Wildlife Conversation
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Lecture - 34
Impacts of climate change

[FL]. Today, we do begin our last module Management of Changes. In this module, we are going to have four lectures on impacts of climate change, plastics and their impacts on biodiversity, the impact of oil spills on biodiversity, and we will also take a case study of the Sariska tiger reserve to learn about crisis and their learnings.

After that we will be having three lectures on the revision of the whole of the course. Let us begin with the impacts of climate change.

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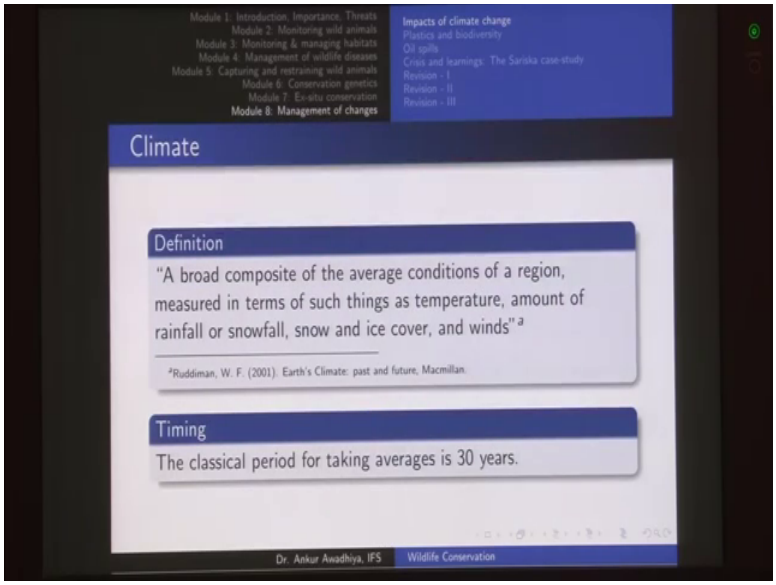

So, what is climate? Climate is a broad composite of the average conditions of a region, measured in terms of things such as temperature, amount of rainfall or snowfall, snow and ice cover, and winds. So, essentially we are looking at all the weather conditions looking at those in a composite manner. So, timing is the classical period for taking averages is 30 years.

So, essentially if we took all of these different parameters, temperature, amount of rainfall or snow falls, snow and ice cover, winds, at any point of time or say in a

particular day, we are talking about weather. But when we take all of these weather conditions and average them out for a period of around 30 years, then we get to the climate.

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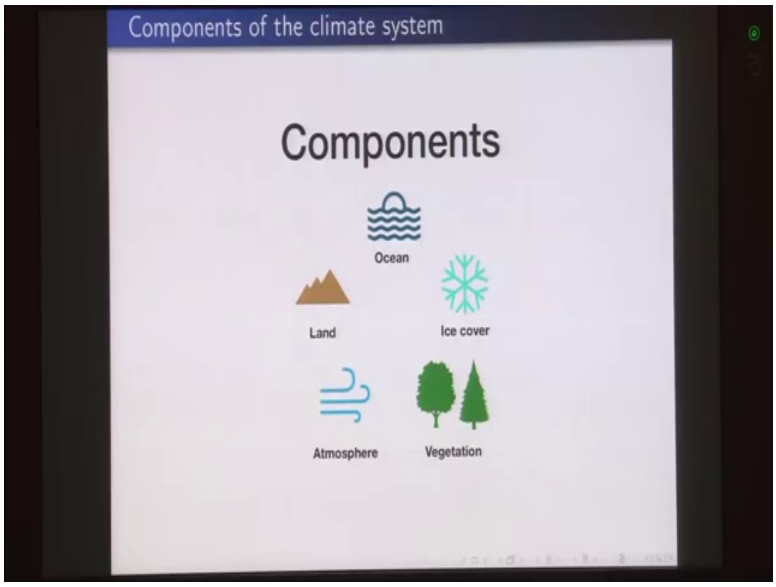

Now, climate is considered to have five different components. So, we have the oceans, we have the lands, we have the ice cover specially all the snow covered areas of the world. We also have the atmosphere and the vegetation. These are the five different components of climate.

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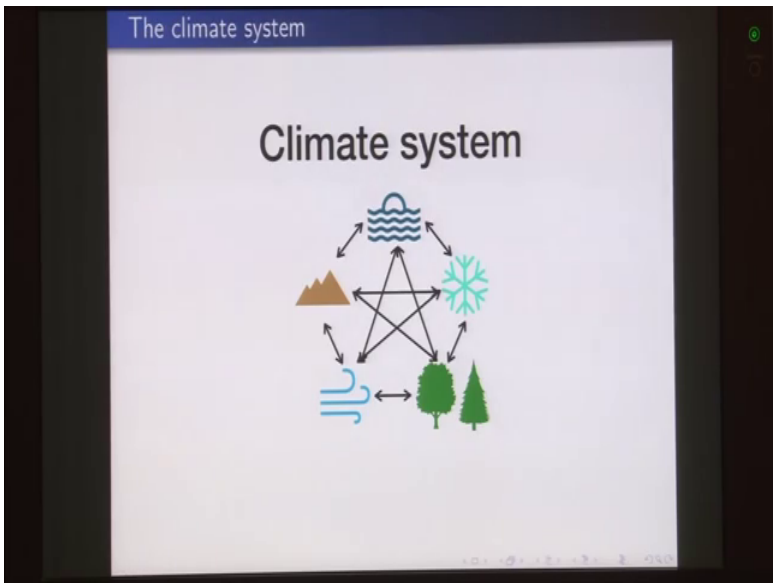

And all of these components are interacting with each other. So for instance, if there is a land mass that is close to the seas, then we will observe that this land mass will be having a more moderate climate. As compared to a land mass that is very far away from the seas. Similarly, if we have winds in an area, so that is going to impact the climate of the land mass, so all of these five different components are interacting together. If there is a wind that is moving over the snow capped areas, then that wind cools down.

So, all of these interacting together are called the climate system. Now, after knowing the climate system, the next point is; what is climate change that we are talking about.

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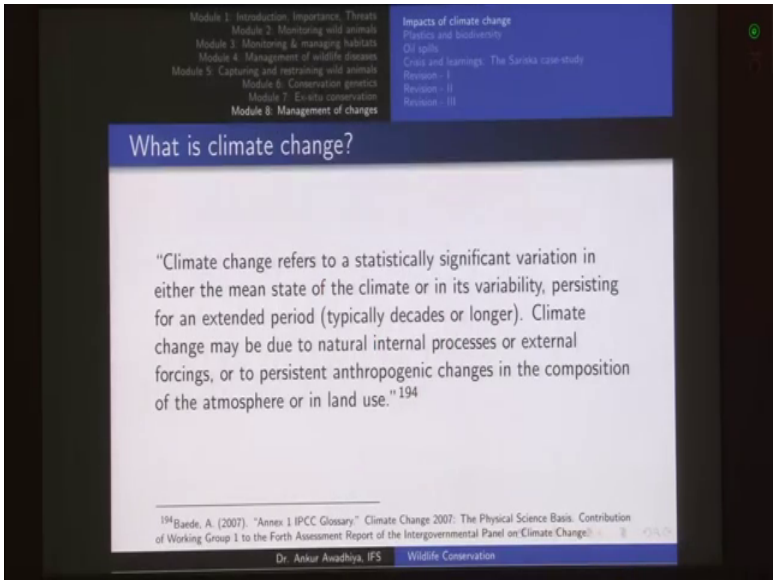

So, climate change refers to a statistically significant variation in either the mean state of the climate or in its variability. So, we are talking about the average conditions if there is a change in the average conditions. So for instance if we say that say around 50 years back, the average temperature of this area was 25 degree Celsius in the peak summers. And now if this temperature has gone up, so 50 years back it was 25 degrees. Then 30 years back it was say 25.5 degrees, and now it has increased to 26 degrees on an average.

So, we would say that there is a climate change if that variation is statistically significant. So, it is either in the mean state of the climate or in its variability. So, variability means that earlier we had maximum temperature minus minimum temperatures. So, this range of temperature was say around 15 degrees. And now this range of temperature has increased to say 20 degrees. So that would also be a parameter through which we would

say that there is climate change happening here persisting for an extended period typically decades or longer.

So, essentially if we have a situation in which only in one year this highest temperature increased from 25 degrees to say 27 degrees, we would not call it a climate change, because it has to persist for an extended period typically decades or longer. Now, climate change may be due to natural internal process or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in the land use.

