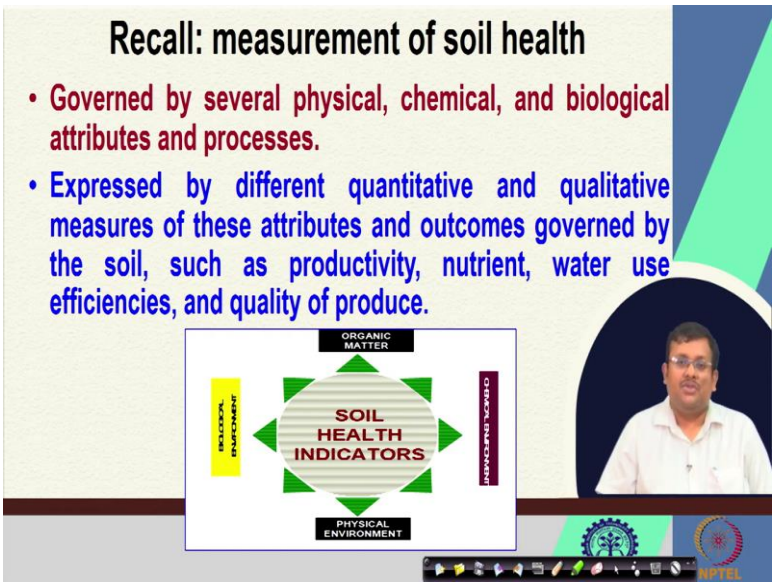
(Refer Slide Time: 19:15)



So, now the next important thing is what is soil health? It will be kind of recap. We already know what is soil health. It is a continued capacity of his soil to function as a vital living

ecosystem that sustains plant animals and humans. This definition was given by Natural Resources Conservation Service of USD in the year 2015. Of course, soil health is an interplay between biological properties, physical properties, as well as chemical properties of the soil.

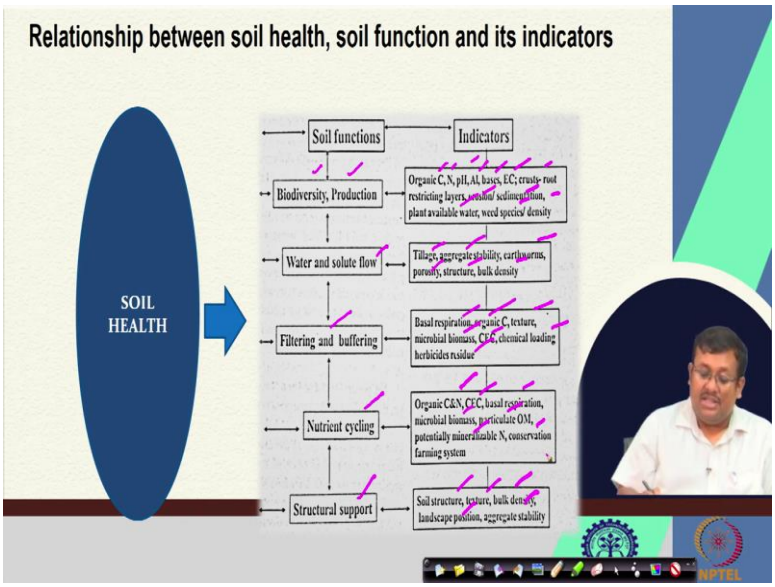
(Refer Slide Time: 19:51)



So, how to measure the soil health. We know that soil health is governed by several physical, chemical and biological attributes and process, and it is expressed by different quantitative and qualitative measures of these attributes and outcomes governed by the soil, such as productivity, nutrient, water use, efficiency and quality of produce, we already have discussed this in our previous lectures.

So, if we see the soil health indicators, there are physical environment, ecological environment, organic matter, and as well as the chemical environment. So, not only the physical, not only the chemical, but also biological and organic matter plays an important role for maintaining the soil health.

(Refer Slide Time: 20:45)



So, if you see the relationship between soil health, soil function and its indicators, it will be quite clear that when you talk about the soil functions like biodiversity and production, these are indicated by organic Nitrogen, organic Carbon pH, then aluminium basis, electrical conductivity, crust roots restricting layers, then erosion, sedimentation, plant available water, wind speed, and density.

