Wildlife Ecology
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Lecture – 06
Biodiversity-II

[FL] In the last lecture, we had started with our discussion of biodiversity and in today's lecture we will look at Biodiversity in greater detail.

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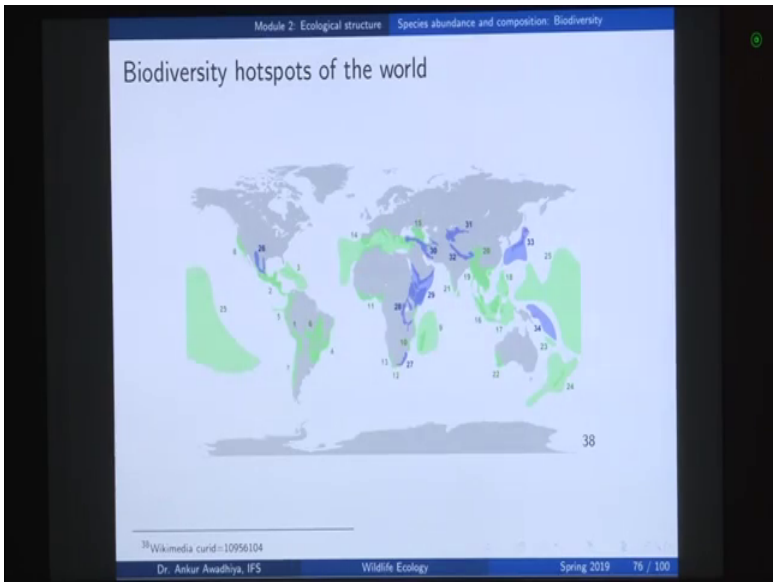

So, we had ended with the last lecture with the slide, biodiversity hotspots of the world and we had defined a hotspot as a region where we have a large amount of species richness that is a number of species are found per unit area there. They are also regions with a high degree of endemism. So, a number of species that are found there are found only there, they are not found anywhere else. So, if we lose them at those locations we would not have any backup of these species. And, third these are areas that are facing a large amount of threat because of say diseases or forest fires or maybe anthropogenic influences like people wanted to convert these forests into plantations or agricultural lands or residential lands or for roads and so on.

Now, if we look at this map these are the locations with a high degree of species richness. Now, a question arises why are there some regions that have a high degree of species richness and why are there some locations on the earth that have a low amount of

species richness. Now, in particular we can see that the areas between the Tropic of Cancer and the Tropic of Capricorn are the areas that predominantly have a larger amount of species richness. On the other hand if we look at the areas that are on the very north or south that is the Arctic region or the Antarctic region there is very little amount of species richness.

Now, what makes certain areas to have more amount of richness and what makes certain areas to have less amount of species richness or more biodiversity or less biodiversity.

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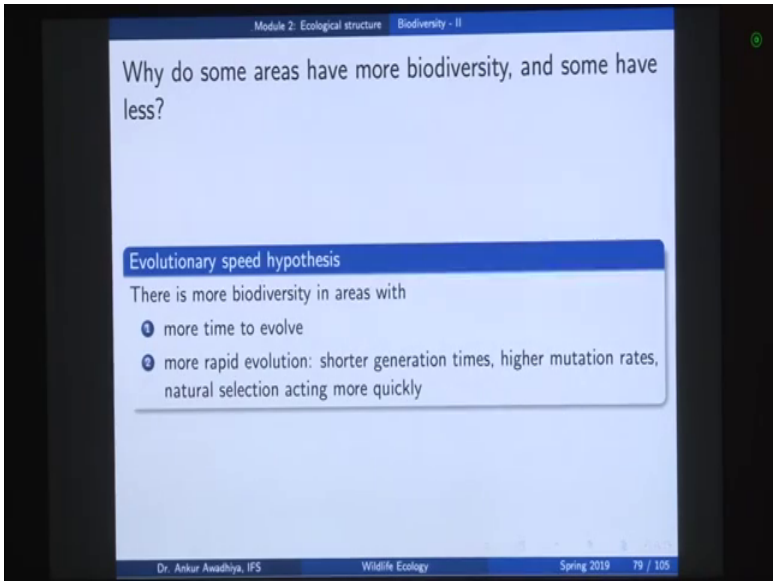

So, there are a number of hypotheses that have been put up and essentially this is a combination of the evolutionary processes and the ecological processes. Now, it is difficult to dissect for any particular region whether it is the evolutionary processes that are dominating all the ecological processes that have dominating. So, which is why we are still talking about the hypothesis and we have not formulated any theories about them. But, then these hypothesis gave us give us a good understanding of the factors that can be responsible for having more or less amount of biodiversity in any area.

So, the first hypothesis is known as the evolutionary speed hypothesis. Now, evolutionary speed hypothesis suggests that all the biodiversity that has been created has been has been created because of the process of evolution. Now, for any pocket of land or water on the earth the number of species that would be there would depend on – 1, the

time for which evolution has happened there and 2, the speed at which the evolution has happened there.

So, essentially there is more biodiversity in areas with more time to evolve. So, basically areas that are older would be having more number of species and 2 – more rapid evolution. So, if there are areas that have shorter generation times or higher mutation rates or natural selection that is acting more quickly than those areas would be having a greater amount of biodiversity. Now, an intuitive example for areas that differ regarding the time of labour for evolution would be the case of old islands versus new islands.

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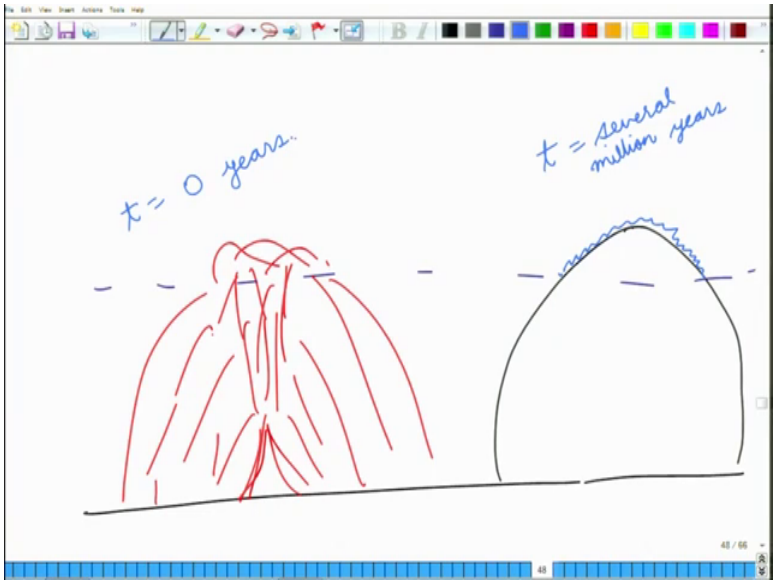

Now, suppose under the surface of some ocean we have; so, this is the seabed and suppose there is a volcanic eruption here which gives out the magma and with time we have a new island that has just appeared on the surface of the sea. Now, because this island was constructed using molten materials so, essentially it would not be having any species whatsoever on the surface of this island. And, if we consider an older island nearby which was created say many millions of years back, so, in that case this particular surface would be teeming with a number of organisms or teeming with a large amount of biodiversity.

Because, here the time available for evolution has been see several million years whereas, here the time available for evolution is essentially 0 years. Now, even this particular island would start getting biodiversity which is through a process that we call

its succession and we look at succession in greater detail in one of the later lectures, but then it is important to note that the time that is available for evolution is an important factor to determine the amount of biodiversity that we will have in an area. The second thing is more rapid evolution now, more evolution could happen because of shorter generation times.

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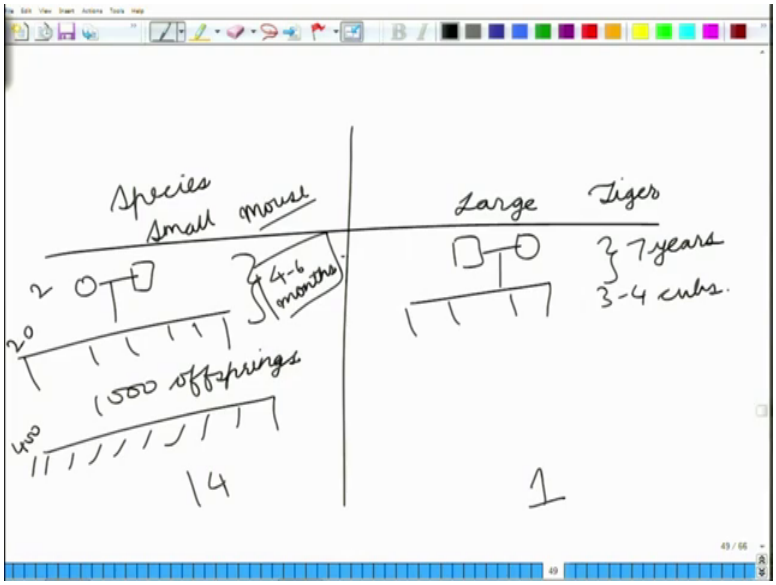

Now, shorter generation times means that for species; so, let us consider two species here: one is a small species and the second one is a large species. Now, in the case of this small species one pair of parents give rise to say 1000 off springs and these off springs and will then give rise to further number of off springs and the time between these two stages is say of the order of a few minutes or a few hours. So, let us say let us consider the case of bacteria. So, E-coli takes around 20 minutes to perform a cell division.