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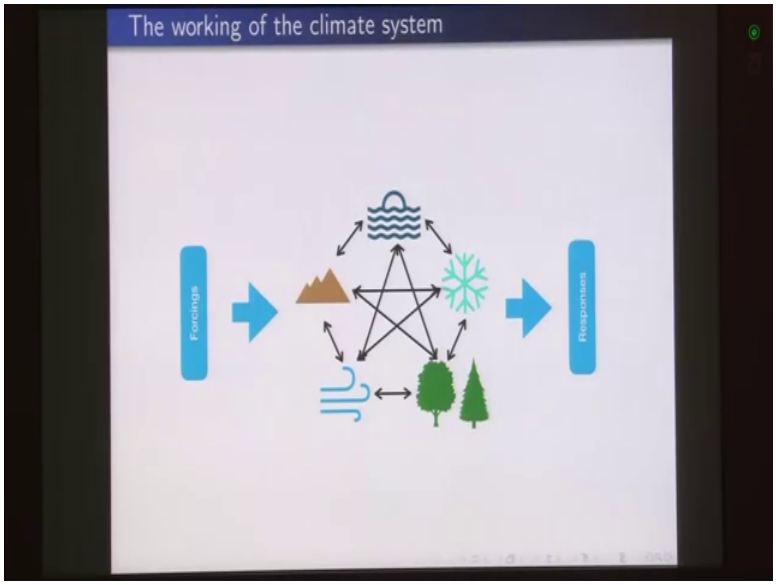

So, how does climate change occur?

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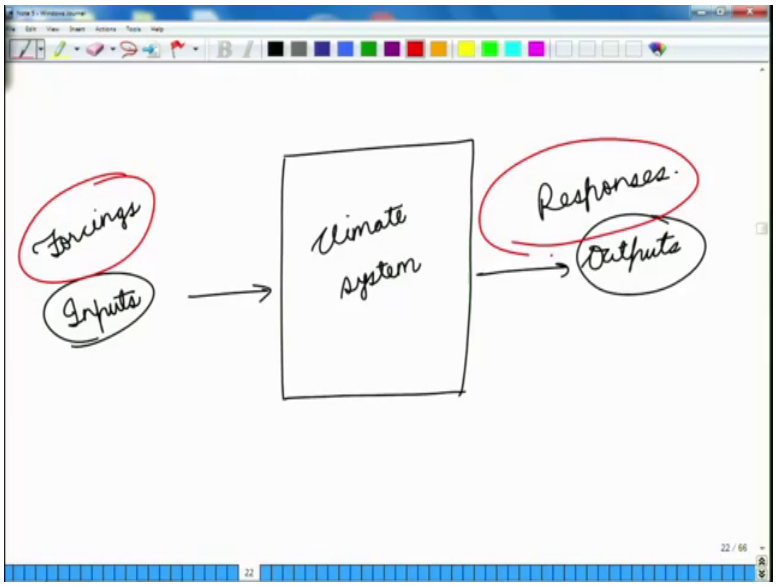

So, essentially we can refer to our climate system as a black box. So, if this is our climate system, now to this climate system we can give certain inputs or certain changes and that would result in certain outputs. In the case of climate science these inputs are known as forcings. So, these are forcing the climate system to change something. And then these outputs are referred to as responses. So, whenever there is a forcing in the climatic system. So, if there is any forcing that is acting on this climate system, it would produce an output which is known as a response.

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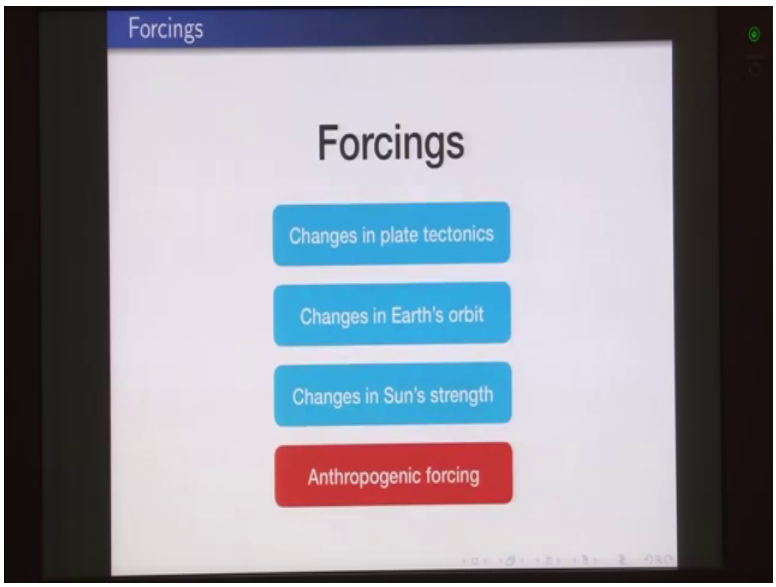

Now, what are the different kinds of forcing that we can have one forcing is the change in the plate tectonics. So, essentially if you have more amount of volcanism in an area or if you are having a situation in which one of our geological plates is going within or under some other plate. So that is changes in the plate tectonics.

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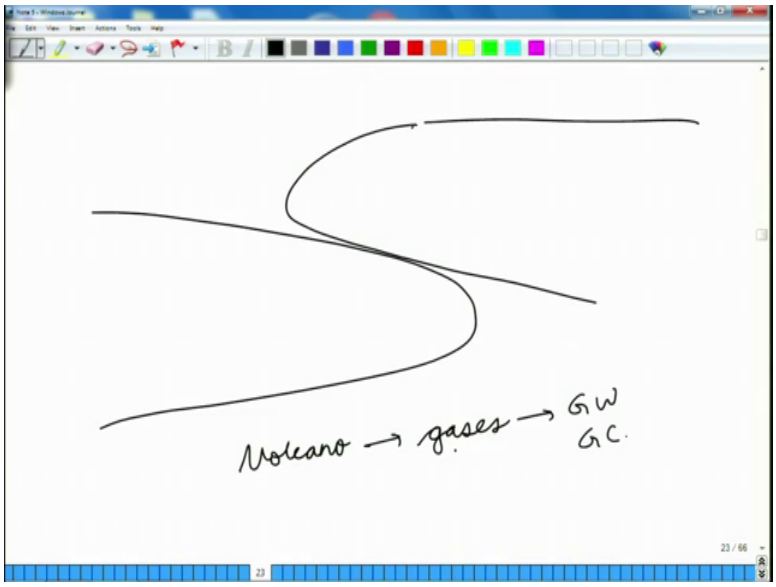

The second is changes in the earth's orbit. So, let us look at all of these one by one. So, if you have in the first instance you had a plate, and that is getting below another plate. So, it might result in say volcanism. So, if you have a volcano, then it would also speared certain gases. And these gases may even lead to say a global warming or a global cooling depending on what sort of gases are being released. So for instance, if you have a lot of carbon dioxide that is coming out then it might lead to a warming of the climate. On the other hand if our volcanoes give quite a lot amount of dust. So that dust would come on the top of our atmosphere.

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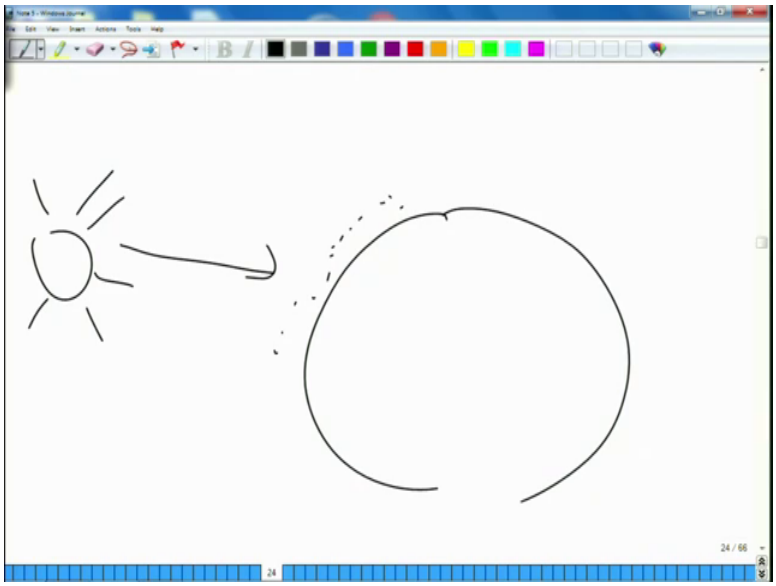

And when you have our earth and you have quite a lot of dust here. So, any amount of the sun's rays that are reaching to the earth there would be lessened out, because of this coating of dust, so that would lead to a global cooling.

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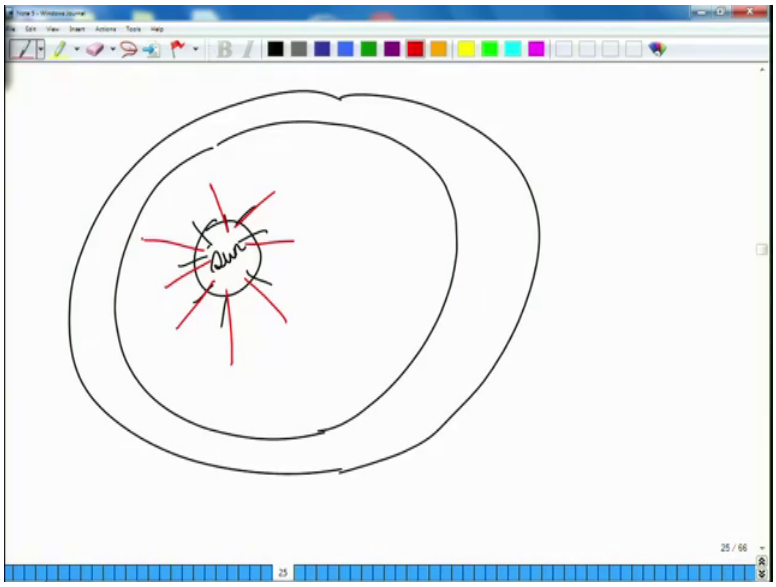

Similarly, when we talk about the changes in the earth's orbit, so we have the sun here, and you have our earth that is orbiting around the sun. Now, if there any change in the orbit which brings our earth say closer to the sun. So we would have more amount of sun's heat that is coming to the earth, so that would also act as a forcing.