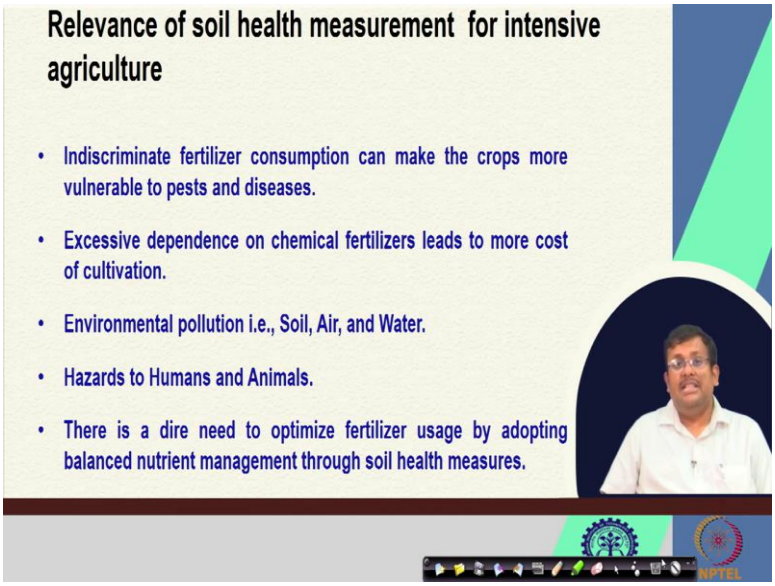
When you talk about water and solid flow, it is indicated by Tillage aggregate stability, earth worms, porosities, structure and bulk density. When you talk about filtering and buffering, it is determined by Basal respiration, organic carbon texture, microbial biomass, Catenation, capacity, chemical loading herbicide residues.

When you talk about when the soil function is basically nutrient cycle, that is determined by this indicators like organic Carbo Nitrogen, Catenation capacity, battle respiration, microbial, biomass, particulate organic matter potential mineralizable nitrogen and conservation farming system. When it is structural support, it is determined by soil structure, texture bulk density, landscape position, and aggregate stability. So, these are the indicators of different soil functions, which governs the soil health.

(Refer Slide Time: 22:14)

Now so, we have to remember that healthy soil support ecosystem function like water storage and infiltration carbon capture, plus storage, or carbon sequestration, biological function, plus diversity, and also productive capacity. So, it is very important to maintain the soil health for maintaining the ecosystem function.

(Refer Slide Time: 22:38)

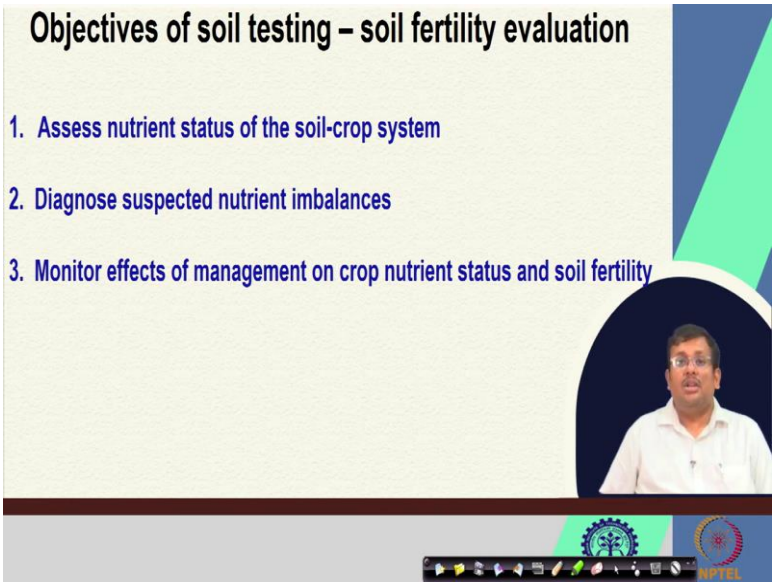


Now, what is the relevance of soil health measurement for intensive agriculture? Remember that indiscriminate fertilizer consumption can make the crops more vulnerable to pets and diseases and excessive dependence on chemical fertilizer leads to more cost of cultivation. So, when we go for indiscriminate fertilizer consumption the crops are more vulnerable to pests and diseases. And, and finally, when we go for excessive dependence on chemical

fertilizers, that also increases the cost of cultivation also creates the environmental pollution like soil pollution, air pollution, water pollution, it can produce hazards to human and animals.