In this particular case let us consider some sexual reproducing organisms. So, for instance we could consider a species of mouse. So, in the case of mouse the generation time would be say a few months say 4 to 6 months. Now, in 4 to 6 months you have moved from 2 individuals to say 20 individuals to say 400 individuals. On the other hand we have some other species that are large in size. So, a good example could be the tiger. Now, in the case of a tiger when you have a meeting it would generally result in say 3 to 4 cubs and the time to sexual maturity for these cubs is of the order of a few years say around 6 to 7 years. So, let us call it as 7 years. Now, in this period of 7 years the smaller

population of mouse would have had a number of generations. So, let us consider that this had 6 months of generational time. So, in that case when it has 1 generation it would be having as much as 14 generations and at the same time the number of off springs that have been produced is also large.

So now, if you have a shorter generation time, so, if you have say just a hundred thousand years for evolution and if the species are such that they have shorter generation times. So, they will be having more number of generations and so, there would be a more rapid evolution. So, we will start observing differences in the populations with the time. Also areas which have high mutation rates; now you can have a high mutation rate in area say that has a uranium mine. So, that has a larger amount of background radiation or areas that are say having some other heavy metals which are leading to some amount or say some chemicals that are leading to higher mutation rate. So, those areas will also be observing a more rapid evolution and third is natural selection that is acting more quickly.

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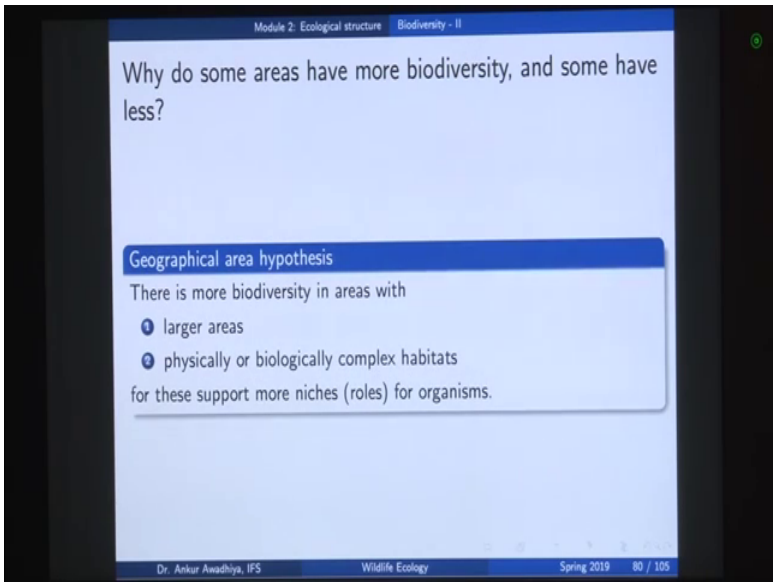

Now, the second hypothesis is known as the geographical area hypothesis. Now, geographical area hypothesis says that there is more biodiversity in areas with have which have larger areas and which have physically or biological complex habitats because these regions support more niches or roles for organisms. Now, what do we mean by that.

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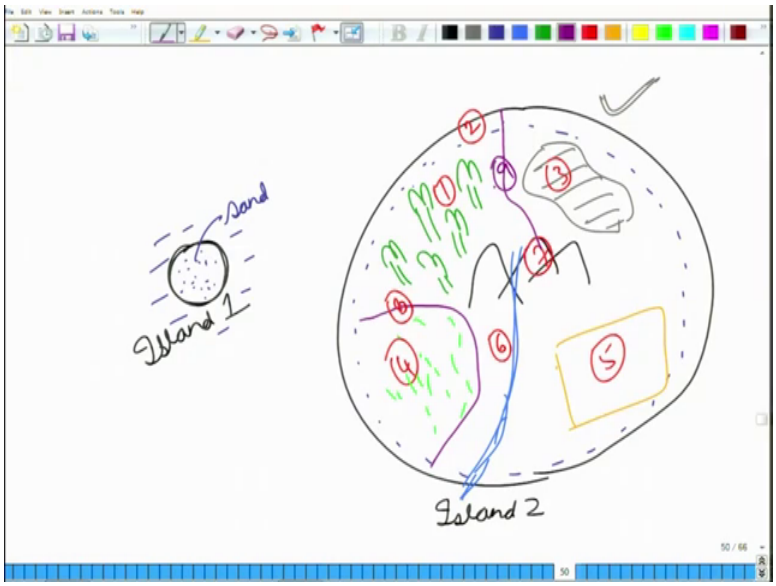

Now, suppose you have two areas; one is this small area and this then this is the second larger area let us consider that these are two islands. So, this is your island 1 and this is island 2. Now, because this island 1 is a small island so, probably it would be having a fewer number of habitats that are around. So, that is quite possible that in a very smaller island the whole of the areas covered with sand. So now, you have sand and then you have water around it. Now, in this case you only have a single kind of habitat.

In the case of the larger island you would have a strip of sand that would be there on the periphery, then it is possible that in the centre you have some hills, you could even have a small rivulet of sorts that flows through these hills. There could be some areas that are plains, there could be some areas that are forested, there could be some areas that are mostly full of grasses, there could be some areas that have a swampy vegetation. So, in the case of island 2 we have a larger variety of habitats.

Now, island 1 would be able to support a very smaller biodiversity because every species has specific requirements regarding it is habitat. So, it would only support those species that can live on sand or can live on the confluence between sand and water. However, in the case of island 2, here we can observe that we will have one species that lives in the forest, another species that lives on the conflict between sand and water, a third is species that lives in the swampy lands, a fourth species that lives in the grasslands, a fifth the species that lives on flat lands, a sixth species that lives in rivers, a seventh species that

lives on the hills and also other species that live at the other confluences. So, here we will be having a species that lives on the confluence between forest and grasslands. So, here you have an eighth species, then you might even have a species that lives at this conference at the ninth conference which is between the forest and the swampy lands.

So, more amount of complexity in the habitat physically or biologically more complex habitats will correlate with a larger amount of biodiversity and for areas that are larger in size it is more probable that you will be having a more varied habitat condition that are available. So, geographical area hypothesis says that you will have more biodiversity in areas that are large and in areas that are physically or biologically more complex.

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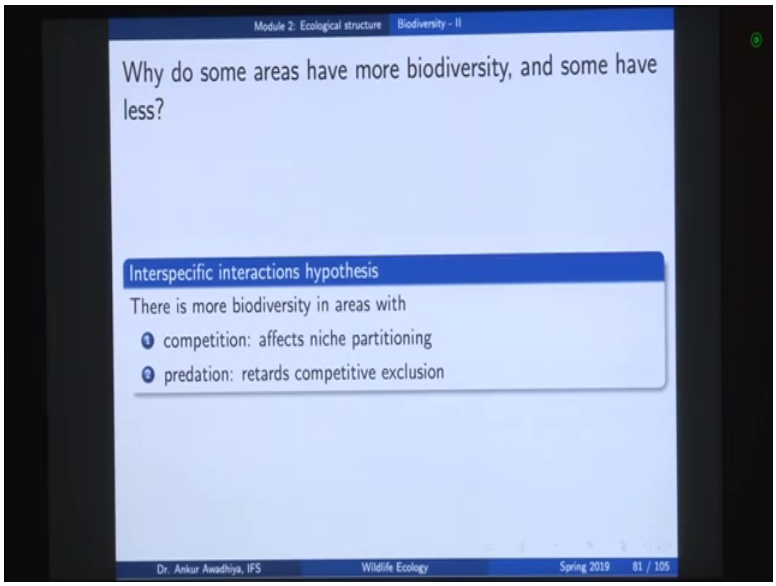

Now, the third hypothesis is called inter specific interactions hypothesis. Inter is between, specific is a species; so, we are considering the interactions that are happening between species. So, these are community level interactions not population level interactions and this hypothesis says that there is more biodiversity in areas with competition because it affects niche partitioning. Now, what does that mean?

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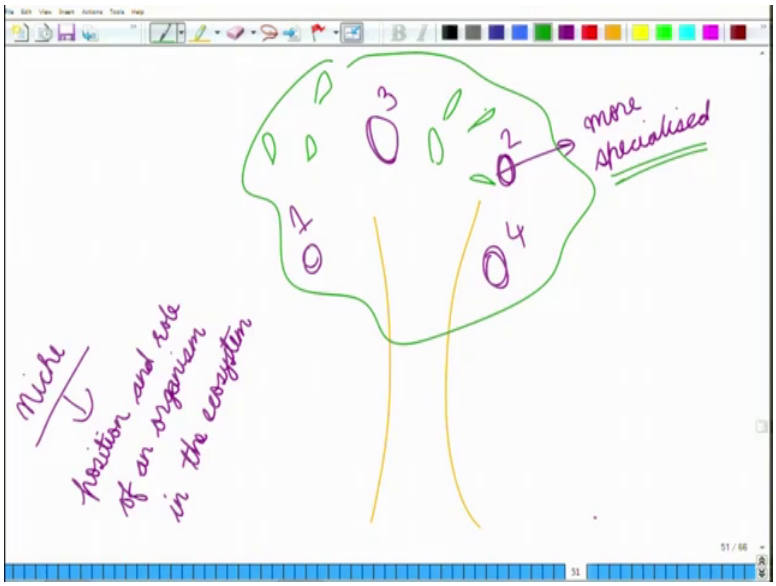

Now, suppose you have an area where you have a tree and in this tree suppose we have say two species of birds. So, this is species 1 and then this is species 2 and because these species are not having a very large number of individuals so, the amount of competition is less. If that happens when the competition level is low both of these species could use the same niche. Now, niche the term refers to the position and role of an organism in the ecosystem.

