

**Conservation Economics**  
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**Module 4**  
**Threats to wildlife**  
**Lecture 3**  
**Ecotoxicology and Developmental Hazards**

Namaste!

We carry forward our discussion on the Threats to WildLife and in this lecture we will have a look at Developmental Hazards and Ecotoxicology. Now you must have heard in a number of circumstances that we are aiming for economic growth and are aiming for economic development. The question is are both of these the same or is there a difference between economic growth and economic development.

Let us look at what growth and development mean, growth is an increase in size of something or increase in the level of output of something. For instance if you see that there is a child and the child over the years is increasing in height it is increasing in its weight, then we would say that the child is growing because there is an increase in size of something.

Similarly when the economy grows it means that the economy is increasing in size, the total amount of income that we are having or the total resources that we are having are increasing with time. When that happens we will say that an economic growth is occurring or an increase in the level of output of something. So, for instance there is an industry that is producing say 100 cars in a day and because of some technological changes or because of certain managerial decisions this output increases to 250 cars a day.

In this case the level of output of the industry has increased and so we will say that the industry is showing a growth and if a number of such industries show a growth we will say that the automobile sector is showing a growth. So, growth is an increase in the size of something or increasing the level of output of something.

This is different from development. Development is the process by which the economic wellbeing and quality of life of a nation, region or local community are improved according to targeted goals and objectives. Now when we are talking about development we are not talking about an increase in size of something, we are talking about things which are wellbeing, we are talking about things which are quality of life.

Similar to our child example when the child is increasing in size or increasing in height we see that the child is growing. But, then when the child learns something new when the child has started to learn the alphabets. When the child has started to walk or has started to talk then we say that the child is developing. So, there is a difference between growth and development.

Growth is an increase in size, whereas development is an increase in wellbeing or an increase in the capabilities.

In the case of economic development we are talking about the economic wellbeing of a nation, region or local community. We can look at development at different scales. We look at development at the scale of a nation or region or a local community. But when the economic wellbeing increases and also the quality of life increases, then we say that there is an economic development.

We generally consider 3 dimensions of economic development or human development, these are the life expectancy index which is how many years can a person or a child that has just been born can expect to learn. So, if for instance there is a society in which sanitation is good everybody gets adequate nutrition and health care is good, then we will see that the life expectancy increases.

And when life expectancy increases we will say that the development has occurred, because there is an increase in the quality of something. Similarly, education index: how much a person can expect to receive in terms of education. If people are literate then they are said to be more developed, if people go to colleges, if they go for a post graduation course we will say that they are more developed than say a person who is illiterate.

Because, education gives you the capability of doing something, so it increases the wellbeing and it increases the quality of life. So, the Education index is also another component of development. Income index: how much income do people receive and what is the level of equality or inequality in the society, when we talk about income index we look at how much can a person expect to earn.

And also what is the level of income inequality in the society, because for instance there is one person who is earning a lot and a majority of people are not earning anything. So, in that case the average income will be high, but because of income inequality we will say that this society is less developed, than perhaps another society where everybody has a similar level of income on an average.

These are the 3 dimensions of the human development index. Essentially what we are saying is that when we talk about economic growth we are talking about an increased output and an increased concentration of resources. But when we are talking about economic development then we are talking about how much is the wellbeing of people, how much is the capability of people to have a control over their lives, so that is economic development.

Now both of these are related, but there is also a trade off. For instance if you want to empower people, this empowerment can be taken as an indicator of development because, when people are healthy, when people are educated and when people are financially capable of doing things, then they are more empowered than when people are unhealthy or they are illiterate.

So, empowerment is a proxy that we are using here for economic development. Production is another proxy that we are using for economic growth, what is the amount of production that an economy is doing? Now this curve is telling us about a trade off between production and empowerment. Suppose society decides that we are going to invest our resources into producing more and more stocks.

In that case the empowerment might take a hit, because the people who were necessary for doing empowerment such as doctors or nurses or teachers that would have helped people to have a much better control over their lives are now being diverted into say production.

In that case we will or this society will have a much greater production, but at the cost of empowerment. The society might even take another decision that empowerment is more important for us and so we are going to divert certain resources from the production sector and we are going to put them into the empowering sector. So, for instance we will take out the best managers that are there in the industries and we are going to put them into academics.