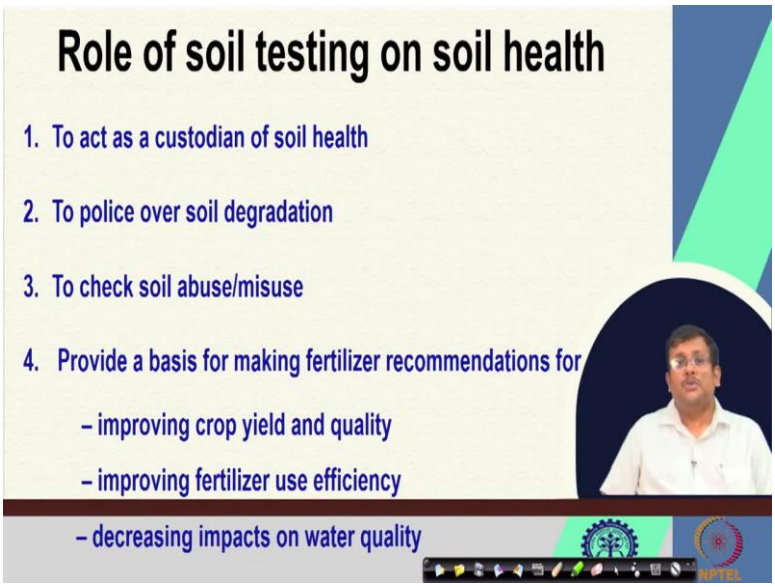
So, there is a dire need to optimize the fertilizer usage by adapting, balanced nutrient management through soil health measures. So, that is why it is, soil health measurements is very important for maintaining the intensive agriculture.

(Refer Slide Time: 23:52)



Now, what are the objectives of soil testing for soil fertility evaluation? We know that first of all, to assess the nutrient status of the soil crop system, second diagnose suspected nutrient imbalances. And third is monitoring effects of management on crop nutrient status and soil fertility. So, these are the 3 major objectives of soil testing for soil fertility evaluation.

(Refer Slide Time: 24:24)

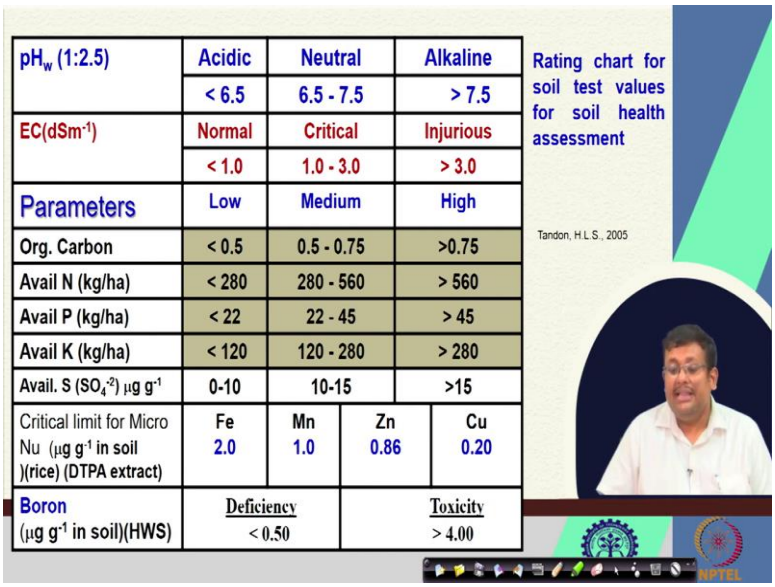


So, the next question comes to our mind, what is the role of soil testing on soil health? First of all, soil testing acts as a custodian of soil health to maintain the soil health. It is very much important to go for soil testing. Otherwise, we do not know as I have mentioned that there are several chemical indicators and physical indicators for soil health, unless we do soil testing, how do we know that which one indicator is present in what quantity that means whether they are present in high, medium, or low quantity.

So, that is why soil testing acts as a custodian of soil health. Also soil testing police over soil degradation. Now, if you continuously test your soil for soil organic carbon and other features, soil, bulk density, soil structure, and all these things, you will be aware of the soil, strength and soil ecosystem functions.

And also you can monitor the soil degradation process. Of course, when you go for the soil testing, you can check for soil abuse and misuse, and you can provide a basis for making fertilizer recommendation for improving crop yield and quality improving fertilizer use efficiency and decreasing impacts on water quality. So, these are the major role of soil testing for maintaining the soil health.