Now, when we see that both of these organisms are occupying the same niche we mean that they are in the same position. So, both of these are cannot be dwelling birds for instance and they are performing the same role. So, for instance both of these species are performing the role of eating fruits and dispersing the seeds. So, when that happens we will have a situation where both of these can live in the same niche.

Now, suppose with time you now have more number of birds; you have a third species and a fourth species. Now, when that happens that the number of fruits that are given out by this tree are limited. So, now, you have a situation of competition not everybody can have access to the food. When that happens some of these birds will try to become more specialized. Now, what do we mean by more specialized?

As we know in the case of a tree the fruit has the largest amount of nutrients. So, that is the most edible part that is available in a tree, but then there could be other parts say leaves. Now, in the amount of nutrition that you can have from leaves is typically less

than the amount of nutrition that you can have from the fruits, but when this bird tries to become more specialized it is a because it is not able to compete with the other species, it now tries to live on the leaves. It tries to eat leaves and get its nutrition from there.

Now, when that happens which time will observe that the that the body parts of the bird will start evolving into structures that are more and more adapted to its new way of life that is within generations we might see that in place of beaks that were adapted to eating fruits now, the structure of beaks is changing because of natural selection in a way that it is becoming more and more adapted to eating leaves. Now, if there is more amount of competition, then probably some might even start eating on eating the branches or maybe eating the bark or maybe some would become insectivorous birds or maybe some would start getting down on the ground and looking for their feed there.

So, with more and more competition we will observe that the niches would the number of niches that would occupied they would increase and when that happens when you have a particular group of birds that is feeding on fruits then their evolution will drive them towards having more and more adaptations to fruit eating, when you have a group of birds that are eating leaves will have adaptations with because of natural selection that become more and more adapted to eating leaves and when that happens the amount of biodiversity increases. So, earlier when we did not have any competition then you had a certain number of birds, but with competition the number of bird species increases.

Now, similarly biodiversity also increases because of predation because predation retards the competitive exclusion. Now, what do we mean by that?

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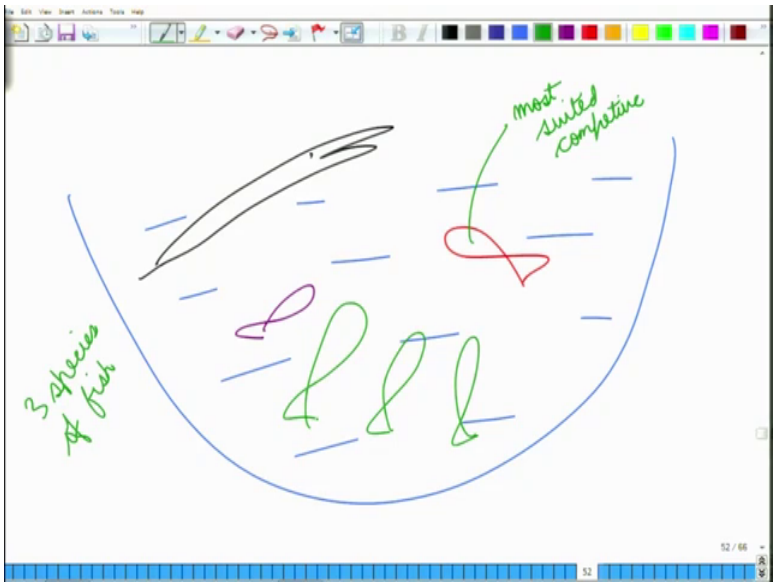

Now, suppose you have a pond and in this pond you have say three species of fishes. So, you have this purple fish, you have red fishes and you have green fishes. So, we have these three species of fish. Now, suppose these three species are such that the red one is the most suited or the most competitive and it is so much competitive because it is so efficient in getting its food that it would even eat the fruit and the food of the purple fishes and the green fishes.

So, if you have this situation in a very short period you will find that this fish would increase in it is numbers and the other fishes would get exterminated and then after a while you will have this pond that only has a single variety of fish which is the red fish. Now, that is when you do not have a predation. Now, let us put a predator in this picture. So, we had these three varieties of fishes, but then you also have a crocodile in the system. So, you have this crocodile and this crocodile does not have a preference regarding which fish to eat, whichever fish it gets it will go and eat it.

So, what happens now, if the population of the red fishes increases then the crocodile starts eating more and more of the red fish and so, this population is kept in check. On the other hand if the number of green fishes increases then the crocodile will go and eat the green fishes at and keep their population in check. Now, just because you have this crocodile here in the system, so that the red fish will not be able to increase in it is numbers so much that it would outcompete the other two fishes.

So, predation also helps in having more and more amount of biodiversity. In the in the absence of crocodile in the absence of the predator you would be having a situation in which you have only one variety of fish the red fish. When you put up a predatory pressure so, in that case you now have three varieties of fishes. So, predation can also increase the amount of biodiversity that we have in the system which is also a food for thought why we require tigers in our forest because tigers are predators and they keep the system in check. But, we will look into it in greater detail in one of the other lectures.

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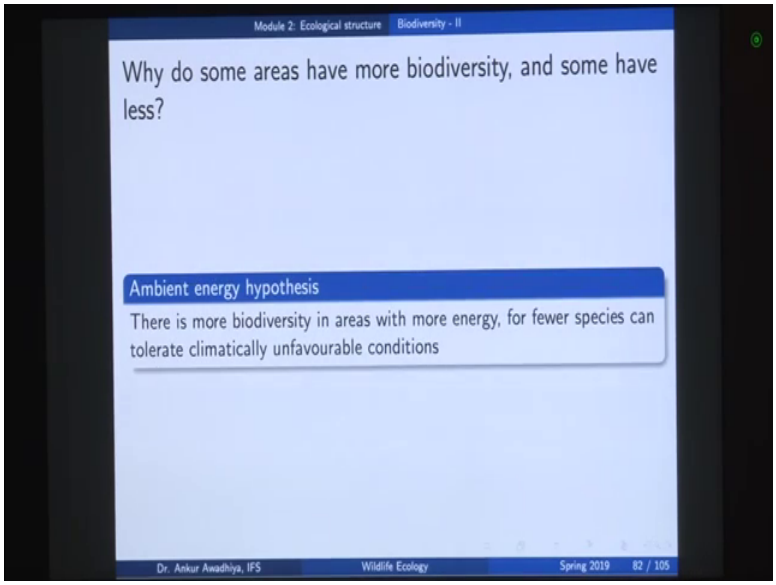

Now, another hypothesis goes by the name of ambient energy hypothesis there is more biodiversity in areas with more energy for fewer species can tolerate climatically unfavourable conditions. So, this hypothesis essentially states that those areas that have more amount of energy in the form of say sunlight and are having more favourable conditions would be having a greater amount of biodiversity.

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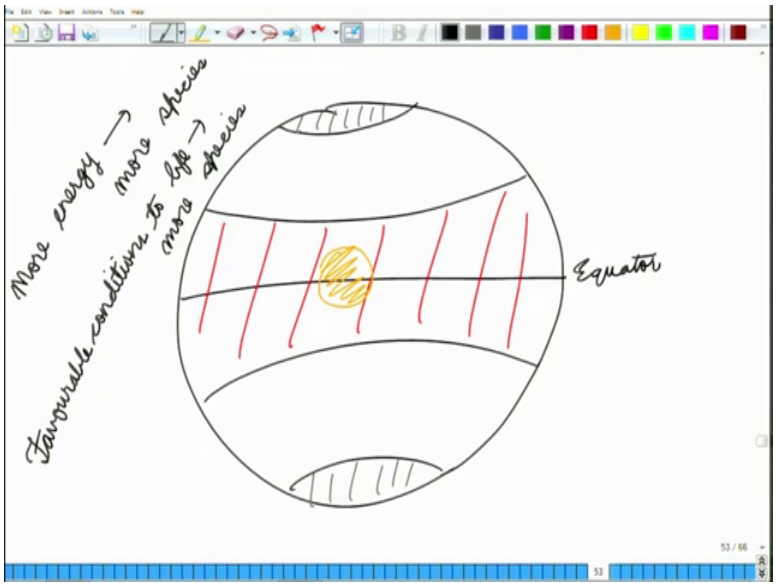

Now, we can look at it by considering the structure of earth. So, in the case of earth here we have the equator, then we have the two tropics – the Tropic of Cancer and the Tropic of Capricorn and then the Arctic circle and the Antarctic circle. Now, if we consider this region, the arctic or the Antarctic regions so, both of these regions get a very little amount of sunlight. So, because of that not enough amount of energies available for plants to thrive and at the same time the temperature is so low that everything is kept frozen. So, it makes sense that we will not have a great amount of biodiversity in these areas.

But, consider the central region the region between that that between Tropic of Cancer and Tropic of Capricorn. Now, in these regions we have abundant amount of sunshine. So, we have abundant energy that can be used for by the plants. We also have more access to water nothing is kept frozen in these areas and. So, more number of species would thrive in these areas, but then we can also look at some other extremes.