When such a thing happens then we will say that the society is focusing on empowerment. Now a curve such as this represents the production possibility frontier. Now it shows us that there is a trade off that needs to be made between production and empowerment and different societies face choosing different things and in a number of cases it might be difficult to have in excess of both of these at the same time. It is possible it is what we are aiming at, but at times there has to be a choice that needs to be made.

When we talk about economic growth we say that the production is increasing. So, this is how the production possibility frontier will look like when the production increases. Now when the society shifts from the black curve to the red curve then the the amount of production in the economy has gone up, but the level of empowerment has not changed.

Probably people are still illiterate, people are still unhealthy, but there are some people in this society that have become richer. So, this is an example of economic growth without any amount of empowerment to the society. Another example is this one where the amount of production remains the same, but the society is only focusing on empowerment. So, in this case everybody has become more capable of having control over their lives, the empowerment has increased without the economic growth.

But in a number of cases what we are aiming at is an increase in production as well as an increase in empowerment. So, there is economic growth, but there is also economic development. Now, why do we require both of these together because we are as a society we are aiming at economic development which is increasing the wellbeing of people.

Now the well-being of people will not increase if they do not have access to stuff. So, to increase their well-being you have to provide them with more resources. So, if there is a society where everybody just has one board of transportation which is walking, then probably they are less empowered than say a society where everybody has a bicycle or say everybody has a car.

To empower people to move from one place to another in a faster manner we will have to provide them with bicycles or cars and this is only possible if there is a production of bicycles and cars. So, for development we want to increase production, but at the same time we also want to increase the level of empowerment that is there with everybody.

So, you need to devote resources to ensure that people are educated and people are healthy. For instance if this if our society just wanted to produce more and more cars and it led to such a huge amount of pollution that everybody in the society became ill. In that case we will say that there has been an economic growth, but at the cost of empowerment and so we will not say that the society has developed economically. So, there is no economic development even though there is

growth. So, this is a distinction that we need to keep in mind.

However in a number of cases what we have observed is that if there is an increase in production people say that the economy has developed. Whereas, in reality we are only having economic growth without having any development, now this distinction needs to be kept in mind before we move further.

What happens when we only focus on growth we do not focus on development or in other words what are the hazards of focusing just on an unsustainable growth. Now remember that when we talked about development we were talking about the wellbeing of people, now the wellbeing of people increases when they have access to nature. The wellbeing of people increases when they live in an area or in a society that has less levels of pollution.

The wellbeing of people increases when they have the joy of watching wild animals such as tigers. So, if we remove all these well beings, if we just provide economic growth and to provide the economic growth we put people into a condition where they have or where they are forced to live in very polluted areas where they are forced to live in a society, where the biodiversity is all gone where the children have never observed a butterfly or birds then probably there is something that is going wrong.

When we focus only on unsustainable economic growth there are a number of hazards that are proper. Now remember here that these are the hazards of going for an economic development which technically should be called only as an economic growth, because these are reducing the wellbeing of different people.

What are these hazards? These results include the loss of biodiversity. So, in this image what we are observing is that there is this net that was used for fishing and to increase the production of fishing we have increased the production of these nets or probably we have subsidized these nets. So, there is an excess of these nets.

Now, if there was not an excess of these nets if they were scarcer, then what people would have done is that if the nets went bad if there was say a cut in the net people would have tried to mend it. But if you can get these nets very cheaply because of the economic growth, what people do is that they do not or they are not incentivized to mend the net, but they go for a disposable culture. In this case what people would do is that if there is even a small cut in the net they will throw this net off and buy a new one, because the economic growth has made it possible for them to get another net very quickly. So, what happens to the previous net? It will be thrown into the rubbish dump and suppose it goes to a landfill and because most of our landfills are already filled up.

It is washed away and when it gets washed away it reaches into a water body. Now the net was designed to capture animals and in this case even though there are a few cuts in this net this net is still capable of catching animals. So, this is an example of the hazard of having economic growth without development.

Because if there was development, if people were made more aware of what are the negative impacts of doing this fashion then probably they would have refrained from throwing this net out they would have disposed of it more properly. But if there is no development if there is a lack of awareness or education then this is what happens. So, one hazard is the loss of biodiversity.