(Refer Slide Time: 26:06)



pH_w (1:2.5)	Acidic	Neutral	Alkaline
	< 6.5	6.5 - 7.5	> 7.5
EC(dSm^{-1})	Normal	Critical	Injurious
	< 1.0	1.0 - 3.0	> 3.0
Parameters	Low	Medium	High
Org. Carbon	< 0.5	0.5 - 0.75	>0.75
Avail N (kg/ha)	< 280	280 - 560	> 560
Avail P (kg/ha)	< 22	22 - 45	> 45
Avail K (kg/ha)	< 120	120 - 280	> 280
Avail. S (SO_4^{-2}) $\mu g\ g^{-1}$	0-10	10-15	>15

Critical limit for Micro Nu ($\mu g\ g^{-1}$ in soil)(rice) (DTPA extract)	Fe	Mn	Zn	Cu
	2.0	1.0	0.86	0.20

Boron ($\mu g\ g^{-1}$ in soil)(HWS)	Deficiency	Toxicity
	< 0.50	> 4.00

So, there is a rating chart for soil test values for soil health assessment. It is, this chart has been compiled from, this source Tandon. And remember that here we have given that different soil properties and their different ranges. Of course, you will see for several elements, the ranges, which is mentioned here will not be exactly matching the ranges which we have discussed in our last week. That means week 6 of lectures, where we have discussed about high, medium, and low.

Remember the critical nutrient concentration as I have mentioned, couple of times. The availability or the, of these, or the low, medium, or high ranges of these different nutrients vary from soil to soil vary from one region to another region. However, if you see there are almost similar to each other.

So, do not guess please do not get confused about the minor differences, which is press, which is there in the normal, and then in the low, medium and high ranges of different nutrients.

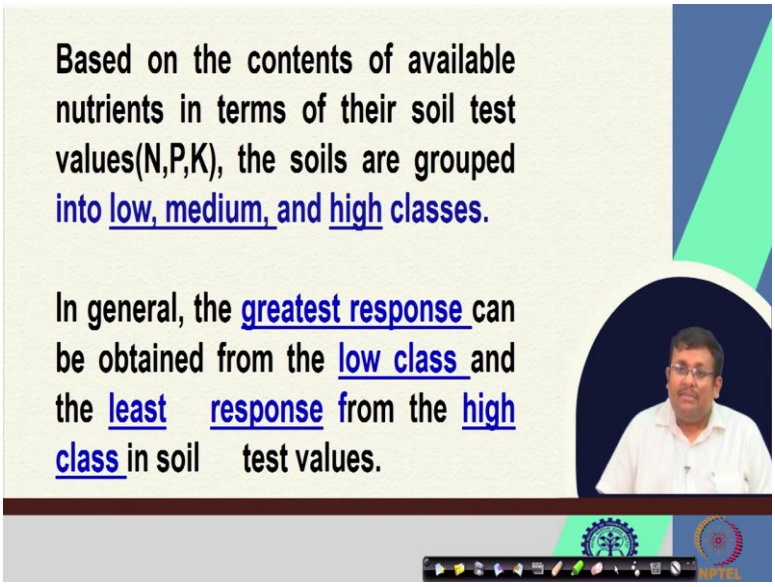
So, if we see the pH of, 1:2.5 soil water suspension, we can see that if it is a less than 6.5, we call it acidic. When it is 6.5 to 7.5, it is neutral when it is more than 7.5, it is alkaline. For electrical conductivity critical is 1, 2, 3 injurious is greater than 3. And normal is less than 1. Sometime we call it a 4 decisisa per meter as a threshold value. When it is more than 4, it is called saline soil.

However, here you can see it is less, greater than 3. So, in general, we consider 4 as a threshold limit. When you consider organic carbon, of course, 0.5 to 0.75 percent is medium

range while less than 0.5 it is low and greater than 0.75 it is high. For available nitrogen 280 to 560 is the medium range. When it is less than 280, it is low, but is more than 560 it is high.

So, in this fashion, you can see available phosphorus, potassium, sulphur and different micronutrients and boron are also given. Remember, these values may not exactly match with the values which you have already discussed, but they are very close to each other. So, these are the rating chart for soil test values for soil health assessment.

(Refer Slide Time: 29:06)



Now based on the contents of available nutrients in terms of their soil test values like N P K the soils grouped into low, medium and high classes we know that. Now in general, the greatest response can be obtained from the low class and the least response from the high class in soil test values. We have already discussed that in our lecture number 30. So, this marks the end of this, lecture 31, where we have discussed about the soil health and soil importance of soil health.

What are the indicators of the soil health? Why we should be concerned about soil degradation? What is soil degradation scenario in India? What are the indicators of soil degradation and how soil testing can monitor the soil degradation processes. And also we have discussed about the rating chart of different soil properties. So, let us wrap up this lecture here and in our next lecture, we will start from here and we will discuss more about soil testing and soil degradation and land capability classification. Thank you very much.