So, consider an area of desert that is found here in the case of the desert you have abundant amount of energy, but you have a very great shortage of water and when that happens then you will not have a large number of species that would be able to thrive with that area. So, essentially what this hypothesis says is more energy would give you more species and more favourable conditions say more favourable conditions to life will

give you more species. So, this is also another way in which we can explain why certain areas have greater biodiversity and certain areas have lesser biodiversity.

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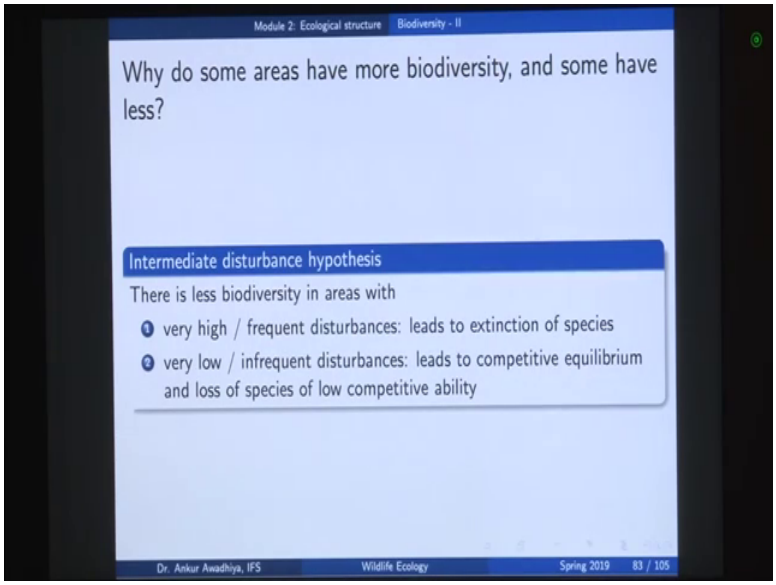

Now, another hypothesis goes by the name of intermediate disturbance hypothesis. Now, there is less biodiversity in areas now till now we were looking at areas with more biodiversity. Now, we are we are concentrating on areas with less biodiversity now there is less biodiversity in areas with very high or frequent level of disturbances because it leads to extinction of species.

Now, what do we what do we mean by frequent level of or high level of disturbance? So, suppose you have a forest and you have a human community nearby and these humans are going into the forest every now and then and they are poaching the wild animals and because the level of poaching is very high because they are going into the forest every day. So, the level of disturbance here is very large or probably they are getting into an equatorial rain forest in cutting all the trees to convert them into plantations. So, here we have a very fast rate of disturbance.

So, a forest that took millions of years to come up into its current shape is chopped down and is converted into a barren land in a period of say a few months or say 1 or 2 years. So, that is a very fast level of disturbance or a very high level of disturbance. So, if you have very high level of disturbances or very frequent disturbances. So, the species that are found in that area do not have enough time to adapt themselves or to evolve

themselves and to and to avoid their own extinction. So, if you have very high level of disturbances or very frequent disturbances that will lead to extinction of species.

However, if you look at the other extreme if there are areas that do not have any disturbances very low disturbances of very infrequent disturbances. So, in those areas it we would observe a competitive equilibrium and loss of species of low competitive ability, that is, if we go back to our example of the pond if we did not have this crocodile that was putting a disturbance in the system then very likely there would be some species that would outcompete everybody else and they would reduce the level of biodiversity that is present in this system.

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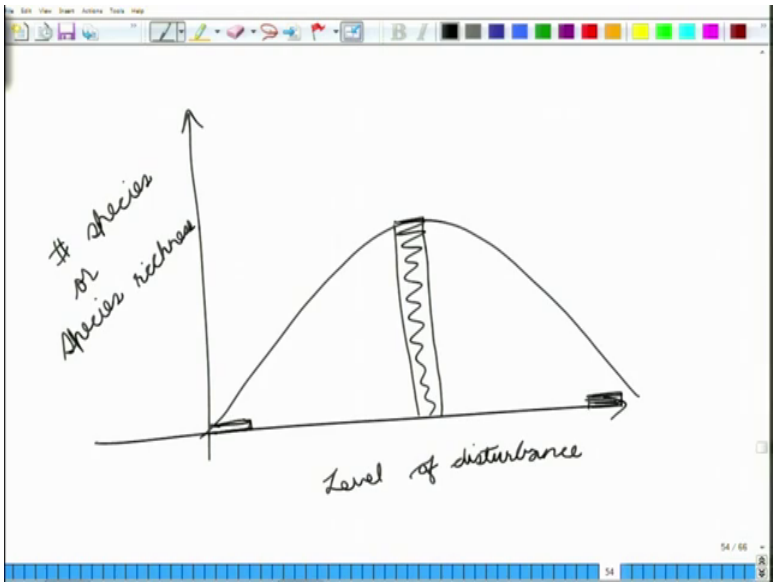

So, essentially if we tried to make a curve of the number of species or the species richness versus the level of disturbance we will find that at very low level of disturbances we have low number of species, at very high level of disturbances we have low number of species, but in the central region with intermediate level of disturbances we have a larger number of species. So, essentially we will have a curve that goes like this. So, this is known as the intermediate disturbance hypothesis if you have an intermediate level of disturbance which occurs at a frequency that is neither very high nor very low. So, you will have more number more amount of biodiversity.

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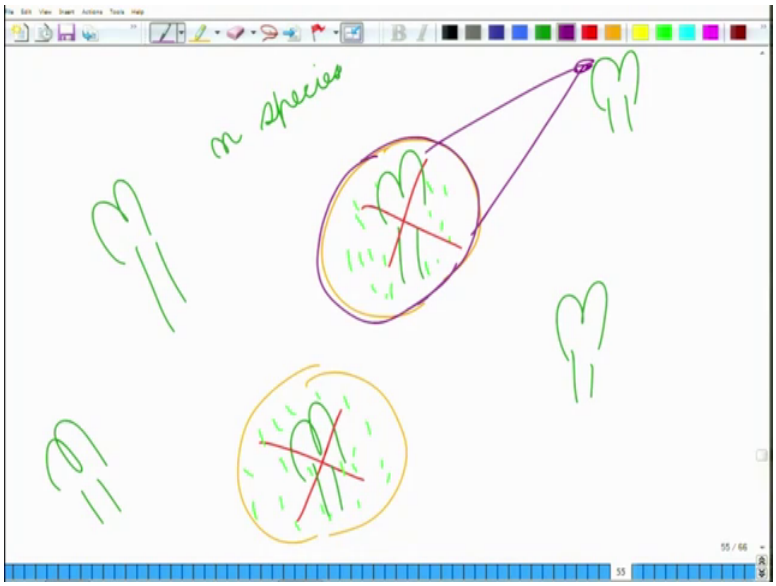

Now, another good example for intermediate level disturbance is that if you have an area that is only full of trees so, in this area there would be say n number of species. Now, if you create some amount of disturbance by say chopping off a few trees, so, these two trees are taken off. So, what happens in this case is that the ground level which was earlier not receiving any sunlight because this area was all full of trees, now you have created some pockets in which you have sunlight that is now reaching the ground when that happens then these areas that were earlier only having a tree will now be having some grasses or maybe some other herbs and shrubs.

Now, when that happens then this also leads to the creation of a more complex habitat. So, earlier you had only one kind of habitat that was available and which was the trees. Now, you have multiple kinds of habitats because you have trees you have areas that are barren, you have areas that are full of grasses, you have all these different ecotones. So, ecotones are areas that are that are joining two different areas. So, you have this particular line in which you have a confluence of a grassland and a forest. So, you will have some other species that can thrive on these confluences because you might have say a bird that wants to sit on top of a tree, so that it can have a vantage look around and whenever it sees in an insect or say a small mammal like a mouse then it can go there and it can eat that species

Now, if you have an area that only has forests so, in that case your bird of prey might not be able to see down below what is happening on the ground. But, now that you have created this opening what happens is that now you can have a bird that sits here and gets the view of the whole of this area and as soon as a mouse ventures out it is able to grab that species. So, some amount of disturbance will lead to more number of species that are formed. So, that is all about why there are certain regions that have more level of biodiversity and why there are certain regions that have less number less amount of biodiversity.

But, then we have another question why should we care about this biodiversity after all? I mean what do we humans derive out of this biodiversity? Because, any subject even ecology needs to meet certain aspirations of human beings. So, if we say that yes we need to have more amount of biodiversity the first question that somebody would ask us why do you need biodiversity I mean say in the case of cheetah. So, cheetah is an animal that was found in India and in the early 1950's it was hunted down and now you do not have any cheetah.

So, now, somebody might ask, so, this cheetah is now extinct from India, but then it did not lead to any collapse of the system. So, what is wrong if we take all the tigers out or say if we take all the leopards out? It should not also not make very much of a difference. So, to understand and to counter such questions we need to understand why do we need biodiversity after all and one way to understand is to look at the economic value of biodiversity.