We are observing all over the world that a number of animals are dying, they are getting

entangled in these pieces of plastic and they are dying off. And when there is a loss of biodiversity this also reduces the wellbeing of quite a number of people, because biodiversity has its own advantages.

Now, the people who live in the cities might be less aware of the advantages of biodiversity, but then if you talk to anybody who works in say an apple orchard he or she will tell you the importance of honeybees. If the honey bees are gone there is nothing that can pollinate the apple orchards and probably the production would go down. So, the loss of biodiversity is a hazard of unsustainable growth.

Another hazard is trashing the planet: you go to even a national park and you will find that there is trash all around. There is plastic that has released into a majority of areas our wildlife are now living with the trash and we are trashing everywhere we are trashing the water bodies, this trash is coming to the beaches we are even trashing the seafloor. So, trash or trashing of this planet is a hazard of a development or an economic growth that is unsustainable.

Another is Clearing a forest because for economic growth you require resources, resources such as land resources such as wood resources such as pores and minerals that are there in the land. Now to have access to all of these there has been a rampant cutting of trees and rampant deforestation which is another hazard of unsustainable economic growth.

This is an example of deforestation for mining. So, this is Balaghat in 2006 this is the same area in 2018 the forests are gone this is an example of going for an economic growth because of which people are diverting the forest into agriculture. So, this was Umaria in 2002 and if you concentrate on this area it is gone. All of these forests are now gone, so this is the Umaria in 2018.

This is a portion of the Brazilian rainforest in or the Amazon rainforest in Brazil Rondonia in 1975 and this is the same place in 2016 the forests are all but gone. Now, why are we seeing this rampant deforestation, this is because we are focusing only on economic growth and the cost of wellbeing of people.

If you talk to the local communities in Brazil a number of these communities are up against this rampant deforestation because it is encroaching upon their lands, it is encroaching upon their culture, it is encroaching upon their way of living. But for an unsustainable economic growth the governments are permitting these things to happen or they are unable to stop people from doing this.

This is another example of deforestation for mining. This is the Ok Tedi Mine and if you concentrate on this area or if you concentrate in the river where the dumps are, there is now a massive amount of deforestation. So, this river has become so toxic that the trees around it are dying off.

Another hazard of unsustainable economic growth is desertification and overgrazing. Now, in the case of economic growth we wanted to increase production. So, every farmer wants to have more and more milk. Now if the farmer wants to have more milk he or she will want to have more goats, but then this environment cannot sustain such a huge number of goats.

What do these goats do? They eat off all the grass they eat off a majority of the herbs and shrubs that are there in this area which leads to an expansion of the desserts. So, this is overgrazing,

overgrazing why because the people are going for unsustainable economic growth.

We are also observing a large amount of fragmentation of the habitats. So, there is this road where you have forest on both sides, if the animals want to cross from here to there they are unable to do that because there is a road in between and if the animal tries to cross it may get hit. And this extreme fragmentation of the habitats is also another hazard of unsustainable economic growth. Another hazard is what we are observing in terms of climate change. So, these are bleached corals because of climate change. So, all of these corals, these beautiful organisms, are now dead.

Because of unsustainable economic growth we are spewing out. So much greenhouse gases such as carbon dioxide that the earth's temperature is rising. It is impacting the coral reefs it is impacting the coral bears whose habitats are now going down. There are a number of instances in which the eye sheet has become so less, that now these polar bears do not have a place to rest. Climate change is impacting the mangrove forest climate change is impacting the kelp forest in our oceans. We are seeing a large amount of habitat level destruction because of climate change and what is causing this climate change. Economic growth is unsustainable economic growth, so this is also another hazard that we are observing.

We are observing changes in the spatial distribution of organisms. The organisms that were living in colder areas now because of an increase in temperature are dying off, because they cannot tolerate that amount of heat or those areas that were. So far inaccessible by certain organisms they are now getting colonized. So, there is a change in the special distributions of different organisms. This is also because of global warming which is occurring because of an unsustainable economic growth.

Another hazard is wars. Why would 2 countries go for a war? Because each country wants to increase its resources for economic growth and because there is a limit to the amount of natural resources that are present within any country. There is a limit to the amount of land that each country has. They try to attack someone else to capture their land to capture their resources and that leads to war that leads to a heavy destruction of the environment. This is another hazard of unsustainable economic growth.