The third is changes in the suns strength. So, essentially if this is our sun, and in place of giving out this much amount of heat, suppose the amount of heat that is given out increases. So, changes in the strength of the sun would also be a forcing on our climatic system. And the forces anthropogenic forcing which is the sum total of what we human beings are doing to the climate. Now, considering all of these forcings what are the responses that are produced.

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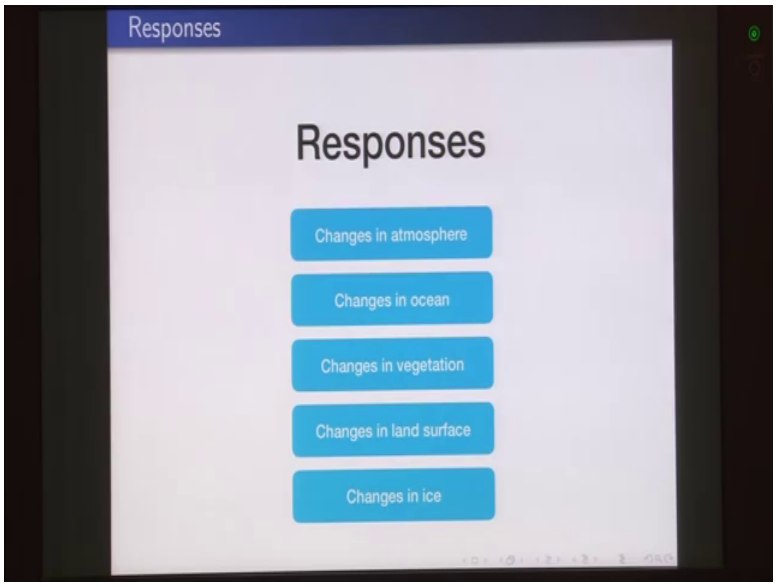

So, here we have the responses. We can have changes in any of the five components of the climate, we can see changes in the atmosphere, we can see changes in the ocean, we can have changes in vegetation, changes in the land surface, and changes in the ice cover. So, for instance: if our sun grows up in a strength; so we will have more amount of heat that is coming to the earth. So, the amount of ice that is there on the earth would reduce all of this ice would then melt and get into the oceans. So, the oceans will also increase. So now, when the oceans increase then the amount of land surface that is there would reduce because all of these lands will now be in undated.

Now, when the land surface has reduced, then there might be changes in the vegetation, because not only some of these vegetations like mangroves will be inundated by with water, but at the same time when we have increased amount of heat that is there on the earth, the vegetation might also change from say a more cooler vegetation like alpine vegetation into a more hotter vegetation like a tropical vegetation. Similarly, we will see

changes in the atmosphere, because more amount of heat that is coming into the earth would also result in more amounts of winds that are being generated.

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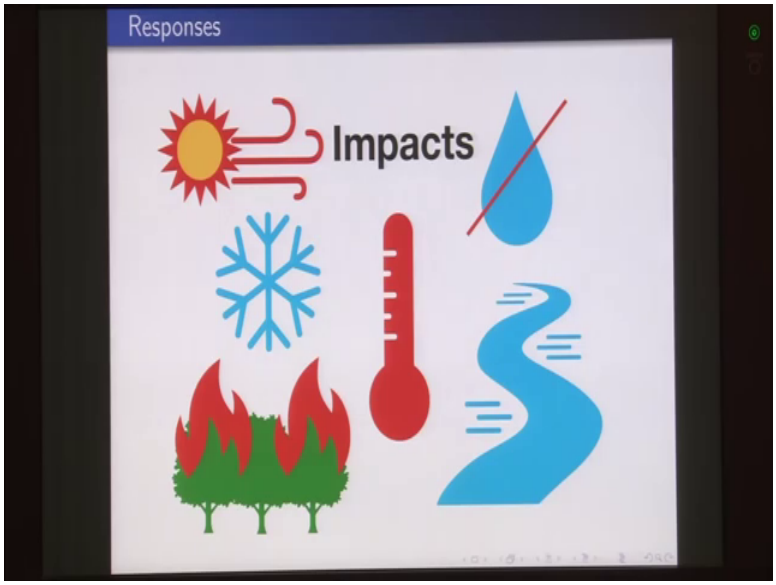

So, we will observe a number of impacts. There could be more amount of hot winds, the ice would reduce, temperatures would increase. Then rainfall patterns may change, because there is a change in the wind pattern. And also we would observe situations of either floods or draughts you might also observe more amount of forest fires in our vegetations. So, these are all the different kinds of impacts.

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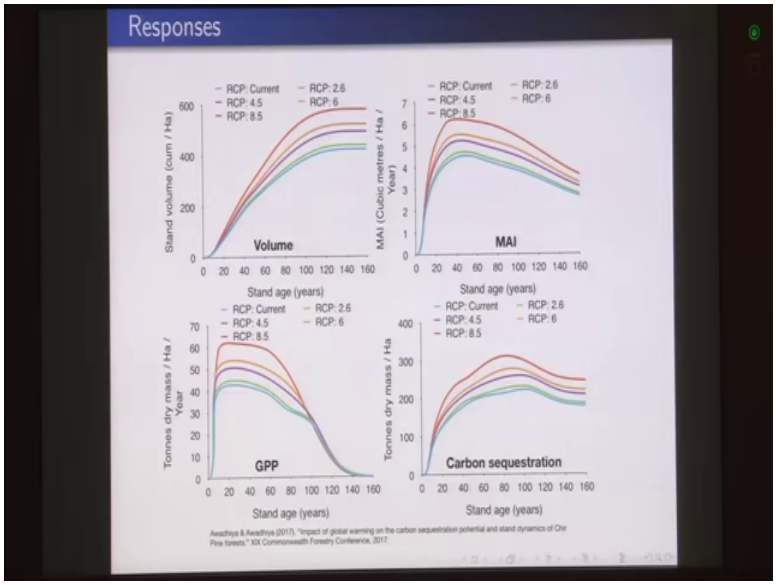

And these days it is possible to simulate all of these impacts using. So, here we are seeing the results of one such simulation in which we are looking at different levels of global warming represented by these representative concentration pathways. On the volume of a forest or a tree stand the mean annual increment the gross primary productivity and the carbon sequestration potential that is there in the forest stand. And we can observe very clearly that as global warming increases we are seeing a change everywhere. So, these are some of the responses that can be simulated.

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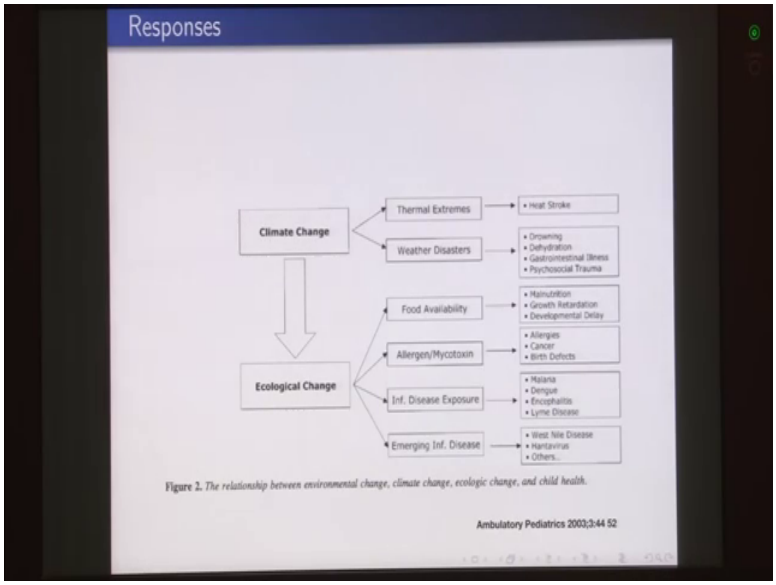

Now, other kinds of responses that we would observe especially, in the case of our wildlife would be things such as these thermal extremes leading to heat strokes. So, we might observe some mortality, because of heat strokes or weather disaster leading to drowning of animals or dehydration of animals or some illnesses like gastrointestinal illnesses or some psychosocial trauma in the animals. Now, this is when people that dealt with mostly with human health, but all of these results can also be directly seen in the case of animals as well.