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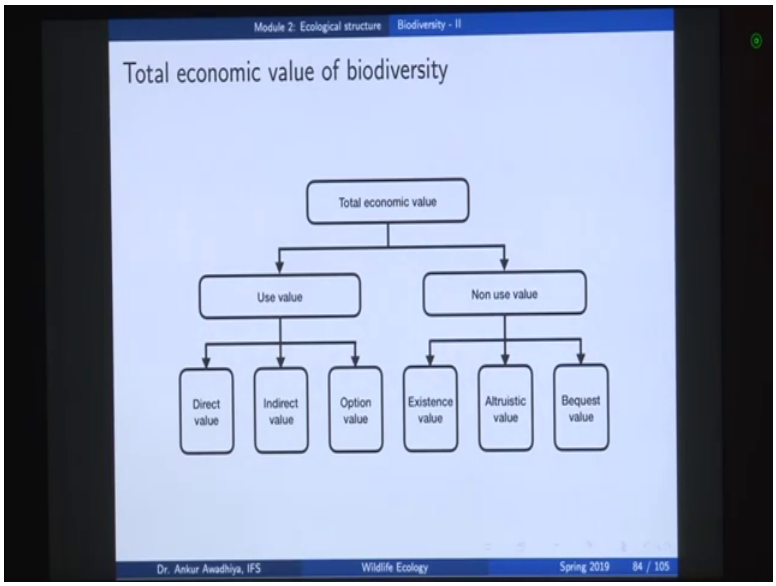

That is what are the benefits, that we are getting out of biodiversity. Now, total economic value is divided into use value and non use value. So, use value is something that you get because you are using that particular resource and non use value is some benefit that you are deriving even when you are not using that particular resource and use value is divided into direct value, indirect value and option value and non use values divided into existence altruistic and bequest values. So, we will now have a look at all of these.

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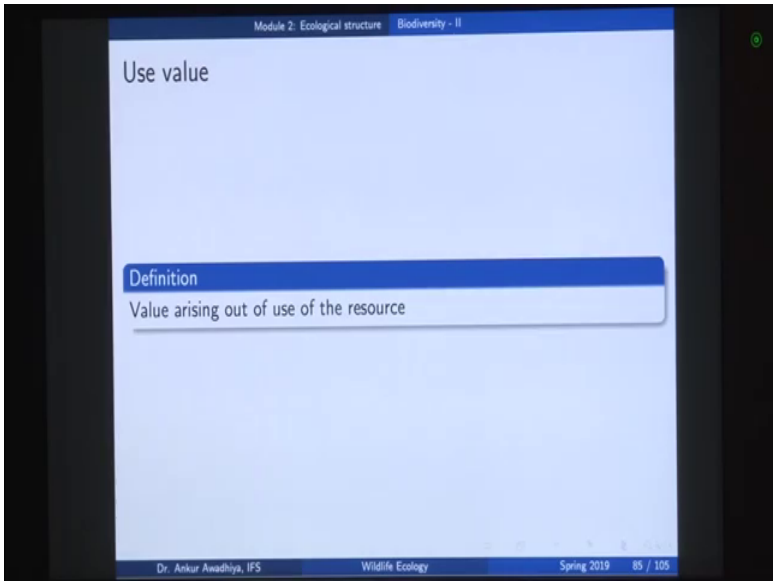

Now, use value is value that is arising out of use of resource.

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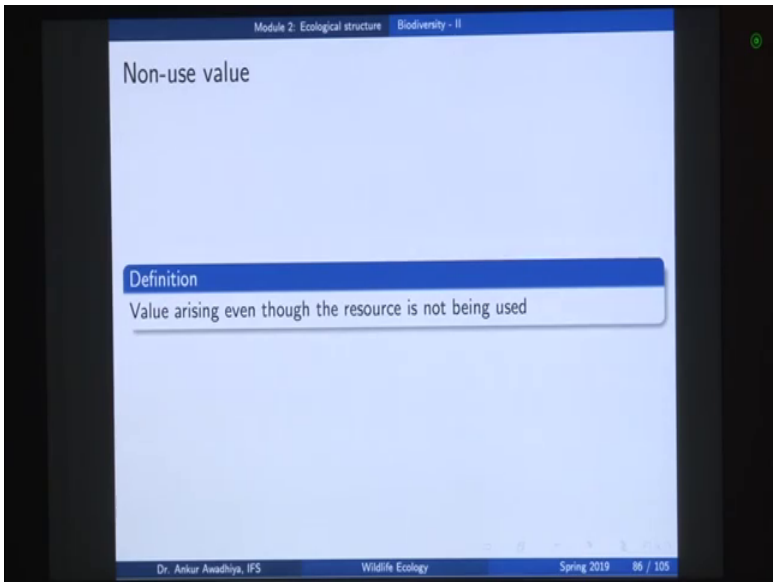

And, non use value is value that is arising through even though the resource is not being used.

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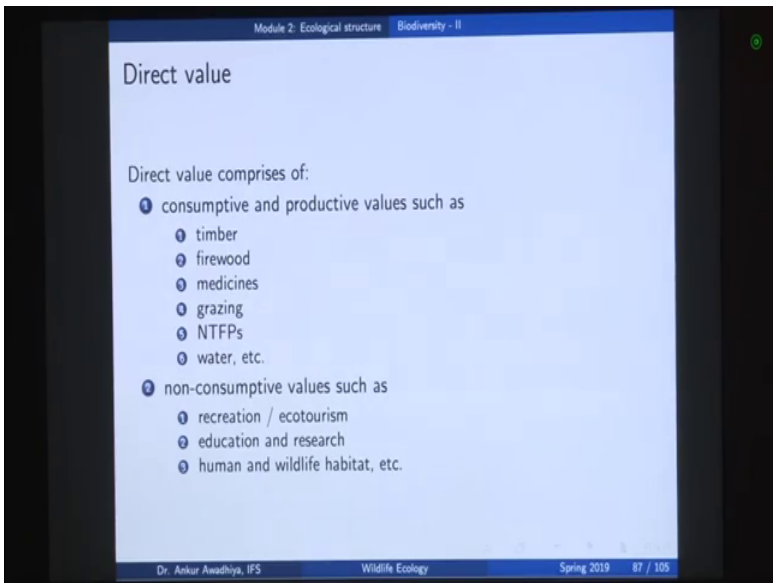

Now, direct value.

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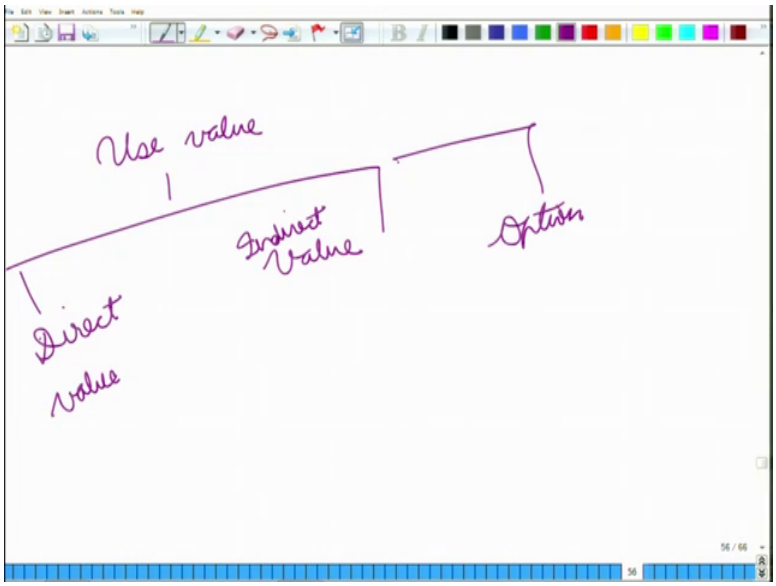

So, we had use value and use value is divided into the direct value, the direct value, the indirect value and the option value. Now, these are the three use values. So, what is direct value? Direct value comprises of consumptive values and non consumptive values. Now, consumptive value is a benefit that we derive when we are consuming a resource. Now, in this case consuming a resource means that if I use a particular resource then it is not available to be used by somebody else. So, for example, if we have biodiversity in the form of forest, so, forest will have a number of trees with those trees we can derive timber, fuel, wood, firewood, medicines we can have access to fodder, we can have non-timber forest produced, we can have water and so on.

But, then these are known as consumptive values because if I take timber out of a forest then that timber is something that I can use, but, but any other person cannot make use of the tip of the same timber. So, essentially if we are using a consumptive resource so, the total amount of resource that is available to be used by others reduces. On the other hand we also have non consumptive resources. So, non-consumptive resources include or non-consumptive values include recreation ecotourism education and research human and wildlife habitat and so on.

So, for instance if I go into a forest and I enjoy the scenic beauty if I go into a forest and I observe a tiger and I am very happy that yes, I was able to see a tiger. So, have I reduced that value? The answer is no, because I can see this tiger if you go into this

forest later on you might also be able to see the same tiger. So, by seeing this tiger I was able to gain a benefit, I was able to gain some amount of excitement or joy, but by using this value in a non-consumptive manner I am ensuring that this tiger is still there. On the other hand if I went for a consumptive use of a tiger, so, if I went into a forest, killed a tiger and took it out and made a trophy out of it. So, now, if you go into the forest you would not see this tiger. So, that is the difference between consumptive values and the non-consumptive values

Now, if we are conserving biodiversity then we are ensuring that we have all of these direct values that are available to us. So, if you have a forest and there are a number of medicinal plants that are found in the forest. So, for instance trees like cinchona. Now, cinchona the bark of this tree is over the first one to be used against malaria. So, it is an anti malarial drug or for instance things like Rauwolfia serpentina it is another medicinal plant. The forests are till date quite unexplored. So, if we get into the forest it is quite possible that we might find some other medicinal plant, but we can only make use of these if the forest is still surviving there. So, that is the first value that is the direct value.