The trash that we are putting into the environment, even if it gets degraded it is still trash. So, we have smaller fragments of plastics that we are finding everywhere. And there are a number of organisms that mistake plastic for their food, these plastic bags look like jellyfishes.

So, an animal that eats jellyfishes might attack these plastics might try to eat these plastic, we have we have seen instances of birds where the parents bring in plastics to feed their chicks mistaking these plastics to be fish and because of that the full of the alimentary canal of this bird gets choked and this bird dies out of starvation. Loss of biodiversity in this way is also a hazard of unsustainable economic growth.

We are seeing it everywhere, even deep in our oceans. We are finding that the plastics have reached, there they are impacting all organisms whether big or small even in the case of microscopic organisms we are finding that their bodies are now filling up with plastics.

The behaviours of organisms are changing. So, this is another hazard of unsustainable economic growth. We have trashed the planet to such an extent that now the organisms are getting more

and more accustomed to these plastics, they are now using these plastics and showing the behaviour that is not a natural behaviour. So, this loss of natural behaviour is also another hazard that we are observing

This image of a seahorse that is sticking to an ear bud or these animals, these hyenas that are living in trash or these rhinoceros that we are finding full of plastic. Now a Rhinoceros in a natural environment does not eat plastics, but we are changing the behaviours of animals by trashing our planet. So, this is another hazard of unsustainable economic growth.

Now, in the quest for having more growth in the quest of having more production we have produced such a huge quantity of plastics that now it has turned into a menace. Changing behaviours of different animals here we are observing that now everybody has access to roads everybody has uh is having big cars and this interaction with wild animals is changing their behaviours.

Now there is a greater interaction of people and animals we are finding that we have developed or we have constructed. So, many roads that now they are acting as big barriers to the movement of wildlife wild life is. Now finding it more and more difficult to cross the road. So, earlier this whole habitat was this, but now we have divided it into fragments.

If they try to cross they might get hit, they get killed or even otherwise there is a huge structure in their habitats. So, these are all different hazards of unsustainable economic growth pollution because of the heavy amount of vehicles that we are flying on the roads.

Now having more vehicles we will obviously say that yes that is economic growth, but is pollution leading to the welfare of people of course not. We cannot say that we are developing economically if these negative impacts are not checked. So, pollution is another hazard of unsustainable economic growth.

There is also a huge number of deaths of birds, because they are getting collided with a number of our infrastructures and the birds are dying. So, that is not leading to the welfare of people that is not development. So, we are just aiming at economic growth at the cost of welfare and that is a big hazard.

We are changing the distribution of species because of our trashing the planet, more and more invariant species are now able to reach more and more areas. And this is an issue not just for animals, but this is an issue for humans because ultimately the wellbeing of humans is getting impacted because of these conflicts because of the trashing of the planet.

What we can say is that if you go for an unsustainable economic growth there will be a huge number of hazards, hazards of pollution, hazards of fragmentation, hazards of loss of biodiversity, hazards of increasing conflicts with wild animals and that is not leading to a welfare for the society. That is not development, that is just economic growth at the cost of development. So, this distinction - this fine point needs to be kept in mind whenever we are doing any economic analysis.

Next we will have a look at Ecotoxicology which is the study of the effects of toxic chemicals on biological organisms especially at the population, community, ecosystem and biosphere levels. Now the point is why do we need to study Ecotoxicology. So, this is important because we are releasing a huge quantity of toxic substances into the environment and they are having an impact

on different organisms at the individual level. Sometimes at the population level and sometimes at the even greater higher levels.

Now, the common toxic chemicals that are present in the environment include pesticides and their residues. These days, because of the need for more and more quantities of food grains we are using a heavy dose of pesticides. Now these pesticides kill the pests such as insects or rodents, but whenever these pesticides are used and they are toxic chemicals some portion of them is always leaked out into the environment and it remains in the environment.

Even though there might be certain processes, certain chemical reactions that will change these pesticides, some of the residues will remain in the environment and that will create a condition that will have an impact on certain organisms. So, Ecotoxicology studies the impacts of pesticides and their residues and we will have a look at what these impacts are in a short while. Heavy metals: heavy metals especially those that we are releasing because of our mining activities such as in the case of tailings dam.