Now, if there is climate change, that would result in some amount of ecological changes which would alter the amount of food that is available to our animals that might result in malnutrition growth retardation or developmental delays in animals or it might lead to more amount of allergens or mycotoxins that are being produced. Now, these allergens could be in the form of say pollen grains, so that would result in some other impacts. We

would have more amount of exposure to infectious diseases, and then we would also give some more some amazing infectious diseases that may come up.

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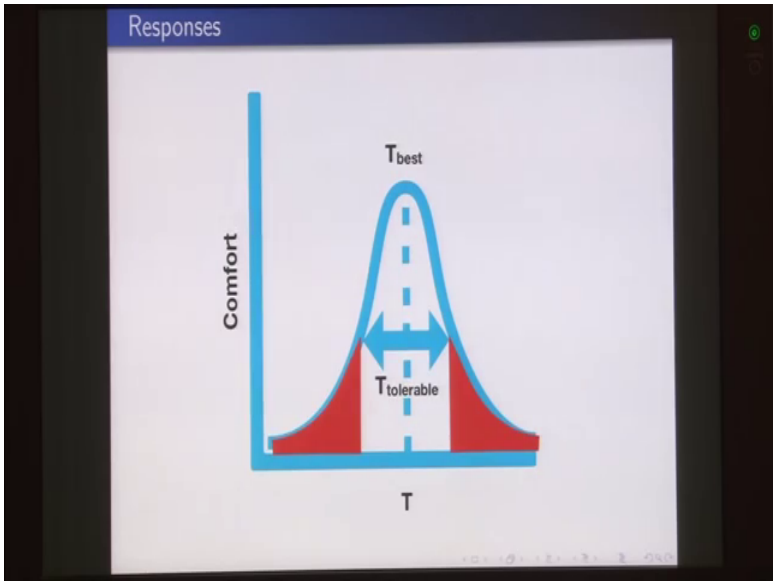

Now, this is also important, because when we consider any organism whether our wildlife or any of the pathogens or their vectors, we would observe that these organisms have a certain level of comfort, when it comes to temperatures. So for instance: in case of us human beings we can say that our optimum temperature is close to say around 25 degree Celsius. Now, if this temperature increases, say it becomes 40 degree Celsius, so we are we are moving towards the right, so we can still live in at 40 degree Celsius, but then our level of comfort is less as compared to what we were having, when we were at 25 degrees, if this temperature, if the ambient temperature increases, even further.

So say if you come in to a range which is say around 60 degree Celsius, so at 60 degree Celsius, we would not be able to tolerate the amount of heat that is there in the ambience. And so we would not be able to survive in those conditions. Similarly, when we are reducing our temperatures, so from 25 degrees, if it goes down to say around 5 degrees. We will feel quite a lot of cold, but then if our ambient temperature on an average becomes say minus 40 degrees we might not be able to survive.

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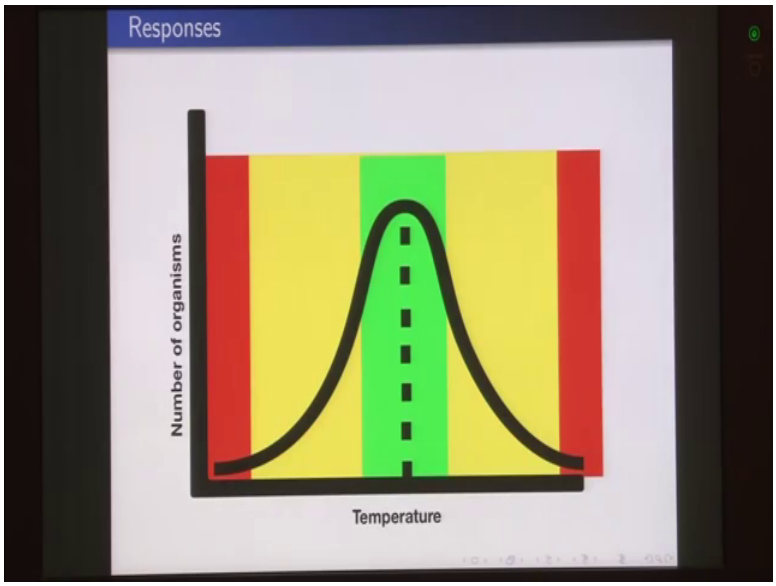

So, all of these temperature ranges can be converted into the survival densities of different organisms. So, here what we are seeing is the number of organisms say per unit area. So, it would become the density of the organisms, and we here we have the temperature. So, in at this temperature range we would observe the maximum density of the organisms, because they are very comfortable. In these yellow regions even though these animals or the organisms are able to tolerate these temperature, but then these are not the most optimum temperature.

So, in this case if you move to the right, the organism has to spend a lot of amount of energy to cool its body. So, maybe it has to go and (Refer Time: 12:49) in a pond for quite a quite a long period of time or maybe it has to spend quite a substantial amount of time in the shades of trees or maybe it has to spend quite a huge amount of energy in sweating out. Whereas on the left side it has to spend quite a lot of energy to keep itself warm. So, in both of these situations the density of animals would reduce substantially. And then we would have certain temperature extremes in which the organisms are unable to survive.

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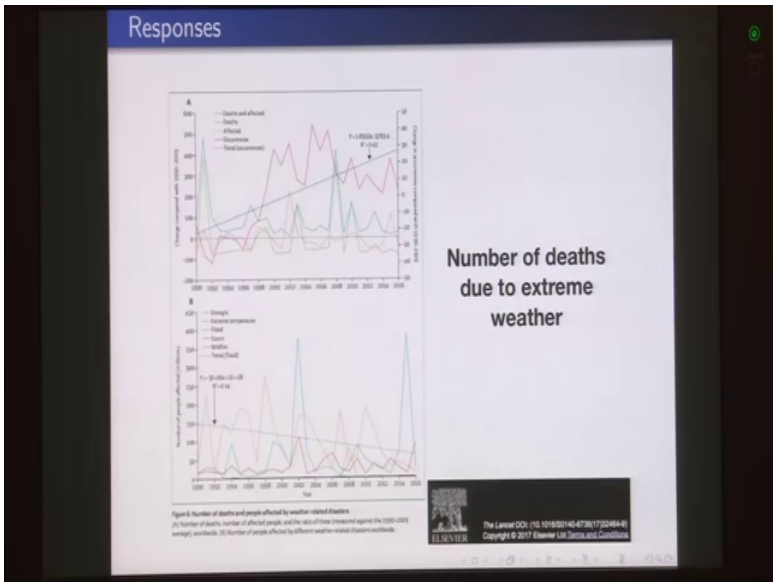

And we can also observe this in terms of the number of deaths due to extreme weather, and these go on increasing as we have the extreme weathers.

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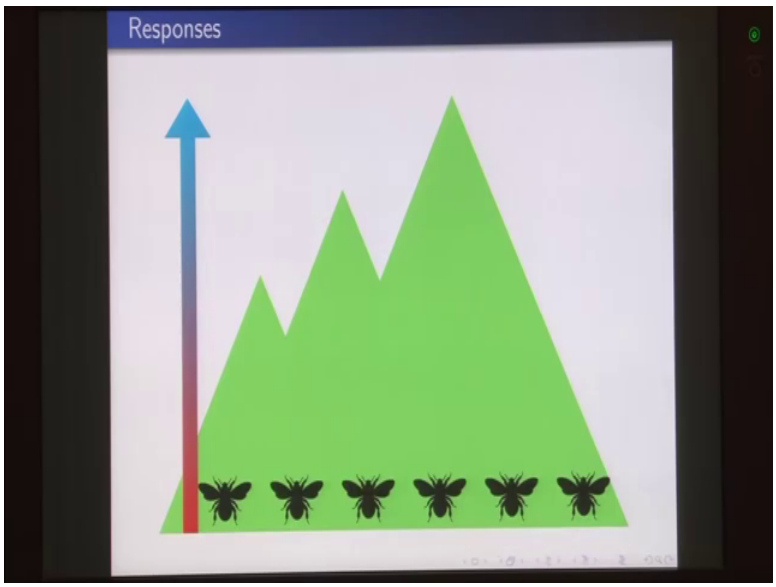

Another response that we observe in the case of say insects or any other organism for the same matter is that if there is an organism, say this insect which is vector for a disease and this insect previous living in the hot climates. Now, in the case of a mountain as we go up we observe a reduction in temperatures in the ambient temperatures. So, this is represented by the red color or warmer temperatures here and then the bluish colors are

the cooler temperatures above. Now, if there is global warming, and all of these temperatures move towards an ascending trend; so the temperatures even on the tops of the mountain would then start increasing. And these vectors would be able to increase their ranges. So, earlier they were found down here. Now they would be found at a greater height.

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And this is something this is also to do with the amount of reproduction that this organism can do. So, if there is more amount of water in an areas say because of more amount of rains, because of the changes in the precipitation patterns. We would also observe more number of vectors that are coming up.