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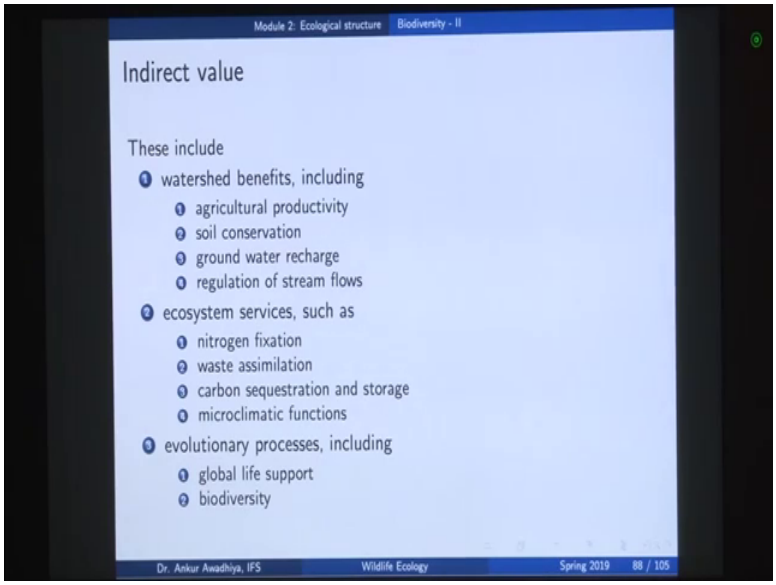

Now, indirect value includes things like watershed benefits that is agricultural productivity, soil conservation, groundwater recharge, regulation of stream flows. Now, these are indirect values, but a even in this case I am not taking out soil to be used in my own farmlands, but because we have a forest so, it is conserving the soil. So, that is not

just being useful for me, but it is useful to the society at large. It is an indirect value or things such as ecosystem services like nitrogen fixation or waste assimilation.

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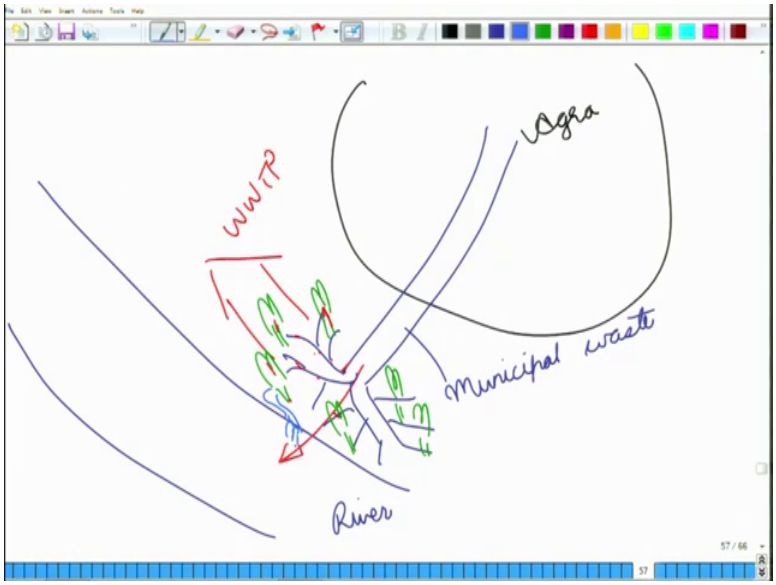

So, for instance we went to an area that is near Agra it is called the Kakraita plant and if you have this thing which is the city of Agra and you have these drains that are carrying out the municipal waste. Now, and here you have a river. Now, if you directly drain this municipal waste into the river what will happen is that the river water will get polluted. So, other people will not be able to use the river water. It might lead to spread of diseases or it might even lead to a situation in which the fishes that are living in the river, the turtles that are living in the in the river or the birds that are dependent on the river will all die off. So, that would also affect the economy and the employment of a number of people such as fishermen. So, it makes a lot of sense to treat this wastewater.

Now, to treat this wastewater you could go for a treatment plant; a wastewater treatment plant, but then what people in Kakraita did was that they before this was left out into a river, this wastewater was divided into a number of channels and around those channels they planted trees. Now, what happens is in the case of municipal wastewater you have large amounts of nitrogen and of large amounts of other minerals that can act as fertilizers if they are used by plants, but that can act as toxins when you put them into the water.

Now, just by doing this you ensured that all of those nutrients get absorbed by the trees and then whatever water remains is so devoid of these nutrients that if you let that into the river it does not produce any amount of harm. So, these sorts of services are known as ecosystem services and this was a the example of waste assimilation. So, a forest can act as a very good waste assimilator. So, in place of constructing a wastewater treatment plant that could cost you lakhs or even crores of rupees, you can just have a small forest and divert all of your water there and that water will get used or things such as carbon sequestration.

Now, we all know that we are in a period of global warming. So, because a large amount of carbon dioxide has been released into the atmosphere and is currently also being released into the atmosphere. So, we are observing greenhouse effect because of it the earth is warming up and we are seeing climatic consequences of that. now, if you have a forest that holds biodiversity, that holds different kinds of trees so, all of these trees will take up all this carbon dioxide from the atmosphere and fix it in the form of wood.

So, these are other indirect values or even things like evolutionary processes of global life support and biodiversity that are being supported because you are having these forests.

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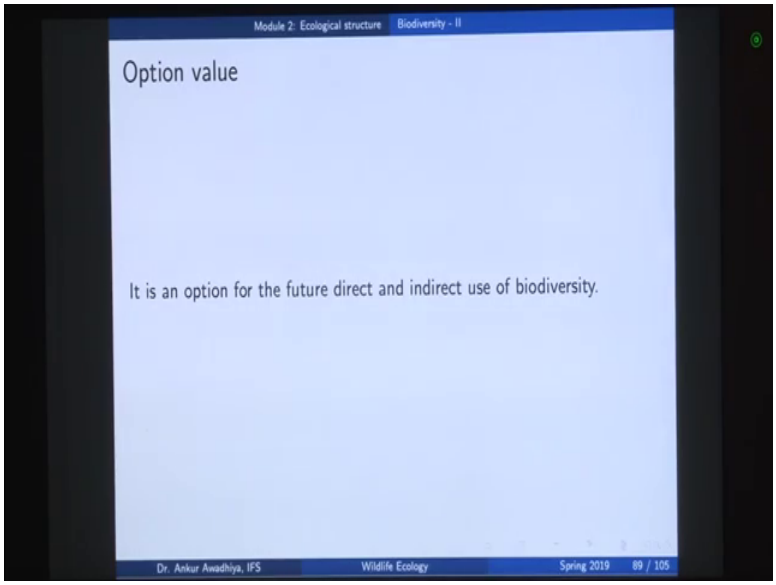

The other kind of values, that we derive out of biodiversity are things like option value. Now, option value it is an option for the future direct and indirect use of biodiversity. So,

for instance if we have a forest we have an option to clear up this forest and use all the timber or we have this option to keep this forest as such and maybe say 10 years down the line if there is some disease that we do not have a cure for, we might get go into this forest and search for different other biological molecules that might offer a cure. Now, option value is the value that we are deriving for keeping this option open that that we are not using this forest now, but we are waiting for some time.

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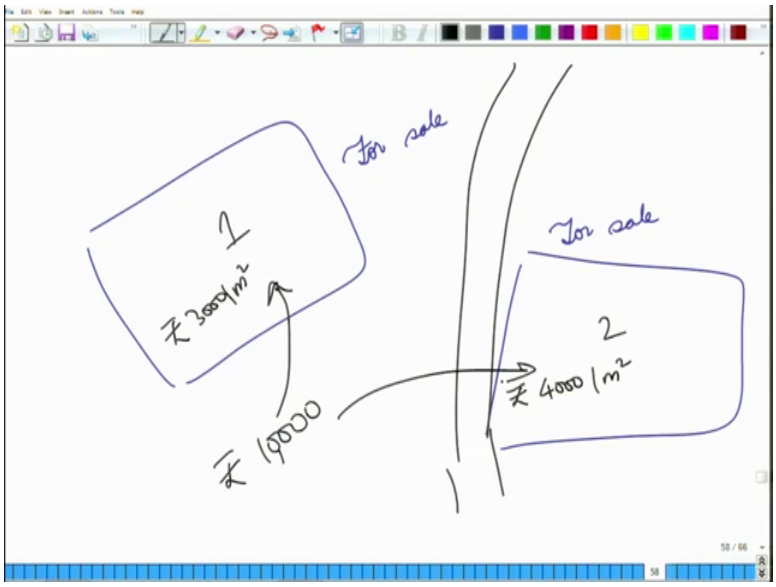

So, to give another example if you have say a piece of land that is available for sale and this is an agricultural land and then you have another piece of land that is also for sale and you have a road that is passing near this one, but not near the first piece of land. However, the second piece of land is costing you say 4000 rupees per square meter and the first land is costing you say 3000 rupees per square meter. Now, you want to have a land that is close to the road, but you are not sure whether you are ready to pay this price of 4000 rupees per square meter or should you go for this cheaper land.