This is an image from Balaghat. So, we have a mine there and this is a tailing dam. Now in the tailings dam the residues that are released from the mine are stored and we can observe that in this satellite image from 2006 we can observe so many trees that are there in between this fake tailing dam.

This is another image from 2018, so we can see that if you concentrate in this area we had trees here in 2006 and in 2018 these trees are gone. Now uh similarly if you consider this section, so we have trees till this line in 2006 and by 2018 that these trees are gone.

Now, nobody is going into a tailings dam to cut these trees, but what is happening is that because you have a heavy concentration of heavy metals. So, that is creating a toxic impact on these trees and these trees are dying off. So, heavy metals and their release and their impact is also something that we study in Ecotoxicology

Plasticizers, so whenever we talk about plastics plasticizers are the chemicals that are added to plastics to modulate their properties to make them more elastic or to make them a little transparent or to improve their properties these are the chemicals that are added to plastics. Now a number of these chemicals have toxic impacts such as this chemical bisphenol-A.

Bisphenol-A is a plasticizer that is added to plastics to make it more supple to make it more transparent, but it acts like hormones in the bodies of different organisms. It disrupts the functioning of the endocrine system in different organisms and Ecotoxicology will try to study what is the impact of this chemical on different organisms at different scales or volatile organic compounds such as formaldehyde.

The formaldehyde is released as part of a number of chemical reactions and it is a toxic chemical or mycotoxins. Now mycotoxins are toxins that are released by different fungi. Myco refers to a fungus and mycotoxin is a toxin that is being created by a fungus. But what is happening is that because we are changing the environment to such a large extent. So, we are increasing the amount of mycotoxins that are present in the environment.

What is the impact of these mycotoxins on different organisms is also something that Ecotoxicology will try to decipher. Or the impacts of things such as Brominated flame retardants. Now these Brominated flame retardants are added to a number of plastic products to reduce the



probability that they will burn up in case a fire occurs.

Now, these Brominated flame retardants are bioaccumulative toxins they accumulate in the bodies of different organisms and in this manner they are able to concentrate themselves and then have a larger impact on different organisms at different levels.

Now talking about toxicity, all of these chemicals will be having different levels of toxicity. Those chemicals that have an oral lethal dose which means what is the amount of any chemical that when given to an organism in the oral route - which is through food or water - will result in a lethality that will kill the organism.

This is the oral lethal dose it is generally expressed in terms of milligram per kg body weight of the organism. Now if there are chemicals which are lethal or which kill the organism at as low as 1 to 50 milligram per kg, then we say that these are the most poisonous chemicals and whenever they are being transported this is the symbol that is used.

If the oral lethal dose is between 51 and 500 milligrams per kg we still call it a poison but it gets a yellow label. If the oral lethal dose is between 501 to 5000 milligrams per kg it gets a blue label and to be call it a dangerous chemical and in case the overall lethal dose is greater than 5000 milligrams per kg we put the label which is green in in color and we say that this is a chemical that we need to be cautious about. So, different chemicals have different levels of toxicity and of course those chemicals that have a higher toxicity will have a much greater impact which will be an acute impact.

Now, an acute impact means that the impact of this chemical on the organism or on its population or community will be quick. That is known as an acute toxicity, an acute impact or a quick impact. It generally occurs in a very short period of time because of a very sudden exposure.

In the case of those chemicals that have less amount of toxicity in a number of places they will observe a chronic toxicity, which means that if these chemicals are released into the environment they will slowly act and produce their side effects. So, it will act over say many months or many years and in that case we will say that it is a chronic toxicity which occurs over a large period of time.

Now, what are the impacts of these chemicals? In very high doses these chemicals will have lethal effects which means that they will kill certain individuals or a large number of individuals in any population or community. So, this is known as a lethal effect in certain cases we can have sub lethal effects in which case the organisms do not die, but they have a reduced amount of functioning.

That is a sub-lethal effect certain chemicals are mutagens which means that they produce mutations in the genetic code. So, we have chemicals that produce mutations, so they have a genetic effect on organisms. Certain others have Teratogenic and developmental effects, now teratose means a monster and genesis means production.