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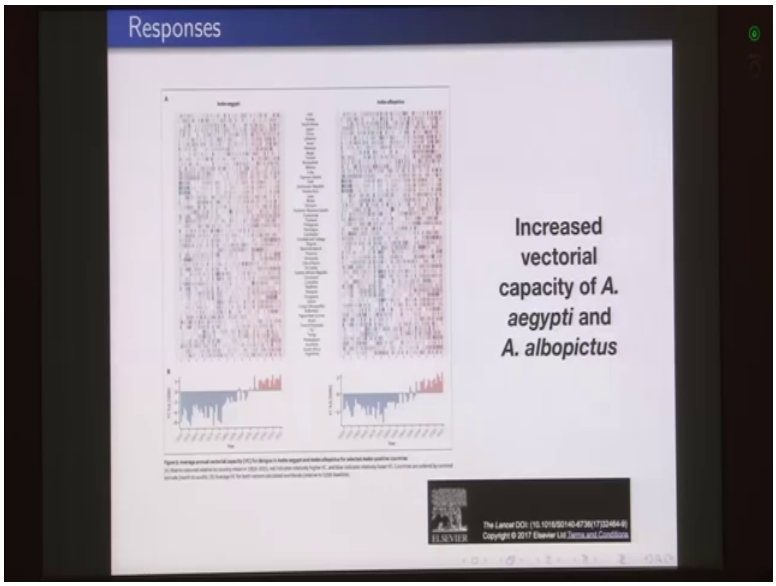

And this is something that we are actually observing in the field. So, this is one paper that came up in the medical journal lancet which talks about the increase vectorial capacity of Adis aegypti and Adis albopictus mosquitoes, because of these rising temperatures. So, we can observe that on the left we have lowered amount of vectorial capacity. And on the right the vectorial capacity is increasing because of the changes in the climate.

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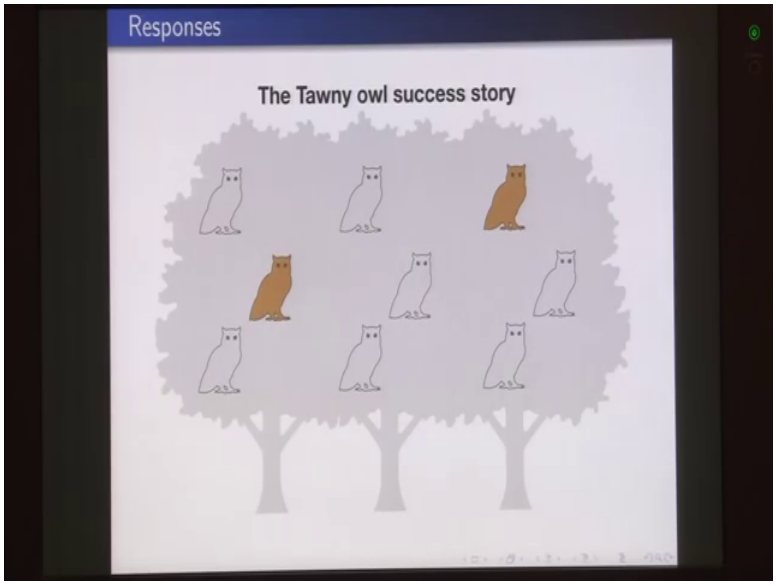

Now, the response of our wildlife could be very different. So, we could have certain wildlife that become extinct because of climate change. And there would be certain wildlife that would try to change themselves because of this climate change. Now, one classical story is that of the tawny owl. Now, tawny owl is an owl species that is found in two colors. So, one is this grey version and the second is the brown version

Now, in certain European locations that have quite a lot of snow following on the trees: so we have these trees that are covered with snow. And in these trees we have both these species of owls. Now, we can very clearly make out that these are the brown owls, but in the case of the white the greyish colored owls they become much more camouflaged in the white colored snow in the background.

Now, how does that impact the fitness of this species? Now, this species is a predatory bird. And it has to hunt on say rats or mice. Now, if the rat or mouse is able to see that there is an owl here, then it would probably not come out or even if it is coming out, it will be having more amount of attention towards these predators. So, it would be always in a position to run away. On the other hand, if there are these white colored birds or grey colored birds in the background of snow, so the prey animals are not able to observe these predators.

So, in that case they are not able to run away as quickly. So, in that situation the these grey colored owls become more fit. They become more fit they become more fit in this particular environment, because these birds these grey colored birds would be able to hunt in a much more efficient manner as compared to these brown colored birds. So, typically a few decades back what we observed was that if we ever went into these forests, we would observe most of the owls in this grey colored variety. And very few number of owls in the brown colored variety.

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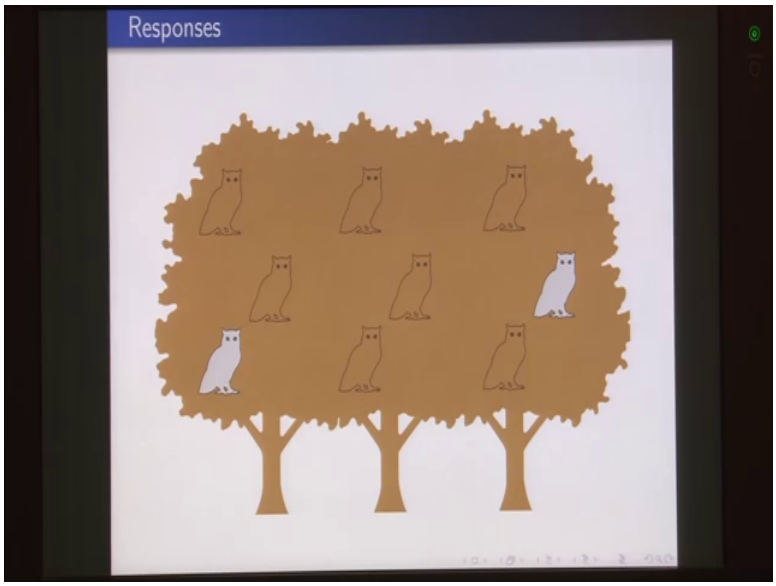

But now, with rise in temperatures there is little amount of snow that is there on these trees. And even the snow that is there melts off very quickly, because the summer seasons approach faster. So, in a situation in which we do not have these white colored snow in the background these white or the grey colored tawny owls they become very conspicuous. So, now the balance of forces has changes. So, earlier these were having the advantage, now these are having a disadvantage.

On the other hand, the brown colored tawny owls. Now they have started gaining an advantage. And we are observing that in terms of a change in the gain frequency or the anneal frequency that is there in this population. So, earlier we had most the birds that were grey in color, now we have most of the birds that are brown in color. So, there would be some species that would able to adapt themselves, because these have these variations already present in their populations. So, they can now utilize these variations to adapt themselves to the change in conditions.

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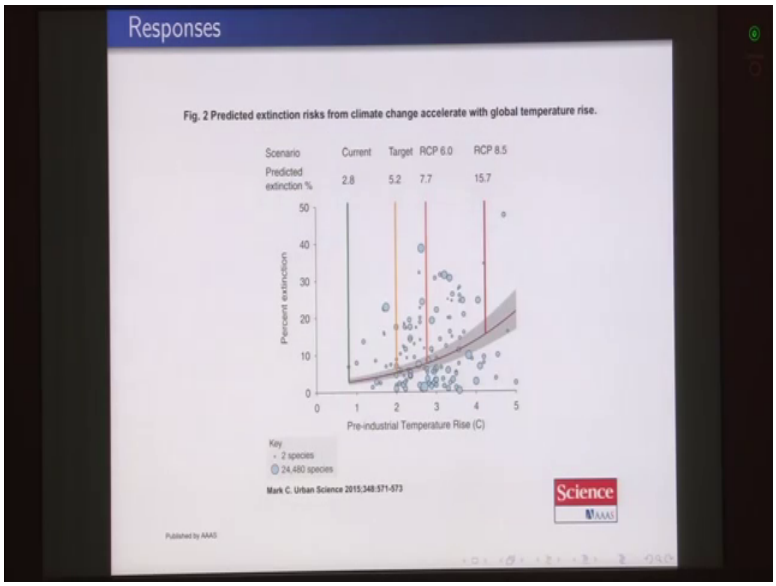

However, not all the animals would be able to adapt like this. So, this is one paper in science that predicted the extinction risk from climate change as the climate is increasing and there it. So, here also we are having the RCP numbers. So, this is our pre industrial temperature and then at different RCPs. It is showing temperatures on the x axis and the percentage extinction on the y axis. And here we can observe as the temperatures increase the percentage of extinction would start going up, because quite a number of species will not be having these variations that they would be able to tap into.

So, if we know that climate change is happening, and we know that it is happening. So, what are the options available for us? Specially in terms of conservation we need to conserve our forests we need to conserve our wildlife. Now, these climatic changes that are coming up say, because of global warming is; because of the amount of the carbon dioxide that is being spewed into our atmosphere. So, what can we as conservationists do. So, there are two options available for us.