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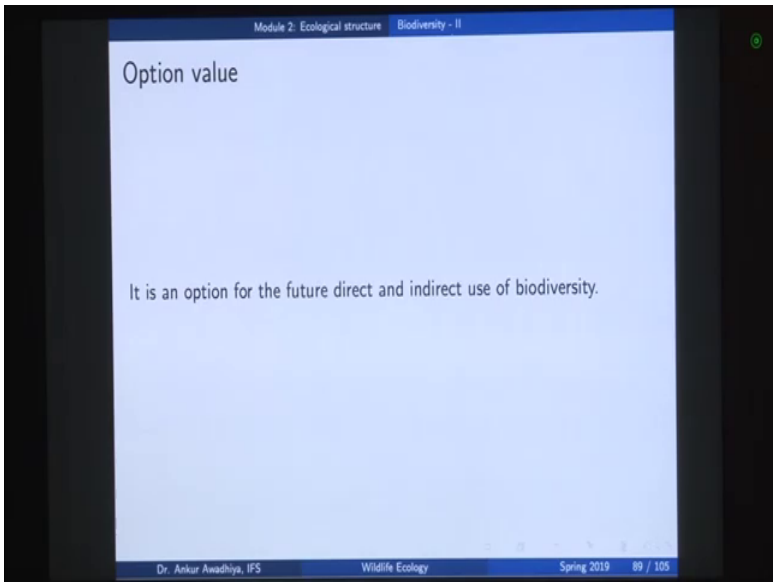

Now, option value would mean that because you are not able to take this decision right now you will pay say 10000 rupees to this person and 10000 rupees to this person and you will say, ok, I am not yet sure that I want to buy this land or that land. So, you take this money and you keep this option open for me. So, that I can make my decision after say 6 months. So, I am paying you these 10000 rupees so that after the end of 6 months I can decide which land I should buy or not buy.

Now, if you have paid this money and this thing, obviously, is negotiable once you have negotiated an amount and you have paid this amount. So, both these people will keep the land available for you, they will not send sell it to somebody else. So, that is an option value. So, similarly in the case of biodiversity the option value is the value that we have that we might derive some future benefit from our biodiversity.

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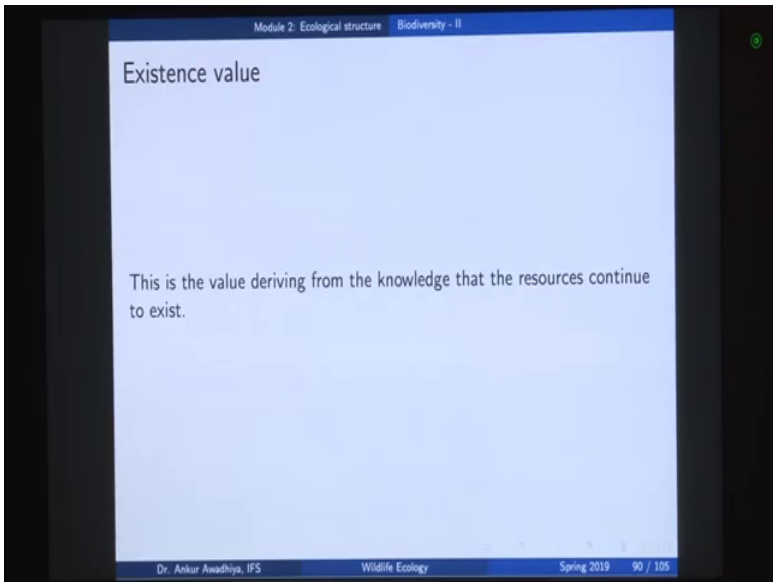

Another value is known as existence value. Existence value is the value that we derive from the knowledge that the resources continue to exist. So for example, a number of children in India look at discovery channel or national geographic and are looking at African lions or are looking at giraffes or things like zebras or ostriches. Now, all of these are found in Africa, but we look at them and we feel happy that these organisms are there and if somebody kills say a rhinoceros or a lion that is found in Africa we feel sad because we because we feel that it would have been much greater if this line continued to survive.

Now, existence value is the value that is that we are deriving from the knowledge that this lion is continuing to exist. So, we are not going to Africa to see this lion, but just because this lion is there we feel happy and if this line dies off we feel sad. So, the difference between this happiness and the sadness is a value that we are deriving even though we are not utilizing this resource and that is known as an existence value.

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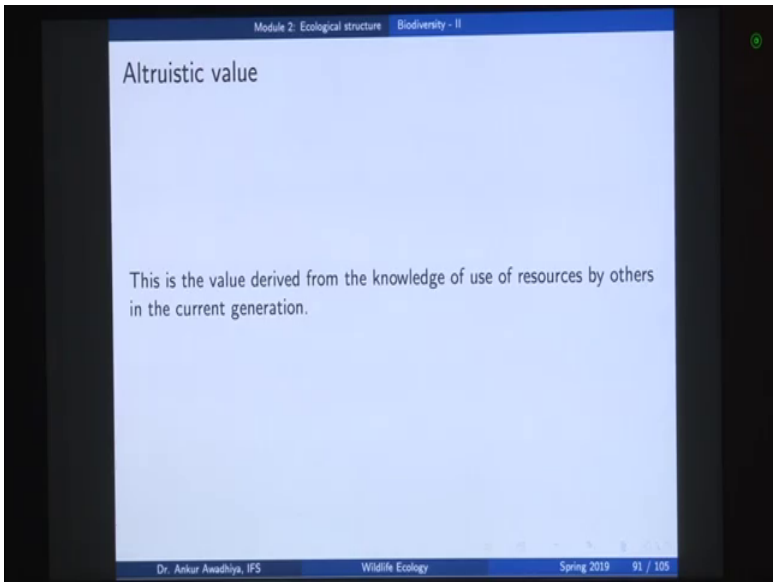

Another value that we derive out of biodiversity is known as altruistic value. Now, altruistic value is a value that is derived from the knowledge that there is some resource that is being used by somebody in the current generation. So, for instance, if I think of say Kaziranga national park and tiger reserve. Now, Kaziranga has a number of rhinoceros in India and it is quite possible that I might not directly be associated with Kaziranga, but I know that quite a number of people in Assam are getting their employment because, of Kaziranga.

Because, tourists are going there and they are going there to see the rhinoceros and when they go there they spend their money, they live in resorts or maybe guest houses and they are also paying money to the local economy for food, for services, for recreation, for transport. So many people are acting as tour guides or forest guides inside this forest and so, I know that Kaziranga is providing employment to quite a number of people who belong to my own country, though Kaziranga is not providing employment to me.

Now, altruistic value we will see that I am deriving a value because somebody in my current generation somebody who is my countryman or somebody who is a fellow resident of Earth is deriving value from a natural resource so, I feel happy that, yes it is providing an employment not to me, but at least it is providing employment to somebody else. Now, that is a value that we are deriving because Kaziranga exists and this kind of a value goes by the name of altruistic value.

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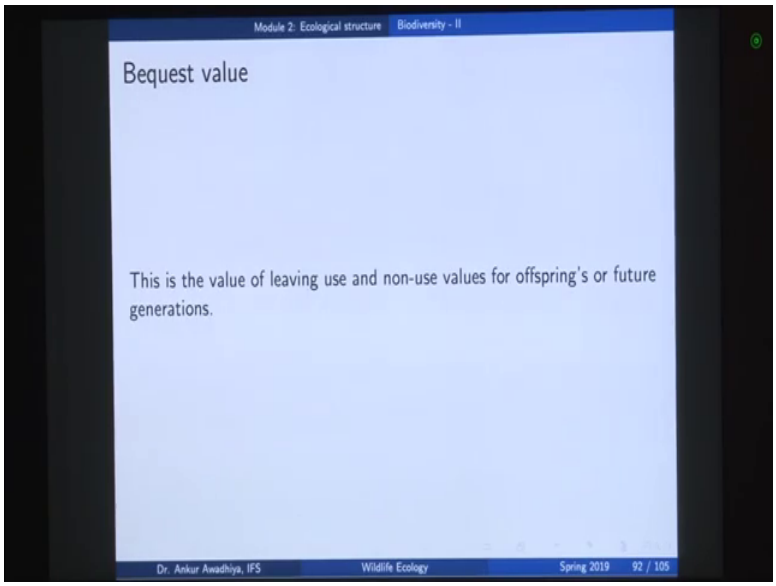

Another value is known as a bequest value. Now, bequest value means that I have this resource, I have a certain amount of biodiversity and I want to leave this biodiversity as such for my future generations, for my children, for my children's children and so on. So, for example for so, for instance today we are able to see tigers and we are able to derive joy out of it. Now, it is we could have this proposal that let us kill off all of these tigers, let us stuff them and let us sell them to foreigners. Now, if that happens we will we might get quite a huge amount of foreign exchange, but then I might feel sad because my future generations will not be able to see tigers, if such a thing happens.

So, bequest value is the value that I am deriving by leaving use and non-use values for off springs or future generations. So, I am not allowing tigers to be killed even though it is giving our country for an exchange because I want yet to survive for the future generation. So, this is a value that I am deriving out of these tigers by not using these tigers. So, this kind of a value goes by the name of bequest value.

So now, if we talk about the importance of biodiversity to all of us, we can count all of these different biodiversity or and all of these values that we are deriving out of the biodiversity. So, for instance Kanha national park is providing a lot of direct values. So, for instance people are going there and people are getting employment because of that that is a direct value some amount of indirect values because tourists are going there and

they are feeling happy. Kanha also has a lot of bequest value because we want to leave Kanha as such for the future generations.