Teratogenic chemicals are those chemicals that are monster producing which means that if the organisms are exposed to these chemicals and especially those organisms that are pregnant. So, these chemicals will act on the fetus and will produce developmental abnormalities which means that you might observe that there is a frog which in place of having 4 limbs is having say 5 limbs

or 6 limbs or there is a tortoise that is born without limbs.

Now, these kinds of organisms can be produced because of Teratogenic chemicals or developmental inhibitors. In certain other cases we observe a reduced fecundity which means that the organisms will be having less number of children or less number of offspring. So, this is a reduced fecundity that you observe in a case of a number of toxic chemicals and especially the chronic toxins.

They manifest their impact in terms of reduced fecundity. This is possible because in certain cases the offspring when they are there in the fetal state they will die off or there will be spontaneous abortions, because of these chemicals and so the fecundity will go down and in any case these toxic chemicals add to the existing stressors. Which means that if the organisms are weakened because of a disease or because of malnutrition and if they also are exposed to these toxic chemicals in the environment the impacts add up. So, they act to the existing stressors that are already there in the environment.

What is the impact of a chemical such as DDT, now DDT is a pesticide which was traditionally heavily used for agriculture and it was also used in the control of malaria. Now when DDT is used as a pesticide a portion of it remains in the environment. So, when DDT is used in an agricultural field to kill off insects that were destroying the crops with the next rains a portion of it may get washed off and beat into a water body. Now DDT may be acted upon by oxygenation or because of certain organisms and it gets converted into another residue which is known as DDE so dichlorodiphenyldichloroethane or ethylene.

Now, these chemicals are very persistent chemicals that remain in the environment for a very long period of time and they can show their impacts on different organisms. Another characteristic of these chemicals or these residues is that they accumulate in the bodies of different organisms and as we move up the food chain their concentration goes on increasing because of a process that is known as bio magnification.

If you look at the DDT or DDE concentration in the water it will be very less because it is only a small fraction of the residue that came to the water body and the concentration in plants or say the phytoplanktons again will be very less, but the zooplanktons they eat these phytoplanktons will have a greater concentration of these residues in their bodies.

The fishes that eat up these zooplanktons will have an even greater concentration of these chemicals in the in their bodies, because what is happening here is that all the the the zooplanktons that the fish was eating they were having certain concentration of these residues in their bodies and the residues from all of these zooplanktons will now get accumulated into the body of the fish. So, the concentration increases.

Those fishes that eat up these smaller fishes will have an even greater concentration, the birds that feed on these fishes will have an even greater concentration. Now what happens is that when the concentrations increase the impact of the chemicals or the toxicity of the chemicals also starts playing a role, because as we have seen there is a lethal dose for different and in between it will start doing certain sub lethal effects.

So, in that case the organisms will not die, but will show impact in terms of reduced fitness or reduced fecundity and this is what was observed in the case of Bald Eagles. Now, Bald eagle is

the natural bird of the United States and it was found that when the researchers looked at the concentration of DDE in the egg shells.

This curve is showing the DDE concentration on the x axis and the average 5 year productivity that is the number of eggs or the or the number of chicks that were that were that were born in every generation on the y axis. Now, this is the average of the curve, this is the regression curve, the sigmoidal regression curve and here we can observe that if the concentration of DDE is less than or equal to 2 microgram per gram then there is hardly any change in the average fiber productivity of these birds.

If the concentration of DDE is greater than 20 microgram per gram in the egg, then we observe that the average 5 year productivity is very less. It is close to 0.1 that is roughly one tenth of what we see in the national conditions. And in between we see that this curve slowly goes down which is telling us that as the concentration of these residues increases the average 5 year productivity or the fecundity of these birds decreases

Now, it was later found out that because of these residues the egg shells that are formed are very thin and they are so thin that when the bird sits on these eggs the eggs break, which reduces the productivity of these birds. So, this is the curve that is telling us that as the concentration of these residues increase they start showing a more drastic impact as was shown or was shown when the concentrations were lesser. And because these chemicals are very persistent chemicals and so these impacts can be shown for a very long period of time.

But then we still have hope because a number of these populations are also resilient. If you look at this curve on the x axis we have the years and DDT was banned in the year 1972 in the United States and when before this ban the this this line is showing us the DDE concentration in terms of ppm of dry weight and the average concentration was close to say around 100 ppm.