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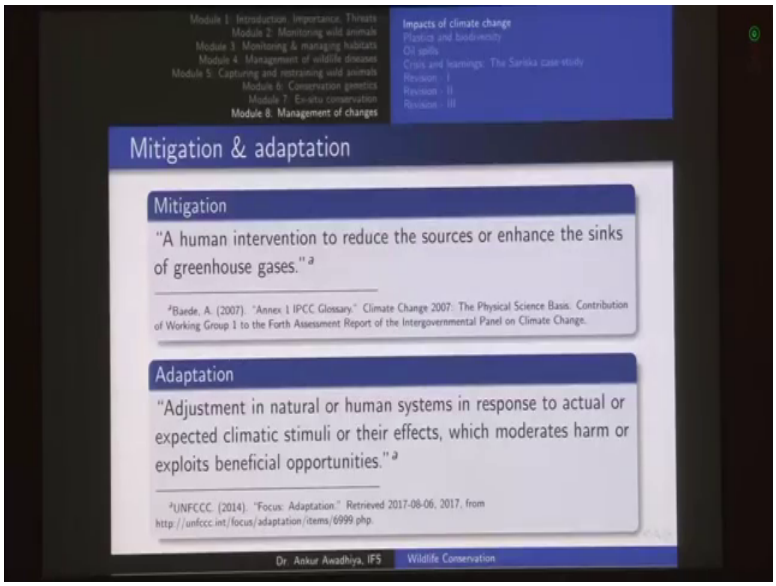

Mitigation and adaptation: now, mitigation refers us to a human intervention to reduce the sources or enhance the sinks of greenhouse gases. So, what we are talking about in this case is that because this climate change is happening because of carbon dioxide, let us reduce the amount of carbon dioxide that is there in the atmosphere. So, that climate change itself can be reversed back.

Now, how do you reduce the amount of carbon dioxide in the atmosphere, we try to reduce the sources. So, in place of say power plants that were using coal, let us shift to say renewable sources of energy say things like solar power or wind power. So that the amount of carbon dioxide that is being released into the atmosphere is reduced or we can try to enhance the sinks of greenhouse gases.

So, sinks of greenhouse gases include things like forests. So, if there is carbon dioxide in the atmosphere and when, the forest perform photosynthesis the plants in the forests perform photosynthesis in which carbon dioxide in the atmosphere becomes fixed into biomass carbon. And so the amount of carbon dioxide that is there in the atmosphere reduces.

So, both these ways reducing the sources or reducing the inputs into the atmosphere, and enhancing the sinks that is increasing the outputs of carbon dioxide from the atmosphere of the greenhouse gases would be called as mitigation. The second option is adaptation

for adaptation in natural or human systems is response to actual or expected climatic stimuli or their affects which moderates harm or exploits beneficial opportunities.

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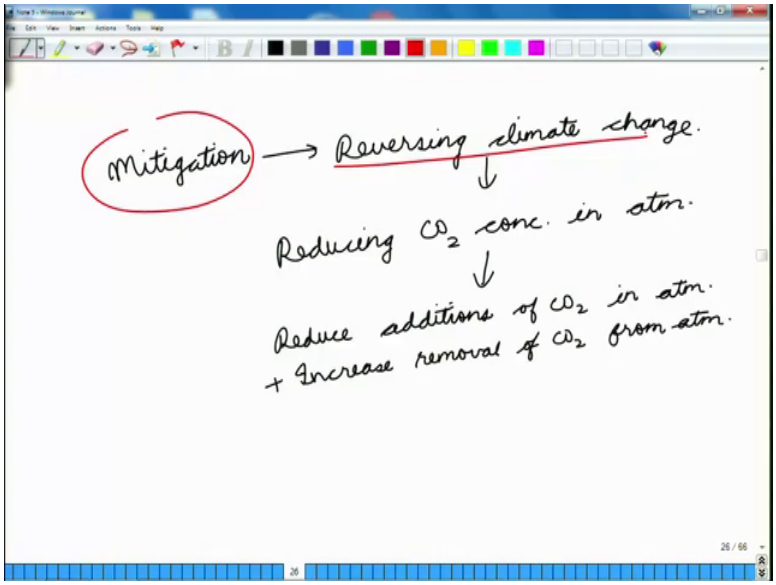

So, what we are saying in this case is that when we are talking about mitigation, we are talking about reversing climate change. And how do we reverse climate change, by reducing CO2 concentration in atmosphere. And how do we reduce carbon dioxide concentration in an atmosphere. We reduce additions of CO2 in atmosphere plus we increase removal of CO2 from atmosphere. So, essentially mitigation has to deal with reversing the climate change.

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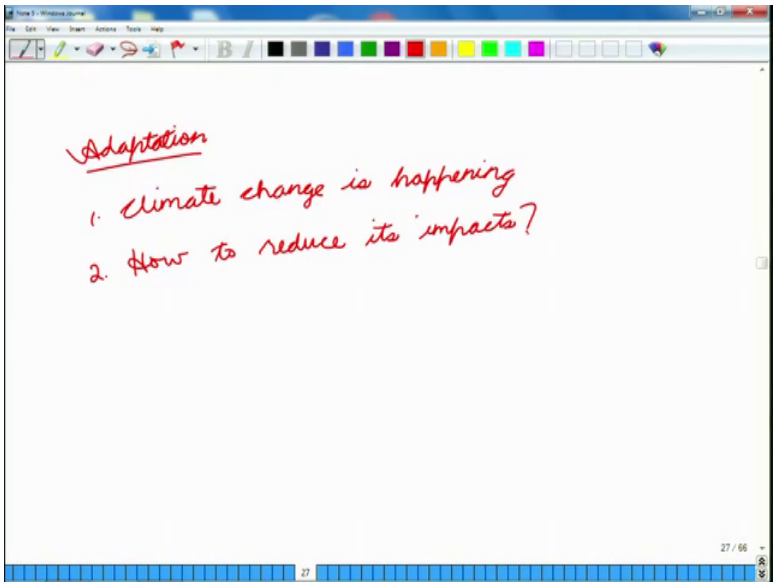

But, in the case of adaptation we begin by saying that climate change is happening. So, our question is how to reduce its impacts. So, in this case we are not trying to reverse climate change, but we are trying to reduce the impacts of climate change. Now, one very easy example is that if the temperatures are increasing, we install coolers or ACs into our homes. So, in that case even though these temperatures are increasing we are able to keep ourselves in a cool position. So that is an adaptation in the case of human beings.

Now, in the case of animals these could include say things like having more and more of water holes in an area, because with climate change there would be areas that would dry out. So, if there are areas that are drying out, let us have more water holes in those areas, so that the animals still get water even when climate change happens or in areas where we expect that there would be floods. So, we would say install more number of greenish channels in those areas. So that even though those areas get more amount of precipitation these water flows away, and those animals are safe. So, these would be known as adaptation options.

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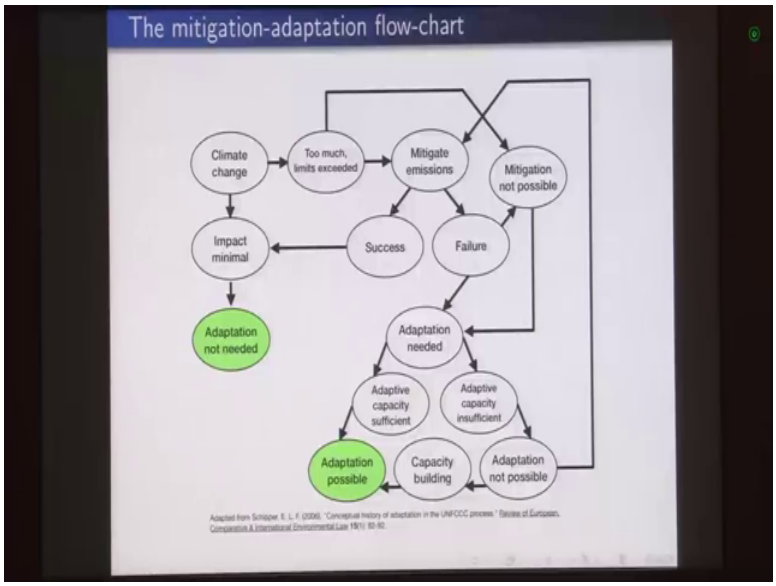

Now, mitigation and adaptation in most situations occurs simultaneous. So, this is one flowchart of mitigation and adaptation. So, we begin here it is climate change. If we say that there is a minimal impact. So in that situation an adaptation may not be needed, but then if in the case of climate change, we have too much of climate change and the limits have exceeded. Then we will have two options. One you can ask for mitigation of in emissions or in other cases you can say that mitigation is not possible.

Now, if mitigation is possible, then again we will have two options here. One is that we are successful in mitigating the emissions in this case we are able to bring back the impacts to the minimum level and so there is no adaptation needed, but then if there is a situation in which our mitigations options fail, so in that case mitigation is not possible, and so now adaptation is needed, because adaptation is now the only option left.