Kanha also has an existence value because people all over the world feel happy that yes, there is a national park called Kanha national park that exists in India. It also has a lot of altruistic value because I know that yes some of my countrymen are getting employment out of it out of Kanha. So, all of these values together signifies the value of biodiversity and which is why a study of ecology becomes extremely important to conserve all of this biodiverse. Now, we looked at different kinds of values, but then can we put a rupee value or a dollar value to all of these different values.

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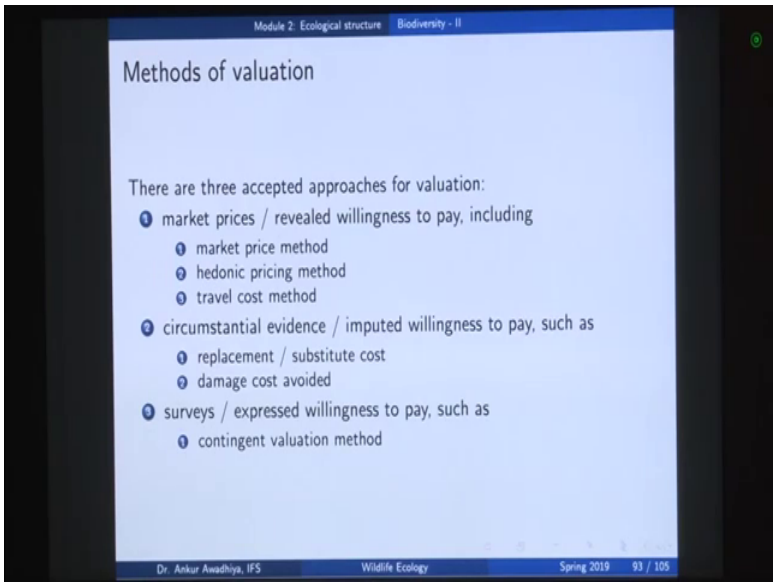

So, now we come to the methods of evaluation or the methods of valuation of all of these. So, there are three accepted approaches for valuation. The first one is called the market price method. So, in the case of the market price method we go for the direct use of biodiversity. So, for instance if there is a forest that is there in Balaghat and we are deriving timber out of it, so, market price method would ask how much of how much volume of timber was extracted from this forest every year and what is the price of that timber that is being extracted from this forest. You multiply both of these and you get a market value of the forest. Yes, this forest is important because it is giving us say 20 crores of rupees every year that is the market price method.

Hedonic pricing method is and it is a way of asking: what is the amount of happiness that I am deriving out of this biodiversity. So, for instance, if you have a tall tower in a city and one side of that tower is facing say a forest area or maybe it is sea facing and that sea facing apartment which is much more price as compared to another apartment that is there in the same tower because when you look at sea you feel good. So, that feel feeling of good is known as headonism. And, hedonic pricing takes into account the difference in pricing between an area that is exposed to biodiversity and an area that is not exposed to biodiversity.

The third is travel cost method. Now, travel cost method asks how many people are coming. So, for instance if we are looking at Kanha tiger reserve how many people are coming to Kanha tiger reserve and how much is each person paying to go to Kanha tiger reserve and to enjoy its facilities. Now, if we add all of that amount and we make this assumption that if somebody is going to Kanha tiger reserve and is say paying 10000 rupees.

So, obviously, the value that the person is deriving from Kanha tiger reserve should be greater than 10000 rupees because; obviously, if I go to the market and say I am going into the market to purchase a computed and somebody says ok, the value of this the price of this computer is thirty thousand rupees. Now, if I think that I am going to derive a benefit that is greater than 30000 rupees then I will be happy to pay 30000 rupees, but if I think that the benefit that I will derive out of this computer is only say 20000 rupees, then why should I pay 30000 to get that computer.

So, similarly in the case of the travel cost method we make an addition of all the expenses that are being borne by different people to reach our area and to enjoy it is facilities and when you make this computation then you get to a figure that is known as the valuation of Kanha tiger reserve through travel cost method. Now, another method of valuation goes by the name of the circumstantial evidence or the imputed willingness to be such as the replacement method or the damage cost avoided method.

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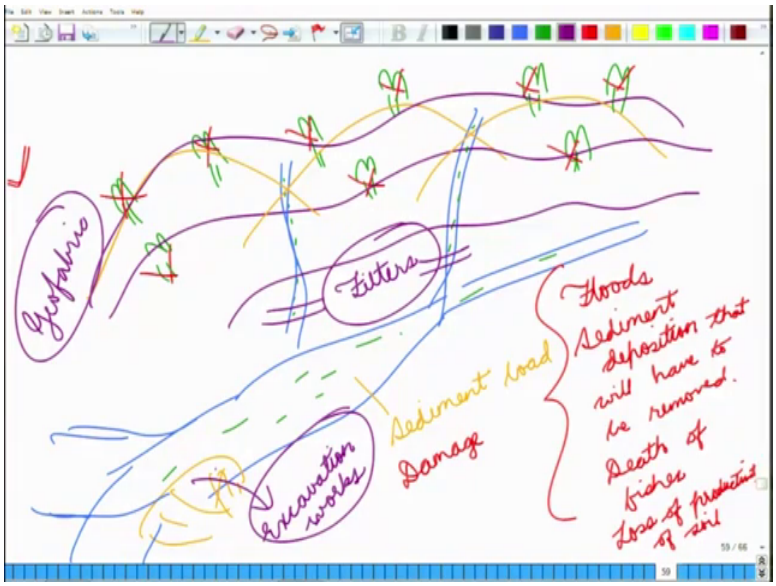

And, a good example is say in the case of Punjab you have some hills and these hills have some rivulets that are flowing through them and these rivulets then become part of the larger river. Now, these small hills have trees and these trees are binding the soil and because they are binding the soil so, soil is not able to reach out through these rivulets and into the main river.

Now, what happens if all of this if all of these trees are cut down and all of this soil comes out what will happen is, we will have a huge amount of sediment load in this river this sediment will go and it will deposit itself somewhere which might create some amounts of problems. So, for instance if this sediment load gets deposited here so, we might have a situation in which this river changes its course. So, in case of flowing like this it now starts flowing like this which might result in a situation of flood somewhere or there could be a situation that because of this huge segment load the fishes die out. So, that is some amount of loss that is being caused if the sediments come down and these forests are protecting this soil and are not allowing to it to be leased out.

Now, the damage cost avoided method would ask if these forests are removed from here what would be the level of damage that is caused. What would be our expenses because of floods? What would be our expenses because we will have the sediment deposition that will have to be removed? What will be the damage because of the death of fishes? What would be the damage because, of loss of productivity of soil? And you add all of

these and you get to a value that goes by the name of the damage that will probably be caused if these trees were cut. So, these trees are avoiding this damage. So, this is at least the value that we should put on these trees or on this biodiversity.

A similar method goes by the name of replacement or substitute cost. So, for instance I can say ok, I want this situation to persist I do not want the sediments to get out, but at the same time I need to get timber out of it. So, I will remove all of these trees. So, I will cut down all of these trees and probably, I will put up some sort of a fabric on top of this area which goes by the name of a geo fabric. So, I put some geo fabric here and maybe I will construct some filters here to ensure that this sediment does not get into the rivers and in those areas where I am supposed to get a deposition of sediments I will maybe go for some amount of excavation works to avoid this damage.

Now, when we are doing all of these, when we are installing geo fabrics, when we are installing filters, when we are installing excavation works and we will have to pay some cost for doing all of these activities. So, if we add up all of these costs then; that means, that this was the cost of the replacement that would be needed if we are removing the forest. So, that goes by the name of the replacement cost method. So, how much amount of expenses we will have to make if we wanted to replace these forests with some other structure.

And, the last method of valuation goes by the name of contingent valuation method which is a form of exercise in which we use surveys or expressed willingness to pay. So, in this case, we might go to Punjab and we might ask everybody all the population around not just in Punjab maybe even in the neighbouring states and we will ask them if these are the forests and these forests have to be cut and if we are cutting these forests and if you do not want these forests to be cut you will be asked to pay some tax and that tax will be paid to pay these people, so that they keep these forests on their lands. So, what is the amount of money that you are willing to pay for these forests?

So, if somebody asked me and if I say ok, I can pay say 100 rupees every year for this you go and ask somebody else and that guy says, ok, I will pay say 80 rupees every year, somebody else says ok, I will pay 10000 rupees every year. So now, this is a survey method in which we are asking people how much amount are you willing to pay and we add up all of these values and we get to a value that this is the value of the forest that is

being that is being considered out of this survey because people are saying that this is the total value of forest because this is the amount I am willing to pay to keep these forests there. So, this method goes by the name of the contingent valuation method.

So, in this lecture, we had a look at biodiversity in greater detail. So, we saw why there are some areas that have more amount of biodiversity, why there are some areas that have lesser amount of biodiversity, we looked at different hypotheses which make some areas to have more amount of biodiversity and some ideas to have lesser amount of biodiversity, then we looked at the values of biodiversity that are there for the society at large.

So, only when you know the value of biodiversity can you convince somebody why the conservation of this biodiversity is important and which is also a role of ecology because ecology is a tool that can be used to conserve biodiversity. And, when we are when we know what are all values we are deriving and if we can get to a dollar value or a rupee value we can say that at least this much amount of money needs to be used for the study purposes, for research purposes and for conservation purposes and this also makes way for ecology. So, that is all for today.

Thank you for your attention [FL].