After the ban it took a few years but then the concentration came down to around 30 ppm. Now remember that here the concentration has not gone down to zero because it is a persistent chemical, but the concentration has come down. Now before the bank the mean number of young for breeding area was 1.3 and then because of the impact of DDT it was coming down. So, from a natural level of 1.3 it had come down to around 0.5.

But then when this ban was enclosed, so slowly and steadily the concentration of DDT went down and the residues such as DDE also went down and after a while we see that this curve is now increasing. So, the mean number of young per breeding area they are now increasing from 0.5 they have reached to around 1.1 they have not yet reached to 1.3 but they have reached to 1.1.

Now, this is showing us that even in the case of a number of these persistent chemicals, if we enforce a ban then there is still a possibility for a number of species to come back. Now this coming back is known as resilience and this curve is also telling us why it is important to study the impacts of these different chemicals, because only when we know their impacts will we be able to act upon them.

Now, such a recovery can also be aided through certain activities that are known as restoration and this comes under the domain of restoration ecology. So, restoration ecology is the scientific study supporting the practice of ecological restoration which is the practice of renewing and

restoring degraded damage or or destroyed ecosystems and habitats in the environment by active human intervention and action.

It is telling us that even when we have damaged the ecosystems and habitats. So, they are now degraded, damaged or destroyed. In the field of restoration ecology we try to put in active human intervention and action and we try to bring them back to their original state. We are aiding in the restoration of these damaged habitats. There is damage that has already been done, but through restoration ecology we are trying to bring the system back to that.

How do we do that we have already released a heavy amount of toxins, we have already released a large quantity of plastic. Is there anything that we can do and if yes what are the steps that we can do? What kinds of actions are done? So, there are certain actions that degrade the environment and there are certain actions that restore the environment.

Degrading actions include things such as precision of prescribed burning. If you do not perform prescribed burning, your grass will be taken over by trees which will be a change in the local system, which will be having a degrading impact.

Cultivation and cropping in a number of cases degrade the habitat, disturbance, excavation or burial or substrate things it is mining. Eutrophication - Eutrophication is excessive nutrients being made available to the system, especially the water bodies because in a number of cases the fertilizers get run off from the fields into the water bodies.

Disruption of hydrology by say construction of a dam invasion by non-native species, especially the invasive species, logging of trees that is cutting off of trees overgrazing, removal of animals by poaching and contamination of soil, so these are all different examples of degrading actions.

Restoration actions could include things such as cessation of the degrading action. So, in case you were doing say poaching in an area, then a restoration action would be to give up poaching. But this is a passive restoration in the case of active restoration you will also reintroduce the animals into this area to make up for the population loss.

Another action is extirpation of the damaging species. So, if there is a non native invasive species you will remove that species. So, that will be a restoring action that will help the system come back to normal more quickly. Nutrient removal in cases where you already have eutrophication, you may try to remove certain nutrients to remove the negative impact planting of grasses and grass like other herbs or pops.

Especially in those areas where you have done an excavation if you plant grasses then the soil will get stabilized or planting of trees or reinstatement of burning if you were not doing the prescribed burning that is the restoration action. The remodelling of topography especially in cases where you have already dug a huge exclamation pit or where you have already created huge amounts of waste.

In that place remodelling of the topography to ensure that these waste do not get washed away, that is restoration action or soil amendments to bind or to dilute the contaminants how to restore the fertility. These amendments can be done in space where there has been heavy erosion. We may try to increase fertility. In cases where there are contaminations we may try to wash away the contaminants to reduce their concentrations. These are all different examples of restoration activities.

Now, it is important to keep in mind that the restoration has certain constraints, as we have seen before there are always tradeoffs and in the case of restoration we need to keep in mind the regional constraints and the local constraints. For instance in certain cases it may not be possible to bring the system back to its original state. We may try to bring it to a state which is a bit better or maybe a bit different from what was there originally, because there are certain constraints at the local level and at the regional level.

Probably the carnivore that was removed or was made locally extinct because of poaching that is no longer available. So, in that case you may try to reintroduce some other carnivore to stabilize the system. So, the constraints have to be kept in mind.