Now, in the case of adaptation we could have two situations adaptive capacity is sufficient or the adaptive capacity is insufficient. So, adaptive capacity refers to the capacity of our system to adapt. So, if this is sufficient, we would have a situation in which adaptation is possible. If it is insufficient and adaptation is not possible then we can either go back and try to mitigate emissions by some other means or else we try to build up our capacity, so that adaptation becomes possible.

So, from this flowchart we can see that we have to work on both the fronts mitigation as well as adaptations. If you are able to mitigate the best option, if you are not able to

mitigate, then we will have to adapt. And if adaptation also is not possible, then capacity building, so that adaptation is possible becomes the only way for survival.

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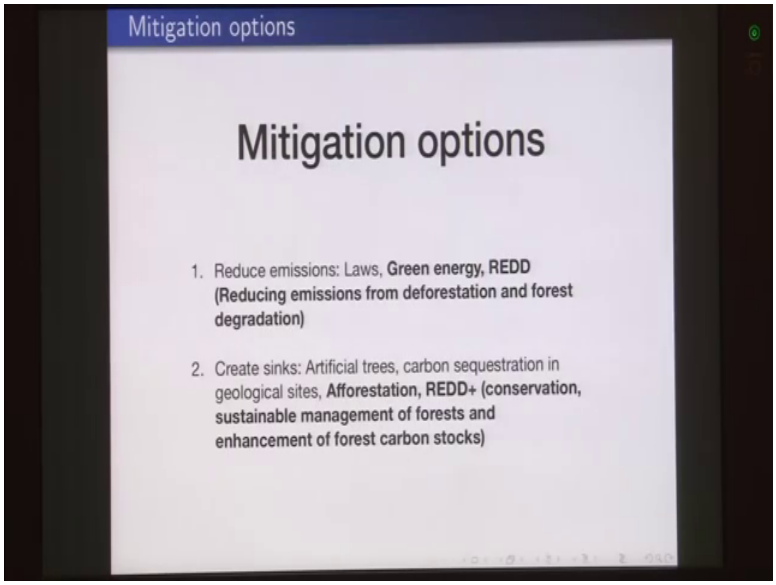

So, what are the mitigation options available with us, especially in the field of conservation. So, the first is reduce emissions. So, we can push for both laws, we can push for more amount of green energy or renewable sources of energy. And then we can go for REED. Now, REDD is a mechanism that has this full form reducing emissions from deforestation and forest degradation.

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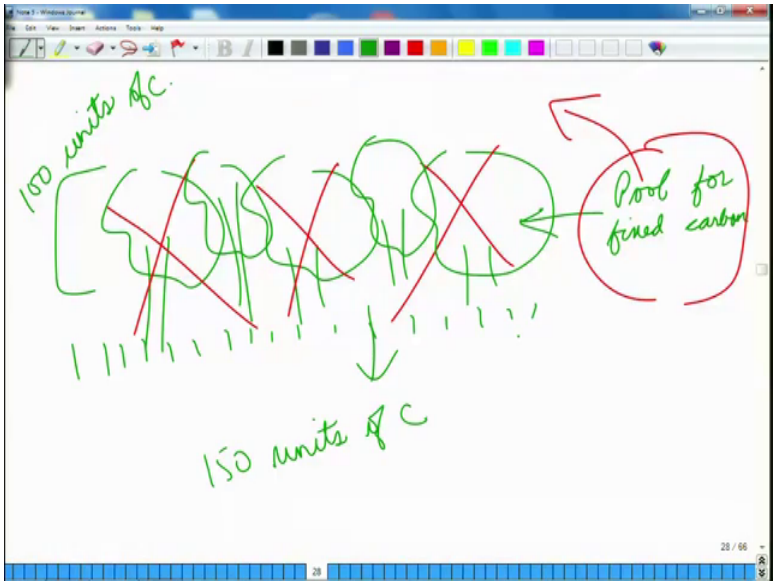

Basically, if you have a forest in an area, so if you have a forest in an area, these forests are also acting as a pool for fixed carbon, because all the wood inside these trees is having carbon fixed in the form of cellulose. Now, if these forests are cut down, so if there is a deforestation; so where would all of this fixed carbon go it will release back into the atmosphere. Now, when we talk about this mechanism of REDD, we are trying to reduce emission from deforestation and forest degradation.

So, essentially if you are keeping your forest protected if you are keeping your forest in a position that they continue to remain pools of carbon, so in that way you are reducing emissions from deforestation and forest degradation. So, these are the mitigation option of reducing emissions. Now, the second option is the creation of the sinks. Now, we can talk about artificial trees or carbon sequestration in geological sites, but the easier options are those of afforestation.

So, you plant more and more trees go for a REDD plus mechanism which talks about conservation sustainable management of forest, and enhancement of forest carbon stocks. So, in the case of REDD plus mechanism what we are saying is that earlier if our forests were able to act as a pool for say 100 units of carbon, can we do something, so, that it becomes a pool for say 150 units of carbon. And how can we do that we can do that by having a conservation more sustainable management of forest and enhancement of forest carbon stocks. Now, this enhancement of forest carbon stocks could be in terms of having say more number of trees in this forest or say having one carbon pool here, but then also having some amount of undergrowth that also acts as a carbon pool and things like that.

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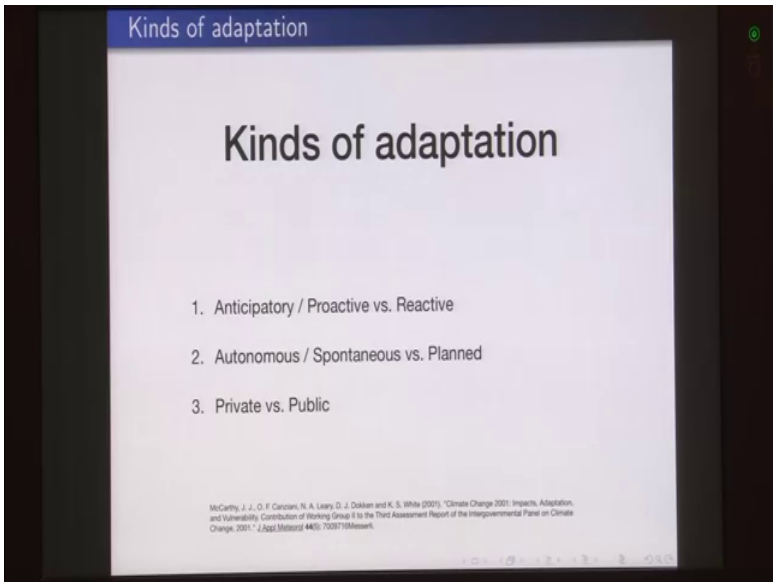

Then what are the adaptation options available with us. So, let us begin with the kinds of adaptation that can be done. One is anticipatory or proactive adaptation versus reactive adaptation. Now, anticipatory adaptation is adaptation before your crisis situation has come up. So, for instance anticipatory adaptation in the case of our wild animals could include that if we know that we are going to have a draught next year. So this year before our rainy season we create big sized water pools, so that in our rainy season all this water will be stored.

And so next year this draught will be prevented. On the other hand, reactive adaptation is an adaptation that is done after the crisis situation has come up. So, we could not do anything for the draught, and the draught has already come into our area. So, we will use some tankers or say pipe lines to bring water into our forests that will be a reactive adaptation.

Next we have autonomous or spontaneous adaptation versus planned adaptation. So, autonomous adaptation is something that occurs by itself. So, for instance: there is more amount of heat animals will automatically try to get into any amount of cover that is available for them in the form of shade. Planned adaptation on the other hand would involve some amount of human planning.

So, for instance we would actively try to increase the amount of shade that is available for animals in that period because in most of our deciduous forests most of the trees are

already divide of leaves in the dry season. So, they could for a planned adaptation. And then the third adaptation is private versus public adaptation. So, this is not very much relevant in the case of wildlife conversation, but what it says is that our adaptation could be done at a private scale. So, at the level of individuals or it can be done at the public scale or at the level of the society.

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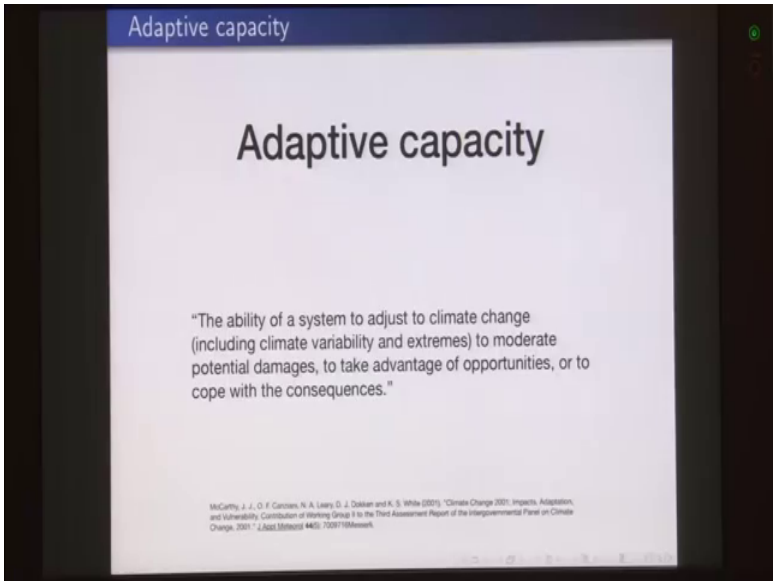

Next we talk about the adaptive capacity. The ability of a system to adjust to climate change including climate variability and extremes to moderate potential damages to take advantage of opportunities or to cope with the consequences is known as adaptive capacity. So, essentially in the adaptive capacity we are talking about the capacity of a system to adapt or the ability of a system to adapt or to adjust itself specially to climate change.