Now we will look at a few examples in the case of mining. If mining was done then a lot of degradation activity had already taken place. Deforestation because to access the earth we remove the trees that are there, because these trees have been removed there will be soil erosion. In the case of mining there will be a certain amount of heavy metals that will be released that will lead to water pollution.

So, anyway metal releases water pollution. Soil erosion and deforestation are all different kinds of degrading activities or degradations that have already occurred in a mine. The restoring actions could be things such as flattening of waste dumps and landfills to prevent erosion, filling up of the duct pits covering with a layer of clay to prevent access to rain and oxygen, covering with a layer of topsoil because there because of the heavy erosion the topsoil is gone.

We cover it with a layer of topsoil and plant trees or evaporate tailings dams, so that the water is removed, the waste gets concentrated and then it can be removed from the area, so these are examples of restoration activities. Similarly, in the case of river systems we can have degrading actions such as construction of dams.

A dam completely changes the hydrology of the area. From a running water system you have converted the area into a stagnant water system. So, that causes a change in the hydrology, it changes the movement of different organisms such as fishes.

Other examples include diversion of land. So, land that was there in a flood plain has now been diverted and made into, say a building area. Overuse of groundwater, channelization of streams - these are all different things that lead to changes in hydrology.

Then we have changes in the habitat clearing of land grazing especially over grazing, mining in the area introduction of the invasive species. These are all different kinds of degrading actions. Restoration actions would include things like restoring the hydrological processes and the geomorphic features. If the floodplains have been diverted into construction areas then probably some of these have to be brought back into the flat plains.

Restoration of the riparian vegetation, so in case certain invasive species have invaded into the area then they will have to be removed and the natural indigenous riparian vegetation will have to be brought back. That will be a restoring action, restoring of animal life that was affected because of the degradation.

And when we are doing restoration activities these days bioremediation has come in a big way to aid the restoration activities. Bioremediation is the process that is used to treat contaminated media including water, soil and subsurface material by altering environmental conditions to

stimulate the growth of microorganisms and degrade the target pollutants.

What we are saying here is that this is a process used to treat contaminated media. For instance there was an oil spill and the oil has been leaked into a water body. Now this oil is bringing up certain toxic impacts. Now to treat this oil we can either make use of dispersants such as detergents or you can make use of bioremediation.

In the case of bioremediation what will be done is that the microorganisms that can eat up these oil spills will be introduced into the area and probably certain nutrients will be added to the area to promote the growth of these microorganisms. And when you have these microorganisms they will act upon the oil and they will eat up the oil, so this is an example of bioremediation.

It is a process used to treat contaminated media including water, soil and subsurface material by altering environmental conditions. Now in this case an altering environmental condition is introduction of the nutrients, so that the microorganisms are able to grow. So, you alter environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants.

Another example is phytoremediation, in which case we make use of those plants that can treat the pollutants. So, a good example is the treatment of municipal waste. So, the municipal waste is very high in organic compounds and that may lead to changes in the body of or the biological oxygen demand of the water bodies. Which means that so much organic material is put into the water body, that it reduces the amount of oxygen that is there in the water body when it gets degraded.

Now, to act upon these organic compounds we can make use of phytoremediation such as root zone treatment. Now in this case the wastewater that is coming from the municipal facility is put into a sedimentation tank, so that a majority gets sedimented and the water that comes out is passed through a bed of wetland plants. And after this water has passed through the root zone of these plants it is then put out into an output.

Now, what happens in this root zone if you look at the root zone there is an oxidized zone and there is an anoxic zone around these roots. Now this reduced zone will be reducing the organic compounds and the oxidized zone will be oxidizing the organic compounds.

Now because of this, oxidation and reduction reactions, what will happen is that a majority of the organic compounds that are there in the wastewater will be acted upon and they will be treated. And once they are treated now the water is safe to be removed and released into the environment otherwise all of these chemicals would have had a toxic impact or a negative impact on the ecology and these methods are pretty efficient.

If you look at the biological oxygen demand reduction you load these plants with the wastewater and they are able to remove the bod. Or if you look at the total suspended solids you load the water and the water that comes out is clean. So, this is acting to purify the water it is clearing off the water, the water becomes transparent and the organic compounds are treated in a manner that it does not cause any further harm to the environment.

That is all for today. Thank you for your attention. Jai Hind!