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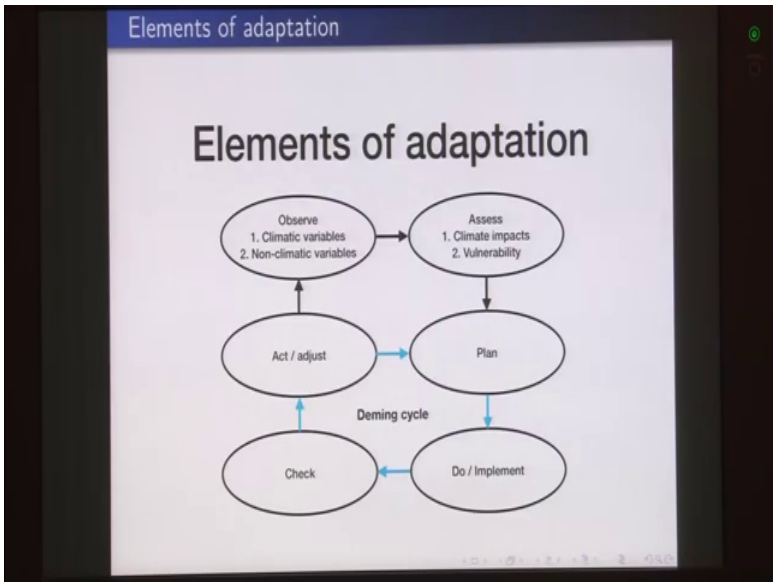

Now, how does adaptation work in the field? So, these are the elements of adaptation. So, we talked about the deming cycle, and one of our earlier lectures as well. Deming cycle that is represented by PDCA cycle refers to planning doing checking and adjusting. So, this is a common management cycle that we use again and again. So, we do some planning when we implement those plans; then we check whether we are getting desired results, and one the basis of those results we then adjust our plans for the next cycle.

Now, in the case of adaptation we the first step is that of observation. So, we observe the climate and the non climatic variables. And then on the basis of those observations we try to assess the impacts of climate and the vulnerability of our system. So, here in the case of observation we could include things like temperature, the amount of precipitation that we are getting. The number of days on which we have rainfalls, the number of days that we are having a cloud cover and things like that.

On the basis of that we would assess whether there is a substantial climatic impact on our system or in the near future are we going to have a climatic impact. So, what are the chances of getting a draught in our area, what are the chances of getting a flood in our area, what are the chances of our forest getting more amount of forest fires. And then we also do a vulnerability analysis whether our animals and whether our systems will be able to cope by themselves or not.

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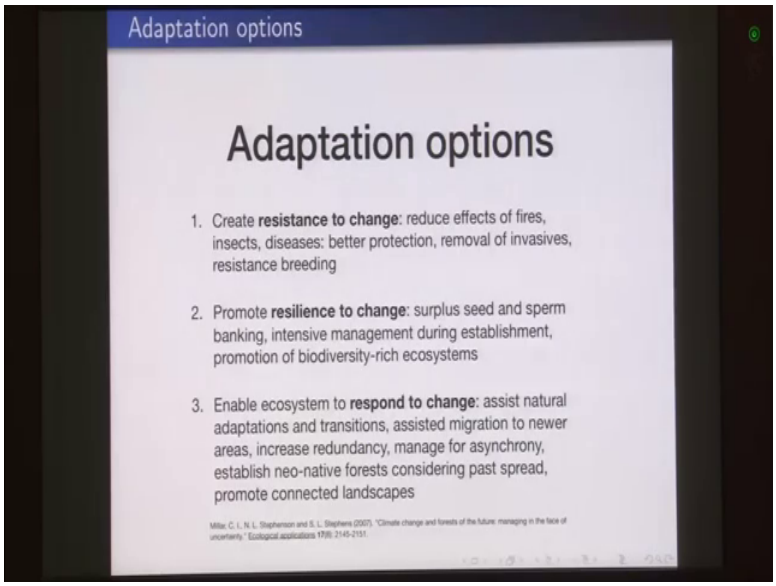

And with that we would go for the adaptation options. The adaptation options could include having resistance to change having more resilience to change and enabling our system to respond to change. Now, resistance to change means that even though climate change is occurring, we are able to resist its impacts or our system is able to reduce to resist to the impacts.

So, these could include say having better protection removal of invasives resistance breeding, so that even if we have situations of a draught, if you have more draught tolerance species, they would be able to reduce the draught. The second is resilience to change. Now, resilience to change means that if climate change impacts our system. And our system has some amount of damage will our system be able to move back will it be able to come back to its original state.

So, this resilience to change can be had in the form of surplus seed and sperm banking, intensive management during establishment, promotion of biodiversity-rich ecosystems. So, what we are talking about here is that if for instance because of climate change, we had a very huge amount of forest fire in our system all our trees died out. So, if we have a surplus seed bank, so this seed bank can then we used to re establish our forest there.

So, we could go for a doubling or we could for plantation to re establish our forest, so that would be a resilience to change, so that even though our forests were destroyed, they are able to come back to their original position. And the third is enabling the ecosystem

to respond to changes. So, we assessed national adaptations and transitions assisted migration to near areas increase in redundancy management for asynchrony and so on.

So, in this case what we are doing is that if there is climate change, if there is an increased temperature in our system, so the animals need to migrate from hotter areas to cooler areas. So, we are enabling our ecosystem to respond to changes by facilitating that migration. So, this could include say creation of corridors into our forest areas or maybe even going into our forest manually picking up some animals and then transfer of heating them to the second area.

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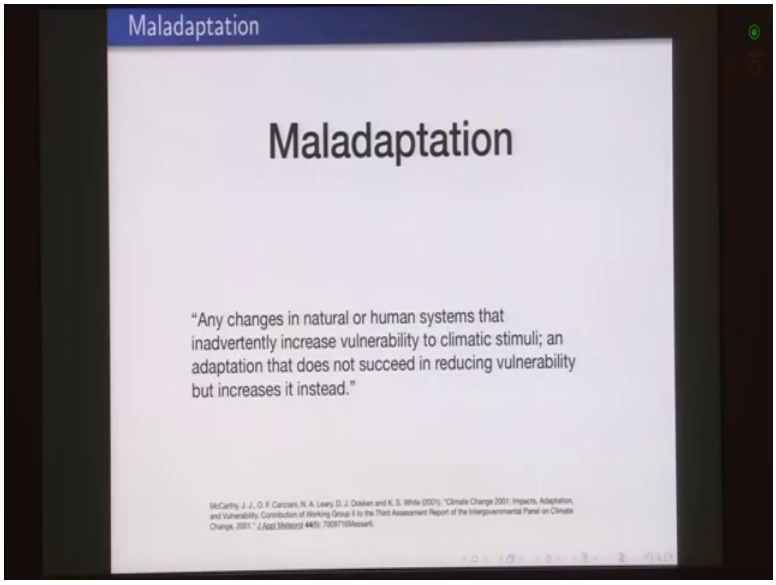

Now, if adaptation works well and good, if it does not work, then we could also have a situation of maladaptation. Now, any changes in natural or human systems that inadvertently increase vulnerability to climates takes stimuli. And adaptation that does not succeed in reducing vulnerability, but increases it instead is the maladaptation.

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So, coming back to the word roots mal means bad. So, this is a bad adaptation. Bad adaptation in the sense that we did something in hope that we would enable our system to adapt to the changes, but it misfires. So, we were trying to increase the resistance of our forest to forest fires for instance. But, by doing that we increased our vulnerability to draught. And so in that case we had a situation in which our forest died out. Even though it had a very good forest fire protection, but it died out because of draught, so that would be an example of maladaptation.

Another example would be suppose we were adapting our forest to resist forest fires, but then the materials that we used or the techniques that we used in our forests, actually increased its vulnerability to fire. So, those were the situation of maladaptation. So, whenever we are doing any amount of intervention into our system, it is extremely important to see to it that our systems are able to adapt and then in our chances of maladaptation reduce.

So, in this lecture, we looked at climate, climatic systems, and how we have different kinds of forcing and responses, what kinds of changes do these responses bring about into our eco systems. So, like changes in the anneal frequencies in these case of tawny owl or increase in extinction potential of some animals or say increasing range of some insects in vector and so on. Then we moved into what can we do to thought climate change. So, we talked about on the mitigation options and also to adapt our system to

resist, and respond to climate change where we talked about all the adaptation options. So that is all for today.

Thank you for your attention [FL].